Journal of the Scholarship of Teaching and Learning, Vol. 23, No. 1, April 2023, pp.1-13.
doi: 10.14434/josotl.v23i1.32483

Mixed Messages: A Disciplinary(?) Response to Physics Lab Reports

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Efforts to promote disciplinary literacy can help students integrate knowledge with ways of doing and being within disciplinary settings. Yet, effectively facilitating disciplinary literacy, even within an upper-level undergraduate physics course like the one studied here, is surprisingly hard. This article qualitatively analyzes an instructor's responses to student lab reports and finds that his comments to students focused on issues of correctness, often at the expense of larger rhetorical concerns of the text. Analysis also suggests that the instructor was thinking about many rhetorical aspects beyond surface-level errors as he read. Together, these findings suggest that efforts to promote disciplinary literacy, especially related to writing instruction, benefit from recognizing the layered contexts of activity in which writing and responding to lab reports take place. These findings hold value for secondary and post-secondary literacy instruction; in broad terms, this study may serve as a cautionary tale by illuminating the overlapping and competing value systems involved in disciplinary literacy efforts.

Keywords: disciplinary literacy, activity systems, lab reports, think-aloud protocol

I start this article by giving away the ending: The physics teacher in this study read his undergraduate students' classroom-based lab reports mostly like a teacher, not like a physicist. This conclusion is probably not all that surprising to many readers, and it builds on something of a false binary. Yet, this conclusion has some important and not-so-obvious implications for current efforts to promote disciplinary literacy, both in K-12 and post-secondary settings.

In describing disciplinary literacy, Moje, Stockdill, Kim, and Kim (2011) see disciplinary texts as key components of disciplinary activity, in part because such texts substantially affect "what can be known and learned [and] provide the grounds by which new knowledge can be produced, communicated, and learned" (p. 455). Shanahan and Shanahan (2012) take a similar view, noting that readers' interactions with disciplinary texts can help to "produce procedures that facilitate the authentic learning demands of the disciplines" (p. 15).

These definitions situate disciplinary literacy within sociocultural perspectives of learning, placing texts at the center of disciplinary learning and belonging (Moje, 2008). And, while texts are certainly important, disciplinary literacy scholars generally acknowledge that conventions of *producing* such texts are also an important factor, since it is through specific patterns of reading and writing that texts become mediational tools for disciplinary activity and belonging. Thus, previous studies (e.g., Reynolds & Rush, 2017; Shanahan, Shanahan, & Misischia, 2011; Wineburg, 1991) have helped literacy researchers understand how experts read, often with a goal of developing instruction to promote disciplinary ways of reading among less-experienced learners.

This view might be referred to as a "centripetal" view of disciplinary literacy, since it suggests that participants within a discipline act (and read) in ways that are pulled toward a common, central disciplinary purpose. Such a view encourages teachers to see "disciplinary" literacies as relatively similar across contexts, including classroom-based learning settings. In this view, the question "How do mathematicians read?" can be answered with a single bulleted list (as in Lent, 2016), collapsing the work of all mathematicians into a central list of skills and habits of mind.

This view is implicitly reinforced in previous studies of disciplinary literacy, including Shanahan, Shanahan and Misischia's (2011) often-cited study of disciplinary experts from math,

science, and history. While acknowledging that, for example, discourses of mathematics pedagogy and mathematics experts are distinct, these scholars still reinforce a notion of stability within disciplines:

> Though the participating historians and chemists were drawn from different branches of their fields, we found coherence in the way they approached reading. Similarly, the historians examined here demonstrated significant agreement with the historians examined in past studies. (p. 401)

By implying that classroom efforts to develop disciplinary literacy can be reductively equated with expert disciplinary practice, this centripetal view of disciplinary literacy potentially ignores different purposes at play across diverse classroom and disciplinary settings.

As a way to challenge this centripetal notion of disciplinary literacy, this article focuses on a simple research question: Does a classroom teacher—one who claims to be teaching students to write a disciplinary genre (i.e., lab reports)—respond to student writing in ways similar to the ways that disciplinary experts respond to similar disciplinary genres? Even more simply: Do teachers read student efforts to produce disciplinary texts in the same way that they might read a colleague's professional work?

After describing the theoretical perspective that underpins this inquiry, this article addresses the problematic status of lab reports as a form of disciplinary writing. Following an explanation of methods and findings of this project, a classic study of disciplinary physicists' reading practices (Bazerman, 1985) then serves as a backdrop for interpreting the results and discussing implications related to the centripetal view of disciplinary literacy.

A Framework for Exploring Reading and Writing: Genre-Oriented Activity Theory

In Russell's (1997) genre-oriented, activity theory framework, genres are mediational "tools-in-use" (p. 511) that allow users to accomplish meaningful work within a disciplinary or other discursive setting. This genre-oriented activity theory perspective views learning as occurring through interaction among writers, readers, and texts-as-tools: students learn what genres *do* in part because of the responses they provoke from readers. Further, this view of genres defines them as typified, recurrent action (Miller, 1984) rather than merely structural features to be learned. In the case of classroom writing, for example, teachers' responses to texts shape students' understanding of the kind of *action* that is achieved through a piece of writing: disciplinary genres take certain shapes because of the types of action they produce—meaning that form, content, and purpose are inextricably linked.

This genre-oriented, activity theory-based perspective suggests that disciplinary literacy scholars and teachers should attend to the work (*i.e.*, action) that is inter-actively accomplished through genre performance, in terms of both student writing and the feedback that (re)shapes further action. However, few scholars have taken an activity-theory approach towards instructors' responses while they read student-produced genres. This study aims to fill that gap.

The Lab Report: A Contested Genre for Developing Disciplinary Literacy

In the physics course I studied, the instructor directly equated lab reports with scientific papers, explaining that he chose to emphasize lab report writing in the course because:

> if you can't do that [write a lab report], then you never make it to the other things. ... That's where you learn how to write a scientific paper. It's the same thing.

He also referred to lab report writing as a "bread and butter kind of thing," reflecting a view that this genre engages students in essential literacy practices in physics. The instructor's perceived equivalence of lab reports to scientific research articles is not uncommon; among science educators, there has been a willingness to accept the lab report as a pedagogical genre (Bawarshi & Reiff, 2010; Parkinson, 2017) closely related to literacy and composing practices within advanced scientific communities.

Some existing scholarship supports the view that lab reports provide an important opportunity for learners to develop disciplinary thinking in ways that align with key functions of scientific research articles. Carter, Ferzli, and Wiebe (2007), for example, call lab reports "a legitimate apprenticeship genre" because of their common introduction/methods/results/discussion (IMRaD) structure, which represents "a shared way of knowing that is mirrored in other professional scientific genres" (p. 294). Similarly, Thaiss and Zawacki (2006) see classroom lab reports as legitimate disciplinary work, partially because they found that students accept teachers' expectations as informed by and embedded within their disciplines.

In contrast, however, Lerner (2007) describes classroom lab reports as an "impoverished" (p. 198) genre, lacking the same clarity of rhetorical purpose and audience of scientific research articles. In Lerner's view, efforts to incorporate laboratory experiences and genres into school settings have resulted in a "reductive view of student writing in science" (p. 207), in which lab reports often become a mechanism for assessing "students' grasp of content" (p. 212) rather than their ability to situate themselves within scientific discourse. Likewise, Keys (1999) has criticized some lab report writing for sending students the message "that they must somehow generate, copy, or paraphrase the knowledge claim that is desired by the teacher" (p. 125). Russell (2002) and Lerner (2007) have referred to some lab reports as "cookbook" activities that have "exalted mechanical correctness over intellectual discovery and [have been] used primarily to evaluate students rather than to introduce them to scientific inquiry" (Russell, 2002, p. 97-98).

Offering a different critique, linguistics-based analyses of lab reports (Parkinson, 2017; Gayani Sanjeewa & Wilson, 2016) found that lab report introductions often lacked parts of the three key moves identified by Swales (1990) as essential to introductions of scientific research articles. In fact, Gayani Sanjeewa and Wilson (2016) concluded, "We may need to reconsider our claims that laboratory programs prepare students to do research—to 'be scientists'" (p. 79), since even an inquiry-based lab course "does not prepare students to identify a niche and pose a question, and may not even alert them to the need to do so" (p. 79).

Together, these bodies of research illuminate the complexity of promoting disciplinary literacy through classroom assignments—and they highlight, too, the tension between goals of academic schoolwork and of disciplinary practice. Most notably, traditional classrooms generally have a desired outcome of *learning*—specifically, of habits, practices, and knowledge appropriate for further disciplinary participation (Moje, 2008; Shanahan & Shanahan, 2012)—while non-classroom activity often focuses on applied *doing* rather than abstract *learning*.

Methodology

As explained above, the classroom science lab report is a pervasive but contested genre. By collecting and analyzing an instructor's responses to student lab reports, I hoped to learn more about how the instructor attempted to guide students towards more effective disciplinary writing—and how competing forms of activity and attention may have misdirected students from understanding disciplinary expectations and habits of mind.

Data for this project were collected during Spring 2018 in an upper-level undergraduate physics lab course in a mid-sized land-grant university in the US Mountain West region. The course

was designed to provide physics and astronomy majors with advanced lab skills as well as to meet the university's general-education requirement for advanced written and oral communication. Over the 15-week semester, students met twice a week, three hours per session. After four weeks of intense, lecture-based content review, class sessions shifted towards lab time, during which students carried out landmark experiments in modern physics. In the course, students conducted 10 lab experiments, wrote 8 lab reports, and participated in several graded, one-on-one oral discussions with the instructor. For this study, I focused on the first partial lab report that students produced.

Participant

The course instructor is a non-native speaker and writer of English who completed his initial training in physics (diploma and doctorate) in Germany. He held a post-doctoral position for several years at the University of Warwick (UK), worked in a nuclear magnetic resonance (NMR) program at Dresden's Max Planck Institute, and moved into an assistant research professor position in the US. He then took a position at his current institution that initially included NMR research in chemical engineering and teaching in the physics department. Since 2005 his position has been entirely a teaching position.

The instructor has been an author on approximately 25 scientific reports (mostly at Warwick, for journals as well as for industrial partners) and has written grants, lab manuals, and presentation papers. For the previous decade, most of his professional activity had focused on physics education, and he had presented at the American Association of Physics Teachers and American Physical Society on various curriculum and instruction efforts.

Data Collection

The data collected for this article were part of a larger, IRB-approved study. To explore instructor response to student attempts to reproduce the lab report genre, I focus in this article on:

1. The instructor's *written comments* on one full set of twelve student lab reports, produced by the instructor on the first draft of the first partial report assigned (LRd1, which included Introduction and Results sections for the first laboratory experiment).
2. The instructor's *thinking-aloud* about the student lab reports (i.e., concurrent protocol). The instructor recorded his thinking while he read the student reports, in the context of reading those reports to achieve his own purposes. The participant conducted this process in his campus office, without the researcher present; protocols were audio-recorded and transcribed.

Think-aloud protocols (Ericsson & Simon, 1984; Pressley & Afflerbach, 1995) were selected in order to capture the instructor's thinking *as* he responded to students' drafts. Instructions encouraged the participant to identify rather than interpret his thoughts as he read, but there was no enforced limit on the length of the instructor's report of his thinking.

Data Analysis

In order to contrast the instructor's thinking with his explicit guidance to students as they attempted to reproduce the lab report as a disciplinary form of communication, both his (1) written comments and his (2) think-aloud transcript were coded.

Coding of Written Comments

Coding focused on two major forms of written comments on the student lab reports: symbols and narrative comments.

> ***Symbol***. *A priori* codes for these comments came from symbols and explanations provided by the instructor in the course syllabus (see Appendix 1). For example, a squiggly line underneath a phrase was coded as "symbol" and as indicating an issue with "expression or phrase," in line with the instructor's definition of this symbol.
>
> ***Narrative***. Emergent coding was used to categorize the instructor's non-symbol feedback; such comments were coded as "narrative" and were further categorized by their focus and in some cases by their form. When a narrative comment was combined with a symbol (46 occurrences), the segment was coded as both "symbol" and "narrative."

Coding of Think-Aloud Protocols

The process of coding transcripts of the instructor's thinking was recursive and informed by memoing and ongoing re-engagement with the data (Saldaña, 2014; Creswell, 2013). A total of 34 first-cycle codes were applied over 900 times to segments of the instructor's thinking-aloud about the lab report drafts. Many segments (ranging from a few words to multiple sentences) were overlapping and were coded with multiple codes.

During second-cycle coding of the instructor's think-aloud comments, I utilized an approach similar to the emic/etic approach taken by Eodice, Geller, and Lerner (2016) as they analyzed data about meaningful college-level writing projects.

Prolonged engagement (Creswell, 2013) with the teacher, students, and classroom setting served as a form of validity check. Member checking also revealed valuable differences between initial analysis and the views of the instructor, and discussion of those differences has informed revision of this article.

Results

Analysis of the instructor's thinking and his written feedback allow for an understanding of his response to students' effort to produce lab-reports—both in terms of what he *noticed* about the texts while reading as well as his directive efforts to guide those students towards more effective lab reports in the future (both within the course setting and beyond the course setting).

Regarding the instructor's think-aloud transcripts, I grouped the initial set of 34 first-cycle codes into two broader categories: *how* the instructor read, and *what parts of the text* he noticed as he read. From a genre-oriented activity theory view of textual performance, these codes helped to identify relationships between textual features (what the instructor *noticed* in the texts) and his response (what *social action* was being accomplished).

Table 1 illustrates that the instructor was actively thinking about his own practices as a reader (articulating the act of scanning a passage of text, for example) as well as the context of his reading (drawing relationships across student texts, for example). In addition, I grouped the types of textual features he audibly noticed during his reading into five groupings: grammar/mechanics, form, authority, relevance, and knowledge.

In general terms, this analysis indicates that the instructor was thinking about a wide range of features, interacting with the writer, his disciplinary knowledge, the report's structure, and other textual and contextual elements.

Table 1. Categorization of Codes for Think-Aloud Segments.

Categories and sub-categories	Number of segments	First-cycle codes included in this category
Category: <u>How</u> the instructor read		
Sub-category: Reading as practice	222	disagreement, misreading, prediction, question, scanning, uncertainty, valence
Sub-category: Reading in context	72	advice, comparison, evaluation of writer, interaction, intertextual reference, reference to other genre, time
Category: <u>Which aspects</u> of the text were noticed by the instructor		
Sub-category: Grammar/mechanics	54	grammar and mechanics
Sub-category: Form	143	content clarity, content location, intra-textual reference, length, representational mode, structure
Sub-category: Authority	61	authorship, citation, tone
Sub-category: Relevance	160	content relevance, lack of detail, lack of detail-math, purpose, too much detail
Sub-category: Knowledge	56	content accuracy, lack of knowledge

To some extent, the instructor's comments on the papers themselves reflected similar concerns as those in the think-aloud transcripts. One hundred seventy-one symbol-based comments on the student drafts were coded: *accuracy* (34 segments), *completeness* (25), *expression or phrase* (31), *mechanics* (53), *precise/insightful* (1), *purpose unclear* (6), *structure* (19) and *vague* (2). In terms of broader categories, symbol-based comments focused on relatively surface-level features of the text (e.g., unclear phrasing, grammatical/typographical mistakes, lack of paragraphing); another set addressed content accuracy; and a third set dealt with contextual issues of purpose and audience (e.g., clarity of purpose, sufficiency of detail).

One hundred thirty-nine segments were coded as "narrative" when they included some written guidance beyond the instructor's pre-defined symbols. Emergent coding was used to categorize the instructor's non-symbol comments, which referred to problems with clarity (9 segments), length (10), structure (22), or citations (9). In 23 cases, comments indicated that an expected component was missing or incomplete. Thirty-five narrative comments suggested a possible correction, often related to sentence-level errors. Other narrative comments were slightly more explicit in their focus on

situation: 27 segments were coded as focused on *level of detail*, and another 27 were coded as relating to issues of *purpose*, *tone*, and *relevance*.

At the surface level, the focus of written comments often aligned with the instructors thoughts, including matters such as grammar and mechanics, representations of disciplinary knowledge, and relevance of information. However, the next section provides greater analysis of mismatches between the instructor's thinking and his patterns of commenting.

Discussion

The notion of centripetal disciplinary literacy suggests that participants within a discipline act (and read) in ways that are broadly united by common, central disciplinary purpose, without much attention to differing purposes across myriad disciplinary contexts. From this centripetal view, we might expect that a physics teacher's response to student-written texts—especially those assigned as roughly equivalent to a genre that circulates among practicing physicists—would be similar to expert physicists' responses to disciplinary text. Or, to put it somewhat more broadly, if teachers are trying to promote disciplinary forms of student *writing* when they assign lab reports, we should expect teachers to *respond* to such writing in characteristically stable, coherent disciplinary ways.

Helpfully, Bazerman (1985) has previously investigated the reading processes and purposes of seven physicists as they read journal articles. This widely cited study indicated that these disciplinary experts "carefully select what they pay attention to and retain based on the needs of their own research" (p. 5-6). Their purposes for reading included goals of gathering information, self-tutoring, or searching for new problems to explore, and their beliefs about the relative pace of discovery in their sub-fields determined how urgently they reviewed new publications in their fields.

The physicists often based decisions about what to read on key terms in article titles, including the names of objects/phenomena, approaches/techniques, and individuals or research groups. They considered the status of authors in their decisions about how much attention to give to a text, and key terms served as an initial filter to help them identify articles worthy of closer attention.

For these experts, the reading process was a selective and non-linear one, often driven by the search for information that the reader considered as "news" (Bazerman, 1985, p. 11) or by information that did not fit expectations. When articles contained unfamiliar or difficult information, the physicists weighed costs and benefits of investing further energy in reading. They read less critically when focused primarily on broadening their general knowledge base and more critically when they intended to immediately apply the information to their own projects. And, they evaluated clarity of writing as an indicator of the quality of methods or of argumentation.

Reading like a Disciplinary Reader?

From a centripetal perspective of disciplinary literacy, Bazerman's (1985) analysis of expert physicists reading journal articles provides one model for predicting how the instructor should respond as he reads: if the lab report is meant to serve a similar function as journal articles (as suggested by the instructor), then we should expect the instructor to read in ways similar to the physicists in Bazerman's study. My analysis suggests that the instructors' response patterns contain some surface-level similarities to the physicists in Bazerman's study, but ultimately his responses depart in important ways from those experts.

In at least two ways, the instructor's reading processes were similar to those identified in Bazerman's (1985) study. First, the instructor actively thought about how information in the lab reports aligned with his existing knowledge. The codes "disagreement," "uncertainty," and "question" indicated that the instructor was checking information against his understanding of key concepts of

physics, similar to the way that Bazerman's physicists were driven to incorporate new knowledge with their existing schema.

Second, the instructor was attentive to the writers' authority, often by noting the presence of citations, by questioning the quality of citations, or by remarking on inappropriate tone in the reports. He also thought about his existing knowledge of and interactions with the students; the students' credibility preceded them into the report-writing content. This is superficially similar to Bazerman's (1985) physicists, who often noted articles' authors as a way to initially gauge the possible value or quality of the reading.

However, the underlying motives for the instructor's responses were markedly different than those exhibited by Bazerman's (1985) experts. First, the instructor was not focused substantially on adding new information to his existing knowledge base. Bazerman found experts placing new information both "within and against personal frameworks of knowledge" (p. 19); in contrast, this instructor placed information *against* but not *within* his existing content knowledge, and there was little evidence he approached the reports with a goal of retaining information. Even in one case when the instructor dwelt momentarily on information that struck him as new, he quickly discarded it as "potentially" wrong information.

Thus, the instructor seemed not to expect to learn new information about physics from his reading—implying that activity of the expert reader in this setting is quite different than it is in other settings for disciplinary reading. Tellingly, however, the instructor *did* think about how student efforts allowed him to evaluate and adhere to his lab report guidelines, as illustrated here:

> She's mixing discussion with results, and I always have that problem. Do I keep those [sections] apart or do I allow them to do it together? This year, I went with keeping them apart and I'm beginning to see some impacts of that.

Thus, the instructor *was* acquiring and assimilating information, but it was about teaching rather than about new physics concepts. This distinction is important because it suggests that the instructor's reading was motivated primarily (and understandably) by teaching/learning activity, not by a goal of assimilating new information for research.

The instructor's thinking about textual authority also focused on pressures of the school setting, rather than on using information about authors to determine where to spend attention on new concepts. For example, although students worked in pairs on several experiments throughout the semester, they were required to write independent reports. Students generally did not acknowledge their lab partner in their reports. For one of these reports, however, the instructor noted:

> The report is actually signed Cam and Julian, although they [wrote] independent reports and they did the work together. But they should really be clear about that.

This comment expresses the instructor's desire to distinguish credit for *grading* purposes; the concern with authorship here is focused on ensuring that individual students wrote their reports independently, rather than being used to gauge the report's potential value for ongoing research activity.

For Diaz, Freedman, Medway, and Pare (1999), the instructor's thinking here might be said to reveal the "sorting and ranking" (p. 47) motive of school writing. For them, this evaluative motive sits in "uneasy tension" with epistemic, or learning-oriented, motives of schooling (p. 47). In the case of student lab reports, the instructor's felt obligation to evaluate students' independent work indicates that he held students in relatively isolated positions, even though most workplace writing (including

writing carried out in many disciplinary research lab programs) is carried out by writers in fluid and collaborative roles (Diaz et al., 1999; Freedman and Adam, 1996).

Other Evidence of Divergent Reading Motives

Identification of errors occupied relatively little of the instructor's *thinking* as he read, yet symbols indicating mechanical errors were *the* most common type of written comment on student work. The instructor's *thinking* about grammatical and mechanical correctness (54 segments) occupied proportionally little of his thoughts, but his *comments* to students about mechanics, phrasing, and error correction (115 segments) made up a high proportion of his written feedback. [1] These data suggest the instructor saw correction of writing as a key motive for his activity, and this imbalance supports Lerner's (2007) claim that lab reports, as school assignments, have tended to "exalt" mechanical correctness (p. 97). From a disciplinary literacy perspective, this imbalance is problematic because it reinforces a focus on surface-level features at the expense of the many other thoughts the instructor articulated while reading.

In contrast to the high proportion of written comments focused on error, the instructor made proportionally few written comments about the relevance of information: just 17 comments on students' papers were about relevance (and another 27 comments focused on the related issues of too much or too little information). Yet, 160 segments concerned the instructor's *thoughts* about relevance. The imbalance suggests the instructor thought a good deal about the situational relevance of information included in the reports, yet he wrote relatively few comments about this to students. Figure 1 illustrates the imbalance of thinking and commenting for issues of both correctness as well as relevance.

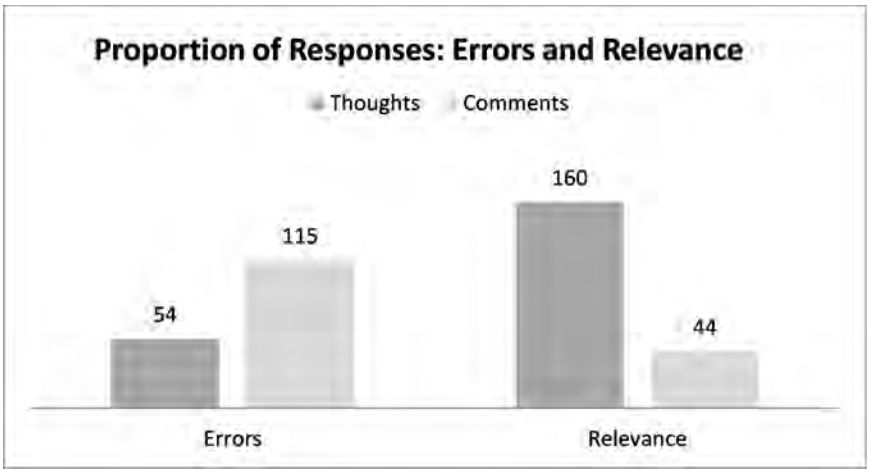

Figure 1. Proportion of Thoughts and Comments regarding Errors and Relevance.

This imbalance between thinking and commenting matters, especially because thoughts about relevance reflect the instructor's sense about information that "should" be included within the lab report. Further, his thinking about relevance reveals the complexity of disciplinary communication attempts within a school setting. For example, when reading one lab report, the instructor thought:

[1] Additionally, because many of the "expression or phrase" symbol comments and the written comments offering possible corrections addressed grammatical mistakes such as subject/verb agreement, the disproportionality between comments and thinking was even more pronounced.

> This has very little to do with our experiment. I think he just wanted to write something to fill a page.

Here, the instructor's assumption about the student's desire to "fill pages" illuminates conflict between goals of effective disciplinary communication and ranking/evaluation activity. (Interviews with students near the end of the semester revealed continuing frustration with determining the "right" amount of information: if they provided little information, some worried the instructor would suspect they did not understand the content, while if they provided more extensive information in an effort to demonstrate their learning, they recognized that the instructor might consider that information irrelevant to the hypothetical disciplinary context.)

The instructor rarely connected his sense of expectation about level of detail explicitly to a communicative purpose; in other words, his thoughts often did not reveal *why* he believed that a student should do something differently. In some cases, the instructor commented with the first-person plural "we," suggesting that he saw his reading as typical of a *category* of readers, providing some support for Carter, Ferzli, and Wiebe's (2011) view that lab reports can effectively function as generic activities directed towards imagined disciplinary readers. Yet, the instructor did not articulate a rationale for why "we" need to see something different in these sections. If students are caught between multiple motives for activity (i.e., the goal of demonstrating knowledge *comprehensively* versus the goal of communicating to hypothetical others *concisely*), they may be even more likely to misinterpret the instructor's limited written comments about issues of relevance and sufficiency of content.

Conclusion: A Small Step toward Reimagining Disciplinary Literacy

In this study, the contrasts between the instructor's thoughts and his written feedback on student lab report drafts suggest that he constrained his feedback, apparently in relationship to his perception of the primary activity he was engaged in. Although his thinking suggested that a range of situational relationships, assumptions, and uncertainties affected his response to the student writing, most of these factors were absent from the response that was provided to the student writers. Instead, his comments were mostly authoritative judgements, especially about the correctness of the writing. A focus on "error," rather than on expert-like meaning making, drove his evaluation of the student work.

As I noted at the outset, these findings may seem fairly unsurprising: Teachers grade student performance with teaching and learning in mind. But the larger takeaway is important: While disciplinary literacy pedagogy seeks to help students learn to read in ways similar to "how chemists read" or "how historians read" (Brock et. al., 2014, pp. 35-36), my findings suggest that the physics educator in this study does something *different* from reading like a physicist, at least in the ways that expert physicists' reading processes have typically been defined and studied.

If students learn to produce disciplinary genres in part through the reader's *response* to those efforts, the moments of textual interaction analyzed in this study are not encouraging: The complexity of the instructor's response patterns suggests that efforts to provide students with opportunities to think, do, and write like physicists may actually misdirect students' attention about what really matters in disciplinary communication. Consequently, efforts to guide students' development of disciplinary literacy may be constrained by barriers to "authentic" disciplinary engagement (Shanahan & Shanahan, 2008, p.15), including especially the pressures of ranking and evaluating that characterize schooling.

However, this recognition also invites educators to understand that disciplinary activity is always layered among other forms of literate behavior. The theoretical perspective adopted in this analysis encourages a view of school subjects as disciplinary discourses *layered within* discourses of schooling; thus, efforts to repackage disciplinary practices, knowledge, and identities for school-based

learning settings involve not merely *re*-contextual (Fang & Coatoam, 2013; Collin, 2014) but *multi*-contextual activity. Put differently, efforts towards some notion of "centripetal" disciplinary literacy are always pulled away from the center by other systems, motives, tools, and participants. Thus, educators' efforts must involve not only helping students move towards literacy practices of university and professional disciplinarians but also helping students to navigate among other layered activities in which disciplinary literacies are situated.

Appendix

Appendix 1: Instructor's list of symbols for writing feedback (from the course syllabus).

√	correct
(√)	mostly correct
~	somewhat correct
≈	vague
(-)	incomplete or sudden end
-	missing
#	wrong
(/)	misses the point, off topic
☺	original, imaginative, good illustration
:-(	sloppy, much too short
∨	repetitive, wordy
?	confused or logic cannot be followed or lack of focus
&	good research
$	well organized or well structured
+	mature writing
*	precise or insightful or thoughtful
^	concise, to the point
!	strong reasoning
(+)	furthers pov
[]	lack of structure or needs paragraph separation or abrupt change
%	evidence missing or incomplete
?	purpose or message unclear
	language metrics
∿∿∿	expression or phrase
⌐	new paragraph needed

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