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Disciplinary Specificity in Engineering Communication: Rhetorical Instruction in an Undergraduate Engineering Research Class

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I. Introduction

A recent program launched at the Massachusetts Institute of Technology (MIT) provides a year-long undergraduate research experience with an accompanying communication course. Designed to build upon student interest in "a deeper undergraduate research experience"[1] the program was initially created in the Department of Electrical Engineering and Computer Science, and expanded in 2015 to the rest of the School of Engineering. The pairing of this research opportunity with communication instruction is intended to provide a professionalizing experience, giving students an understanding of the world of academic and industry research. This year-long communication intensive course enrolls approximately 170 students from departments across the School of Engineering, including Aeronautics and Astronautics, Biological Engineering, Chemical Engineering, Civil and Environmental Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, Mechanical Engineering, and Nuclear Science and Engineering. Each individual research project is overseen by a faculty member within their lab, often with direct mentorship from a graduate student or post-doctoral fellow. Several communication deliverables - a proposal, a conference poster, a journal article and an oral presentation - are required throughout the year, based on each student's research.

We have two principal challenges. First, our students' numerous and varied engineering disciplines each possess their own underlying and often tacit reasoning patterns, habits of mind, and foundational assumptions[2, see also 3-6] - all of which must be taken into account as students communicate their research. Second, the tacit quality of these assumptions and mental processes creates for each discipline its own set of learning "bottlenecks" that novices must confront and overcome.[7] The number and variety of engineering disciplines in "Preparation for Undergraduate Research" makes it impossible to design instruction with attention to identifying and working through each field's bottlenecks, though this is what many students need. Thus, we as communication instructors cannot provide expert insight into how students experience their disciplinary bottlenecks and understand underlying reasoning patterns, habits of mind, and foundational assumptions of their sub-fields.

Drawing upon a combination of approaches from Writing in the Disciplines (WID), Rhetorical Genre Studies (RGS), and educational research, we develop a method that trains this diverse set of engineering majors to draw upon their own disciplinary knowledge to decode and resolve bottlenecks in their own specific sub-field. We present a two-stage model that supports disciplinary specificity through explicit rhetorical instruction, guided practice, and peer review.[2] The first stage teaches broad rhetorical concepts supporting the composition of two professional genres: a proposal and a poster, genres typically geared toward a broad audience. In the second stage, students by now familiar with rhetorical analysis learn to perform genre analysis on texts in their own field. They identify and then deploy the rhetorical moves and strategies appropriate to their next communication task: a journal article intended for their specific disciplinary audience. In this paper, we propose that explicit rhetorical genre instruction can bolster student understanding of disciplinary reasoning patterns and assumptions of their specific sub-fields. Our

model's attention to the specificity of different engineering discourses makes our method applicable in a wide range of engineering communication courses.

II. Course Context and Theoretical Framework

A. Engineering Communication Pedagogy

"Preparation for Undergraduate Research" presents a weekly seminar on topics such as current faculty research, technical innovation in industry, entrepreneurship, and professional development. Each semester, we communication instructors additionally teach students in a series of three to four workshops in preparation for the communication deliverables that are due throughout the year. For both logistical and pedagogical reasons, the composition of these workshops is drawn from the entire student enrollment and cannot be segregated by discipline. In addition to scheduling constraints, communication instruction occurs with very limited input from technical faculty on the class. This phenomenon is frequently found in WID research, which shows that faculty frequently do not explicitly articulate their own criteria and expectations for student performance on communication assignments.[2, see also 8, 9] Further, the true experts on each research project in "Preparation for Undergraduate Research" serve as individual technical mentors to students, separate from the four to six technical course staff who read and assess papers well outside their own area of expertise. Thus, communication instructors face a complex set of challenges in teaching such a large variety of students in such a wide range of disciplines. Even beyond the many departments in which students do their research, each individual research project has its own disciplinary norms and requirements. Essentially, this course must give instruction on how to write in up to a hundred sub-disciplines, without the benefit of domain experts at any point in the process.

Our work was inspired in part by situations in which a standardized set of writing requirements shifted students away from the authentic, professional genres we were attempting to teach. These situations illuminate the pressing need for new methods of communication instruction to address the challenges that engineering students typically face as they learn to write for their specific sub-fields.[9-14] Often in WID and Writing Across the Curriculum (WAC), rhetorical instruction in engineering assumes a uniform set of rhetorical moves, following the models suggested by Swales,[15] from the field of applied linguistics, and Bazerman,[16] from the field of Rhetorical Genre Studies (RGS). For instance, the most commonly studied structure of a research article is the IMRaD format,[e.g., 17] common among the experimental sciences such as biology and many biological engineering fields. However, some engineering fields organize papers according to project-specific sections. One example of a professional networking design paper, offered in an early version of this class as a model, included sections titled "Understanding [project]'s gains," "Implementation details", and even "Making it work."[18]

Recently in the broader context of STEM writing, communication scholars have recognized this variation and criticized the uniform approach, first for its tendency to apply the Classical paradigm too liberally to the rhetorics of STEM,[19, cited in 17] and second, because the speed with which STEM genres and modes of argument - particularly visual modes of argument - outpaces existing methods communication scholars use to analyze them.[20, cited in 17] Indeed, more recently Swales himself has encouraged methods of move-structure analysis that attend to variation.[21, cited

[in 22] Such variation is frequent and significant in our course. For instance, most research papers require that a conventional rhetorical move explicitly connect their technical project to a real-world context or a gap in scientific knowledge. However, a typical paper in theoretical math may only offer a motivation in the form "[XYZ topic] is frequently studied in [subfield]," a self-referential move which may not register as a motivation to readers in other fields.

More broadly, RGS contends that teaching generalized conventions of professional genres is insufficient.[e.g., 16] Even a feature such as a figure can also vary dramatically. In our course, EECS faculty advised that all papers include a block diagram, a type of organizational visualization common to their discipline but which is rarely if ever seen in other fields such as chemical engineering or synthetic biology. When an experimental apparatus must be depicted, faculty in some fields required photographs of experimental setup while those in other fields viewed this as an unprofessional shortcut that is inferior to a diagram.

Foundational to RGS is the assumption that while genres cohere out of typified social actions,[23] they are also as dynamic as their social contexts.[24] Thus, the various forms that engineering genres take will tend to outpace rhetoric scholars' analyses of them. Further, the wide variety of engineering sub-fields, each with its own dynamic genres, means that teaching engineers to communicate through broad rhetorical principles will not suffice. In the context of "Preparation for Undergraduate Research," given the number and variety of sub-fields – each dynamically generating new discursive genre variations – such standardized genre instruction would serve to undermine students' learning to communicate effectively as professionals. We have given examples, above, of several cases in which such standardized genre instruction actually requires students to produce works that are less authentic to their future professional genres.

Students thus need instruction in the forms, practices, and disciplinary systems of knowledge production that govern genres in their specific engineering fields. Beaufort argues for the adoption of an instructional model that "account[s] for the multiple knowledge domains activated in expert writing performances."[14] These knowledge domains include subject matter and disciplinary discourse knowledge, genre and rhetorical knowledge, and writing process knowledge. To successfully perform rhetorically effective professional writing, students need to learn how these domains work together. Beaufort proposes that this model be implemented from students' very first year of college so that, through a scaffolded approach, they can develop the ability to assess and perform well in increasingly specific disciplinary rhetorical situations throughout college and beyond. Embedded communication instruction at MIT adopts a very similar perspective to Beaufort's, with regard to teaching engineering students to draw upon all five knowledge domains to perform and communicate effectively as professionals. But again, communication instructors in our course, "Preparation for Undergraduate Research," more so than other Communication Intensive courses at MIT, must negotiate students' numerous and varied disciplinary communities of practice[25, cited in 2] through a unified curriculum of classroom instruction.

B. Tacit Learning vs. Explicit Instruction

Our teaching approach provides explicit rhetorical genre instruction to support what students learn about disciplinary communication within their immersive research experiences. As we

know, faculty across the disciplines often leave their expectations for student writing unstated. An abundant literature in WID explores the tension between these unstated expectations and the complex underlying reasoning patterns, habits of mind, and foundational assumptions of each discipline that students must learn to recognize and perform. Over the last few decades, WID researchers have extended rhetorical theorist Stephen Toulmin's concept of warrants (i.e., the often implicit assumptions and premises upon which rhetors rest their arguments as they appeal to their audience's values) to the underlying assumptions and reasoning patterns of disciplinary communication.[2, see also 26, 3-6] As Wilder explains, these shared disciplinary assumptions "allow each discipline to do its rhetorical work with an efficiency that would be absent if scholarly writers had to explain and defend all of their first principles and grounding assumptions in every argument."[2] In addition to making disciplinary argumentation more efficient, writers can appeal to these underlying assumptions and shared values to indicate the depth of their knowledge and authority.

Generally, students are not taught these disciplinary warrants; rather, it is assumed that they will be learned through experience working and doing research in the discipline. For example, in "Preparation for Undergraduate Research," the assignments for each of the four major genres (i.e., proposal, conference poster, journal article, and brief oral presentation) were initially comprised of lists of content, layout, and formatting requirements, assuming either that students were familiar with the genre or that its rhetorical attributes were self-evident. Because faculty, in engineering and across the disciplines, often learn the warrants of their fields in this implicit, accumulative manner, even when they wish to train their students to think and write like professionals in the field, they struggle to recognize how their expert reasoning patterns and habits of mind enable them to do the work of their discipline.[7]

Central to a novice's progression toward expertise in a given field is this incorporation of disciplinary warrants into their identity, so that the shared values and reasoning patterns of their field become part of the way they think. Thus, RGS and WID scholars continue to debate whether explicit rhetorical genre instruction should buttress what students learn through what Wilder calls the "meaningful social interaction"[2] of immersive work experience.[25, 27-28] Freedman takes a view of explicit rhetorical genre instruction that reduces disciplinary specificity to more general "rules," and warns that such instruction can cause students to ignore the reasoning patterns, habits of mind, and underlying assumptions that govern the rhetorical genre features in favor of those "rules," and thus produce less rhetorically effective work.[27, 2] On the other side of the debate, several WID scholars[2, 6, 29-31] argue that allowing genre instruction to remain tacit diminishes both the efficacy and the ethics of disciplinary teaching, and consider it worthwhile to explore questions about the efficacy and "portability of rhetorical strategies across contexts."[12] Artemeva's findings, from her longitudinal study of novice engineers, indicate that "rhetorical strategies *may* be portable but only if a novice *already* possesses a combination of particular genre knowledge ingredients,"[12] including cultural capital, formal education, "domain content expertise," and "workplace experiences."

In "Preparation for Undergraduate Research," students certainly obtain many of these ingredients through the "meaningful social interactions"[2] of their research experiences, but communication instructors find that students often struggle to communicate the work they do in their labs to their peers. To guide our students through these "bottlenecks,"[7] we communication instructors call

upon their accumulation of tacit disciplinary genre knowledge to inform our explicit rhetorical instruction. Indeed, our model seeks to teach students how to identify their own discipline-specific genre-knowledge ingredients for themselves. To accommodate a broad range of engineering students working in a great number and variety of research labs, each offering its own brand of expert-novice training, we suggest that our two-stage communication curriculum of explicit rhetorical genre instruction can teach students to negotiate the rhetorical complexity of genres in their sub-fields and communicate with rhetorical effectiveness.

III. Our Model

A. Rhetorical Genre Studies and "Decoding the Disciplines"

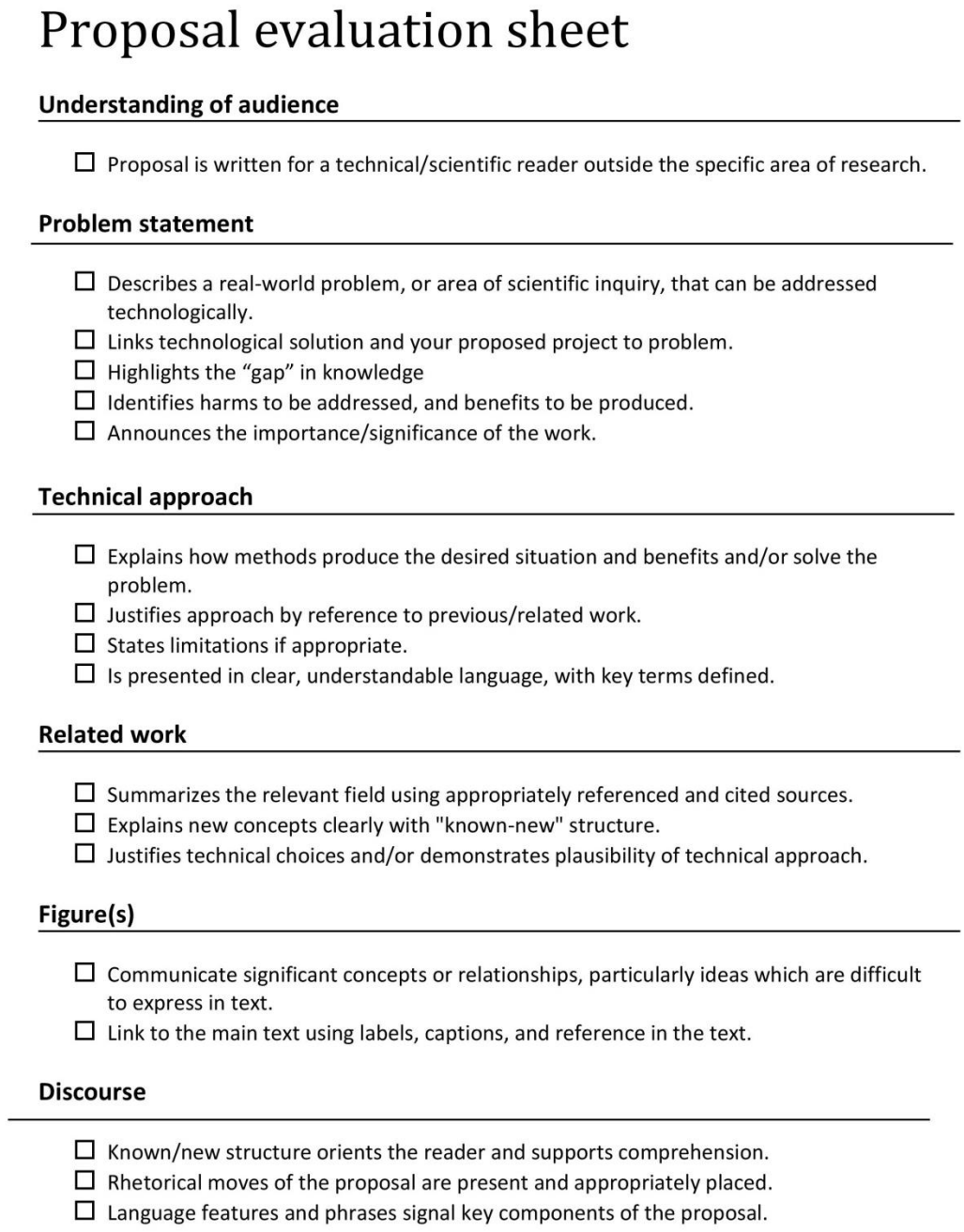
Drawing upon a combination the above described approaches from RGS and WID, as well as education scholars' Middendorf and Pace's "Decoding the Disciplines" method, we have developed a two-stage model to train our diverse class of engineering majors to draw upon their own disciplinary knowledge to decode and resolve bottlenecks in their own specific sub-fields. Middendorf and Pace's method guides disciplinary faculty through a series of questions to help them to identify bottlenecks to learning in their fields, to understand better "how students think and learn," and thus to help students progress toward disciplinary proficiency.[7] This method has proven useful to communication instructors of single-discipline courses at MIT, who have worked through the steps of decoding the disciplines in conversation with technical-expert faculty.[e.g., 32] However, professional communication in "Preparation for Undergraduate Research" is taught by communication instructors – not disciplinary experts – and contains far too many sub-fields – and thus far too many bottlenecks – to manage this model as originally designed. Instead we have developed a different framework - inspired by "Decoding the Disciplines," but theoretically informed by RGS - upon which students reflect on their own aspiring-to-expert domain knowledge, in order to make the rhetorical genre knowledge of their discipline explicit.

B. Stage I: Identifying and Communicating Contributions

In the fall semester, major deliverables (i.e., proposal and conference poster) necessarily address a more general audience, and thus the rhetorical genre attributes are less field-specific. In the first workshop, students are introduced to the fundamentals of rhetorical choices based on context, audience, and purpose. A predetermined set of rhetorical moves (derived from Swales)[15] are used along with requirements from technical staff to define the requirements of the proposal assignment. Because the proposal is typically addressed to a non-expert audience that reads across a broad range of topics, both the content and the rhetorical moves can be generalized. For instance, we required five specific moves (shown in Fig. 1) in the "problem statement" section: describing the real world problem; linking it to the technical solution; highlighting the gap in knowledge; announcing the importance of the project; and identifying harms and benefits of problem and solution.

Not all of these moves are necessary to communicate to a reader from a related community of practice, whose technical knowledge and understanding of tacit assumptions closely match that of the writer: for instance, a supervisor or peer working in the same area, for whom certain moves (e.g., the real-world problem or how the technological solution links to it) are self-

evident. But in order to communicate projects to non-expert audiences, all of these moves are needed.



Proposal evaluation sheet

Understanding of audience

- ☐ Proposal is written for a technical/scientific reader outside the specific area of research.

Problem statement

- ☐ Describes a real-world problem, or area of scientific inquiry, that can be addressed technologically.
- ☐ Links technological solution and your proposed project to problem.
- ☐ Highlights the "gap" in knowledge
- ☐ Identifies harms to be addressed, and benefits to be produced.
- ☐ Announces the importance/significance of the work.

Technical approach

- ☐ Explains how methods produce the desired situation and benefits and/or solve the problem.
- ☐ Justifies approach by reference to previous/related work.
- ☐ States limitations if appropriate.
- ☐ Is presented in clear, understandable language, with key terms defined.

Related work

- ☐ Summarizes the relevant field using appropriately referenced and cited sources.
- ☐ Explains new concepts clearly with "known-new" structure.
- ☐ Justifies technical choices and/or demonstrates plausibility of technical approach.

Figure(s)

- ☐ Communicate significant concepts or relationships, particularly ideas which are difficult to express in text.
- ☐ Link to the main text using labels, captions, and reference in the text.

Discourse

- ☐ Known/new structure orients the reader and supports comprehension.
- ☐ Rhetorical moves of the proposal are present and appropriately placed.
- ☐ Language features and phrases signal key components of the proposal.

Fig. 1. *Proposal evaluation sheet*. This document was used at several stages in the proposal-writing process: (a) as guidelines for students drafting the proposal; (b) as a template for feedback from communication instructors; (c) as a structure for students giving peer review; and (d) in a modified format as a final grade sheet for the proposal.

Teaching students the rhetorical moves necessary to make those tacit assumptions explicit enabled our communication instructors to guide students through a difficult bottleneck. Because students working in these research labs are essentially novice engineers, they may elide the logical progression that links their own work to a real-world problem. As communication instructors teach the rhetorical moves of the problem statement - focusing in particular on the first three, and on student identification of the hierarchy of their contribution - students learn to articulate their own discipline-specific contribution to the major problem or area of inquiry (see Fig. 2). This rhetorical approach allowed non-technical instructors to guide novice researchers through learning bottlenecks and toward writing a proposal that communicated discipline-specific knowledge to a broad audience.

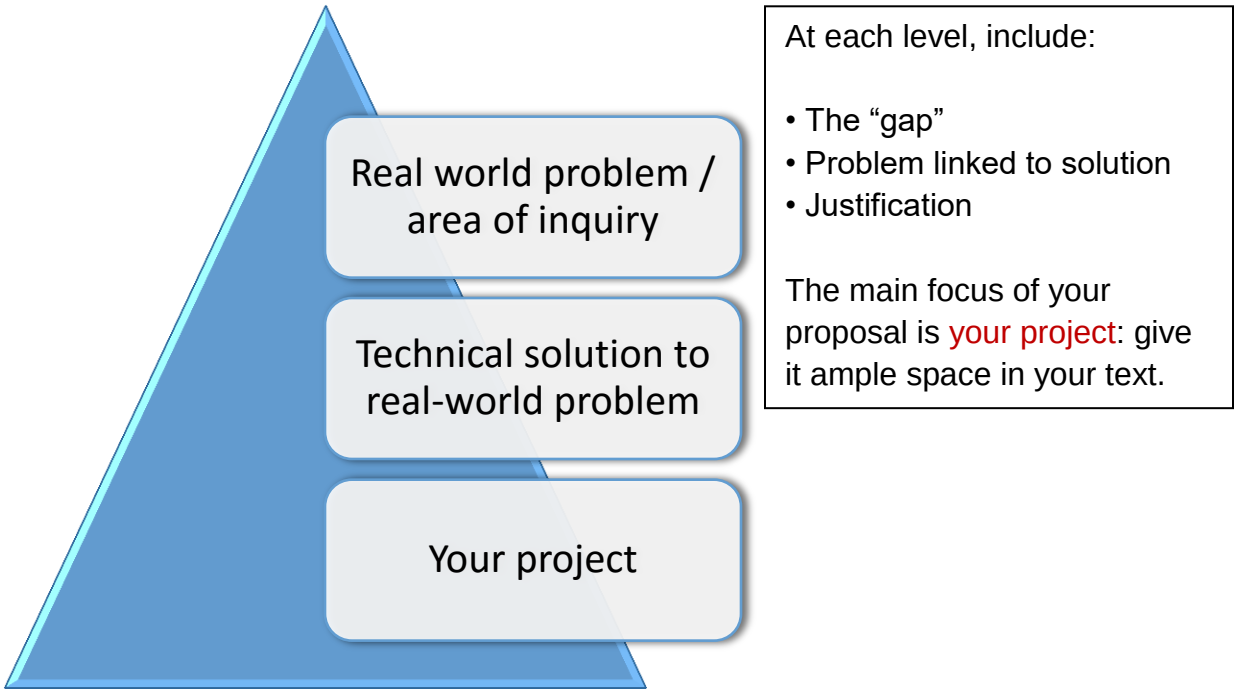


Fig. 2. *Hierarchy of a problem statement*. Sample slide used to give instruction on presenting the "problem statement" of a research proposal. This structure translates the logical series of problem-solution statement and justifications into a rhetorical framework.

We reinforced our rhetorical genre instruction in the second workshop, a peer review session. We designed a worksheet listing the same set of rhetorical moves, shown in Fig. 1, to structure students' feedback on their classmates' proposal drafts. Students then discussed the feedback worksheets in structured in-class peer review. Through this process, students gain the benefit of feedback from technical readers outside of their specific community of practice, which buttresses feedback from communication instructors.

The third workshop extended these moves to the multimodal genre of the conference poster session (See Fig. 3). Students prepared for the workshop by reviewing a selection of student posters from the previous year, with videos of the accompanying presentation. Then they identified the key moves and noted whether they occurred in the visual, textual, or oral mode. In workshop, students discussed the posters in small groups and then reported on their assessments (i.e., which moves seemed most important, and how different implementations were more or less effective in communicating key concepts or relationships). The workshop also provided a brief introduction to visual design, which students drew on to articulate how information was, or was not, communicated. Notably, a few key visual or structural techniques highlighted in class by students appeared on many posters at the final session.

Title of poster being evaluated and/or name of student:

Rhetorical move	Image/figure	Text	Oral
Announcing importance of the field			
Overview about the subject			
Indicating a gap/raising a question			
Stating goal of the study			
Describing procedures			
Detailing equipment			
Justifying procedures or methodology			
Stating results or findings			
Suggesting further research			

Fig. 3. *Preparation for poster workshop*. Selected rhetorical moves from the proposal guidelines were used to guide student analysis of a set of conference papers and associated oral presentations.

C. Stage II: Analyzing and Performing Specific Disciplinary Moves

The spring semester (in progress) revisits the key rhetorical moves, but this time with a focus on the disciplinary specificity and dynamic attributes of genre. Spring communication deliverables include a journal article and a brief project overview, or "pitch" presentation. These new genres require a new approach and more expert knowledge. Because a journal article is addressed to an expert audience in the specific field of research, the generalized and standardized rhetorical moves used in the fall will not be sufficient. With at least a hundred different research topics and

faculty mentors, it is impossible for communication instructors to create individual guidelines on a per-topic basis, or to use strategies such as a modified Decoding the Disciplines model to interview experts. Further, no set of rhetorical "rules" can suffice given what we know about the inherent dynamism of disciplinary genres and questions raised in debates about supplementing tacit learning in specific communities of practice with explicit rhetorical instruction. Instead, workshops in this semester actually train students to do complex rhetorical analysis themselves.

Students have already identified reference materials including journal articles in their own discipline, and these form a corpus for each student to analyze. In the first workshop, instructors present a list of key features used in journal articles (e.g., figure captions, reference to real-world context, presentation of methods, use of visuals, etc.) and guide students in a comparative analysis of several examples. For instance, in biological fields figure captions tend to be lengthy and descriptive, while captions in mechanical engineering are quite sparse. A paper in robotics might describe a specific real-world application to motivate its main contribution, while an information theory paper might present an unproved theorem as its motivation. This guided analysis will help students observe and articulate the variation and specificity of disciplinary writing. After this in-class practice, and drawing on a sample list of potential rhetorical moves, students will use their disciplinary knowledge (developed in their research and through the "meaningful social interaction"[2] of their communities of practice[25]) to develop a set of guidelines for a journal article in their own field. This document will be submitted with both the article draft and the final journal article, and will be referenced in communication feedback and in student peer review.

In preparation for the second workshop, students prepare their discipline-specific guidelines. The workshop's first activity is an informal small-group peer review, in disciplinary groups when possible. In the second activity students begin to draft their problem statement or introduction to execute key moves as identified in their guidelines. These guidelines both help students connect rhetorical choices to disciplinary knowledge, and give them the opportunity to justify their choices by making explicit the rhetorical choices appropriate to the genre in their own sub-field. This addresses the extraordinary challenge faced when non-disciplinary instructors must teach and evaluate disciplinary writing.

A third workshop reprises the fall semester peer review, with students reading peers' article drafts together with the student-written guidelines. With this feedback and individual feedback from instructors, the article is revised for final submission. A fourth workshop again offers instruction on how to translate the key moves and content into a very brief presentation, along with brief instruction on presentation skills.

IV. Methodology, Results, and Discussion

A. Survey Instrument

Our survey instrument (Appendix A, with responses on 7-point Likert scale for fine-grained results) is excerpted from MIT's Writing, Rhetoric, and Professional Communication Division (WRAP) "Communication Self-Assessment Inventory", which was itself derived from the Oregon State University "Writer's Personal Profile" (WPP). The WPP is a self-assessment and

goal-setting survey developed to measure student learning in Oregon State's Writing Intensive (WI) upper division courses. The WPP is comprised of both multiple-choice and short-answer questions that assess a range of learning goals from across the WI program; the survey was validated through a research study of 23 WI courses from throughout Oregon State University.[33, 34]

Two key findings from the Oregon state study prompted our program to adopt the WPP model: first, students who fully participated in the entire survey learned to "direct their own experience" via self-reflection and "personal goal-setting"; and second, these student responses produced "a body of information that their instructor can use to target course content and assignments more specifically to the current cohort of students."[33] In an effort to expand Oregon State's WPP model toward long-term program-wide assessment, our program has adopted and revised the WPP's survey questions to test such theories of writing instruction as Beaufort's RGS-informed concept of five knowledge domains and the Council of Writing Program Administrator's habits of mind framework. Our program's "Communication Self-Assessment Inventory" includes over 60 survey questions that measure student understanding and learning outcomes, according to these theories, on a fine-grained 7-point Likert scale. Different Communication Intensive (CI) courses in the program have drawn upon and revised survey questions from the program's full communication inventory in order to assess both student learning in particular single-discipline courses and correlations across CI courses. Thus, in an effort both to assess the effectiveness of our method of explicit rhetorical instruction and to contribute to our program's long-term program assessment, we have derived questions for our survey instrument from the program's larger communication inventory.

Our initial study of Stage I investigated communication practices and self-assessment of communication knowledge and performance, using a 12-question communication inventory (Appendix A). Student responses to a brief baseline assessment before the class were compared to responses to the same survey at the end of the semester. In the pre-assessment, 58 individual students out of 180 responded to the survey. In the end of term assessment, 36 students responded. Approximately 10 students dropped the class over the course of the term, bringing the final enrollment to 170.

The results of the communication inventory highlighted the specific communication experience and requirements of this particular population. Incoming students reported a very high confidence in communication skills across the board, with 11 of the 12 questions averaging a response above 5 (out of 7) ranging from 5.03 to 6.36. Because of these very high initial averages, we found no statistically significant changes to ten of those questions (primarily assessing audience-awareness, work with peers, citation, and process). For Stage II, the Survey Instrument will be revised in order to assess how these high averages correlate to a variety of other skills, habits of mind, and communication practices.

B. Students' Shifting Conceptions of Professionalization and Disciplinary Identification

In the Stage I Survey, two questions measuring changes in student professionalization and disciplinary identification did show dramatic shifts. Q2, "I recognize responses from my technical mentor and instructors as opportunities to improve and refine my work," showed an

increase of 2.27 (P value < 0.00001 using an unranked T-test), from 4.09 to 6.36. The increase in recognition of the technical mentor as an authority on communication work indicates the increasing identification of our students with the community of practice in which they perform research. It also highlights entering students' lack of certainty about this primary area, with a start-of-semester average score (4.09) almost a full point below the next lowest question. But in the end-of-semester assessment, this question reversed position to become the *highest* average score.

Q1, "I have sufficient experience and knowledge about writing in my field of research," showed a *drop* of 1.75 (P value < 0.00001 using an unranked T-test), from an initial 6.36 to a final 4.61. Interestingly, the place of these scores almost exactly reverses Q2, going from the highest initial score to the lowest final score. We have not seen previous studies on this drop in self-efficacy at a time of increasing knowledge in the literatures of writing or communication. We understand this shift as a clear indicator of a transition stage between novice and expert, and as a step in professionalization.

We also saw a small increase (+ 0.35, P value 0.0193 using an unranked T-test) in Q8, "I understand how to reflect on the communication choices I make in light of context, purpose, and audience." These terms were used consistently in workshops, so the increase may indicate greater confidence in the reflection described in the question, or it may simply indicate greater certainty about what those key terms mean.

C. Communities of Practice, Explicit Rhetorical Instruction, and Professionalization

"Preparation for Undergraduate Research" is intended for undergraduates without previous research experience, and thus students begin the course with a set of assumptions that their general, "student" knowledge will translate to professional and disciplinary work in their communities of practice. Responses to Q2, which show an increasing reliance on their individual mentors and lab group members, may indicate a shift in their expectation that class faculty will provide all necessary instruction. This transition stage from novice *toward* expert, with its increased reliance on the disciplinary community of practice, is likely accompanied by a richer understanding of the knowledge and skill sets needed for true expert status, producing a re-evaluation of self-efficacy based on their larger scope of what "sufficient experience and knowledge" means.

Communication and technical instructors both observed indications of the role of rhetorical instruction in solidifying disciplinary knowledge. In previous semesters, technical instructors reported that the quality of the research proposals was erratic and not consistently satisfactory. This semester, the weakest proposals largely corresponded to students who were struggling with their project in a variety of ways. Most commonly these struggling students were not in contact with their mentors, did not know what the research goals were, or had been assigned a project they did not want to work on. Thus, failure to deploy the appropriate rhetorical moves frequently signaled a need for intervention by class faculty to resolve the actual research issue.

V. Future Work

We had hoped to present a rhetorical analysis of papers selected by faculty as exceptional writing, but logistical difficulties delayed the selection of papers. This analysis will be presented in our future work. Further, Stage II's assessment will include a broader and more robust subset of 45 questions from the longer "Communication Self-Assessment Inventory." Our very brief initial 12-question survey included only one or two questions for each major learning outcome, and, as discussed above, we found very little change from pre- to post-assessment. In the case of Q8, we were not certain whether the change measured student knowledge or greater familiarity with vocabulary; further, some items may have been over-broad (Q6) or may have presented students with more than one question to answer (Q3). These questions have been re-written for the Stage II assessment. Additionally, the expanded survey in the spring will allow us to correlate responses on conceptual questions (e.g. Q1) with responses to questions about skills-based knowledge (e.g. citation) vs. rhetorical knowledge.

VI. Conclusion

In semesters prior to Fall 2015, students in "Preparation for Undergraduate Research" received the same implicit training in genres and discourse of their specific sub-fields, but did not receive explicit rhetorical instruction. Under those conditions, proposals assessed as inadequate might reflect either a lack of knowledge about writing requirements or a weakness in understanding of the research field. Based on the assessment of both communication instructors and technical faculty, the addition of explicit rhetorical instruction appeared to bolster, not undermine, student understanding of disciplinary reasoning patterns and assumptions. This indicated a strong link between the rhetorical moves required in this class and students' understanding of how their work in the lab contributed to the development of a technological solution to a real-world problem. This finding, which will receive further study in Stage II of our project, indicates the value of *both* explicit rhetorical instruction and the tacit knowledge acquired in "meaningful social interaction" within their disciplinary community of practice.

Appendix A

Data Table, Stage I

Question	Pre-test Average	Post-test Average	% Change	Difference	P-value
Q1	6.36	4.61	-27.52%	-1.75	< 0.00001
Q2	4.09	6.36	55.50%	2.27	< 0.00001
Q3	5.03	5.36	6.56%	0.33	0.305
Q4	5.79	6.08	5.01%	0.29	0.17
Q5	5.21	5.31	1.92%	0.1	0.707
Q6	6.00	5.97	-0.50%	-0.03	0.477
Q7	5.07	5.42	6.90%	0.35	0.146
Q8	5.33	5.78	8.44%	0.45	0.0193
Q9	6.26	6.33	1.12%	0.07	0.646
Q10	5.50	5.89	7.09%	0.39	0.0545
Q11	5.67	5.97	5.29%	0.3	0.0839
Q12	5.72	5.83	1.92%	0.11	0.51

Fig. 4. *Results of pre- and post-test assessment.* A twelve-question survey (instrument presented above) was used as pre- and post-test student assessment.

Survey Questions, Stage I
All questions measured on 7-point Likert scale

1. I have sufficient experience and knowledge about writing in my field of research.

2. I recognize responses from my technical mentor and instructors as opportunities to improve and refine my work.

3. I generally understand the principles for writing in my field of research, but want to learn more.

4. I believe that writing helps me to develop stronger ideas and to explore complex issues in my research

5. In my research, I use inquiry as a process to develop questions relevant for appropriate audiences in my field.

6. I recognize that conventions (such as formal and informal rules of content, organization, style, evidence, citation, mechanics, and usage) are dependent on discipline and context.

7. In my writing, I communicate research findings to multiple audiences using discipline-appropriate conventions

8. I understand how to reflect on the communication choices I make in light of context, purpose, and audience

9. I recognize responses from my peers as opportunities to improve and refine my work.

10. I understand how to engage with and incorporate the related work of others, giving credit to those ideas by using appropriate citation methods.

11. I know how to use what I learn from reflections on one communication project to improve writing on subsequent projects.

12. I am comfortable giving feedback to my peers.

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