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Writing to Learn by Learning to Write in the Disciplines

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The traditional distinction between writing across the curriculum and writing in the disciplines (WID) as writing to learn versus learning to write understates WID's focus on learning in the disciplines. Advocates of WID have described learning as socialization, but little research addresses how writing disciplinary discourses in disciplinary settings encourages socialization into the disciplines. Data from interviews with students who wrote lab reports in a biology lab suggest five ways in which writing promotes learning in scientific disciplines. Drawing on theories of situated learning, the authors argue that apprenticeship genres can encourage socialization into disciplinary communities.

Keywords: *writing in the disciplines; laboratory report; situated learning; apprenticeship; genre*

In "The Promise of Writing to Learn," Ackerman (1993) challenged the assumption of a strong causal relationship between writing and learning. This assumption, he said, is based on "soft" research promoted by scholars such as Janet Emig and James Britton, research that is accessible to writing teachers and attractive to them because it puts writing at the center of learning. He argued that because this model of learning became the foundation for the process-over-product and writing-across-the-curriculum (WAC) movements, both movements are suspect. In his review of empirical research on writing to learn, Ackerman found mixed results that, to some extent, seemed to be driven by researchers' grounding assumption that writing "inevitably" leads to learning. He suggested that, at best, the results show how complicated the relationship between writing and learning is. In

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response to the questionable assumptions supporting the promise of writing to learn, Ackerman asserted that “the field of composition and rhetoric is poised to advance a different model of writing and learning: more social than developmental, more situated than conceptual, more tied to activity than knowledge” (p. 362).

In 1993, of course, the advancement of this new model was well under way, as represented in the shift from WAC to writing in the disciplines (WID). McLeod (1989), in “Writing Across the Curriculum: The Second Stage, and Beyond,” examined WAC programs that had entered a second stage, that is, a level of maturity beyond the beginning stage. Toward the end of the article, however, she described the emergence of two competing models of WAC programs: one “cognitively based (on the idea of writing as a mode of learning)” and the other “rhetorically based (on the idea of introducing students to the discourse communities of various disciplines)” (p. 342). In a review of WAC books, Bazerman (1991) declared WID itself as WAC’s second stage, pointing to

the end of the first stage of WAC, driven by the missionary zeal of composition and the institutional designs of administrators looking for broad structural fixes, and the beginning of the next stage, based on a realistic assessment of the roles written language actually takes in disciplines and disciplinary classrooms. (p. 209)

And Jones and Comprone (1993) argued that WAC programs should leave behind the generic writing-to-learn approach and focus instead on “encouraging a more precise understanding of how different disciplines . . . treat the writing process and discourse itself” (p. 62).

The dichotomy between WAC and WID, then, is often characterized as “*writing to learn*—i.e., writing as a means of acquiring information, understanding concepts, and appreciating significance in any discipline . . . [versus] *learning to write*—i.e., acquiring the socially-mediated communication skills and genre knowledge appropriate to a specific discipline” (Broadhead, 1999, p. 19). This dichotomy is, to be sure, broadly drawn to highlight crucial differences in pedagogical approaches—students writing low-stakes expressive discourses in classes across the curriculum versus students writing disciplinary discourses in disciplinary settings—and in theoretical assumptions—writing as a cognitive act that encourages learning through personal engagement in the subject matter of a course versus writing as a social act that encourages socialization in a discipline (Bazerman, 1988; Berkenkotter & Huckin, 1995; Fulwiler, 1981, 1987; Russell, 1990; Walvoord, 1986).

One problem with this dichotomy, however, is that it tends to downplay WID's focus on learning. Students do not learn to write the discourses of the disciplines simply to master those discourses; rather, they write to learn, in addition to the subject matter of the discipline, the ways of knowing and doing that define the discipline (Carter, 2007). Herrington (1985), for example, in her study of the functions of writing in a chemistry lab and a design class, concluded that "writing can be used both to create a community and to learn the intellectual and social conventions of a disciplinary forum" (p. 357). The titles of the classic collection *Writing, Teaching, and Learning in the Disciplines* (Herrington & Moran, 1992) and the journal *Language and Learning Across the Disciplines* (now *Academic Writing*) indicate the importance of learning in WID. And surely those of us who work with faculty in the disciplines assume a causal relationship between writing and learning in the disciplines. The difference in theoretical assumptions between WAC and WID is not, as our shorthand dichotomy suggests, that one focuses on learning and the other does not. Rather, it is that they are founded on different concepts of learning: For WID, learning is largely social; learning is the act of being socialized into disciplines. Thus, WID may be better understood as writing to learn by learning to write in the disciplines.

The problem with that understanding, however, is that it may place advocates of WID in a position similar to the one Ackerman (1993) described for advocates of WAC: Acting under the assumption that writing in the disciplines encourages learning in the disciplines but with little evidence of *how* writing encourages such learning. One of the difficulties with addressing this issue of how, is that, as Hawthorne (1998) and Hilgers, Hussey, and Stitt-Bergh (1999) noted, the preponderance of evidence for the effectiveness of both WAC and WID is based on change in teachers, not in students. Another difficulty is that many of the studies of writing and learning in the disciplines on the college level have focused on relatively general forms of academic writing, such as daily essay quizzes, essay exams, short papers, and journals or on writing that is done outside disciplinary settings, such as in first-year composition courses or introductions to disciplinary writing taught by teachers from English departments (e.g., Carpenter & Krest, 2001; Connor-Greene & Murdoch, 2000; Driskill, Lewis, Stearns, & Volz, 1998; Herrington, 1981; Kerr & Picciotto, 1992; MacDonald & Cooper, 1992). Although useful for describing writing and learning in these genres and settings, such studies do little to illuminate the relationship between writing and learning through disciplinary discourses in disciplinary settings. And studies that have investigated students writing in disciplinary genres in disciplinary settings (e.g., Berkenkotter, Huckin, & Ackerman, 1988; Blakeslee, 1997; Dias, Freedman, Medway, &

Paré, 1999; Freedman & Adam, 1996; Freedman, Adam, & Smart, 1994; Herrington, 1985; Prior, 1994, 1998) have not attempted to describe specific ways by which writing encourages learning, typically focusing instead on textual analysis of genres or on sociohistoric contexts of disciplinary discourses.

But the question of how concerns us here: How does writing in the disciplines encourage learning in the disciplines? We are especially interested in learning understood as socialization into the disciplines. Ackerman (1993) pointed to the limitations of quantitative methods in studying the complexities of writing in disciplinary settings, recommending qualitative methods instead. One qualitative method that has demonstrated the potential for answering our how question is the use of student interviews. For example, Hilgers, Bayer, Stitt-Bergh, and Taniguchi (1995), in an effort to evaluate the effectiveness of an extensive WAC program at their home university, interviewed 82 students who had taken three or more writing-intensive (WI) courses. Hawthorne (1998) interviewed students from five WI majors, that is, students in departments that had been particularly active in instituting the university's WAC program. The interview questions concerned writing in general, the perceived value of writing for learning and for students' development as writers. And Hilgers et al. (1999), in a follow-up study to their earlier one (Hilgers et al., 1995), investigated the effects of a shift in the focus of their university's faculty development program from general writing-to-learn strategies to discipline-specific inquiry and their university's new requirement for WI courses in the students' majors. They interviewed 34 students taking those courses, once at the beginning of the term and once at the end, the latter interview focusing on a writing assignment selected by each student. The researchers designed interview questions to elicit responses from the students about how the discipline shaped their writing experience and what they had learned about writing.

These studies are useful for our research because they show that interviews can offer a sense of the richness of writing from students' perspective. The excerpts from the transcripts demonstrate that students are much aware of themselves as writers and are able to speak about writing in sophisticated ways. The studies also show that interviews can elicit descriptions of how writing encourages learning, even when the how question is not the focus of the interview. In Hilgers et al.'s (1995) study, students described how writing helped them to understand and retain course content and to improve problem solving. In Hawthorne's (1998) study, students said that writing helped them to be more involved in a course, to reflect on course content, and to organize and synthesize course material. And in Hilgers et al.'s (1999) follow-up study, students reported that writing encouraged them to engage multiple sources of knowledge, synthesize information, find connections

among apparently disparate things, clarify ideas, organize thoughts, and so forth.

What is missing from these three studies, however, is a sense of specifically how writing disciplinary discourses in disciplinary settings promotes learning in the disciplines. Hilgers et al. (1995) is clearly about writing in general, an investigation of a classic WAC program. Although Hawthorne's (1998) study moved toward an emphasis on WID by interviewing advanced students in WI majors, it provides little sense of how writing engenders learning in the disciplines. In the excerpts from the transcripts, none of the students cited specific courses, and the only specific genre that was mentioned was the journal; the other kinds of writing were referred to simply as papers and writing assignments. (Of course, the complete transcripts may have contained discipline-specific information about students' writing, but clearly the focus of the study is still on writing in general.) With its explicit concentration on WID courses and on particular assignments for mainly capstone courses in students' majors, Hilgers et al. (1999) holds the greatest promise for illuminating the relationship between writing and learning in the disciplines. Indeed, the students reported that writing in their majors is more engaging than writing in nonmajor courses, that writing encourages learning about the body of knowledge that constitutes their disciplines, and that the research assignments helped them learn about the methods used by their disciplines. But these excerpts provide little information that indicates specifically how writing promotes learning. And when the students do talk explicitly about how writing promotes learning, they tend to talk about how writing in general encourages learning in general, not about specific disciplinary kinds of writing and learning.

In this study, we report on data from interviews with students who had written a particular disciplinary discourse, the laboratory report, in a disciplinary setting, a biology lab. Because this study focuses on one disciplinary discourse instead of a broad range, it provides the opportunity to move from writing and learning in general to writing and learning in particular. We examine how writing lab reports encourages learning in biology, emphasizing in particular the relationship between writing and socialization in the discipline. This study is a preliminary step in investigating the assumption that writing in the disciplines encourages learning in the disciplines.

Theoretical Background

The theory we used to ground this study of writing and learning in the disciplines comes out of the work in situated cognition or situated learning (see also Blakeslee, 1997; Freedman and Adam, 1996; Russell, 1995, 1997). In her

seminal work in situated learning, Lave (1988) applied a social anthropology of cognition to critique the assumption that education must be grounded in teaching general cognitive skills in context-free environments so that those skills can be transferred to use in particular situations. The problem with this decontextualization of learning, she argued, is that cognition is separated from the situations in which it is applied. She called on research in the Adult Math Project, which suggests that everyday mathematical practice is strongly embedded in the situations in which it is used, to support her contention that people tend to rely on effective informal procedures that are tied to particular situations rather than on formal, abstract procedures that are generalized across situations.

Brown, Collins, and Duguid (1989) extended Lave's (1988) critique of cognitive assumptions about education by pointing to the disjunction between knowing and doing that seems to define formal education, knowing as abstract and decontextualized and doing as concrete and situated. In contrast, they argue that cognition is always situated and that we learn by doing. Learning is enculturation, the act of taking on the behaviors and worldview of a culture or knowledge domain that may be achieved through engaging in the authentic activities of the culture. Brown et al. distinguished the authentic activities of a culture from traditional school activities, the latter framed by the culture of school itself instead of the domain of practitioner knowledge. Drawing on Lave's observations of the success of everyday practices, they proposed cognitive apprenticeship as a way of bringing authentic activities of knowledge domains to the classroom: a master-apprentice relationship in which the teacher models an activity for students, provides coaching as students practice the activity, and then fades into the background while students develop expertise on their own. The learning model of cognitive apprenticeship is based on the principle that the ways of doing that define an authentic activity in a knowledge domain embody the ways of knowing of that domain.

Whereas Brown et al. (1989) explored apprenticeship in the classroom, Lave and Wenger (1991) looked beyond the classroom to identify characteristics of learning as integrated into broader social practices (see Freedman & Adam, 1996). Specifically, they investigated the ways by which newcomers to a community of practice become full members of that community, a form of apprenticeship defined as *legitimate peripheral participation*. This "historical-cultural theory of learning" (Lave & Wenger, 1991, p. 37) describes learners not as outsiders but as participants in a community of practice, engaged in activities that, though peripheral to the community, are legitimate within the context of that community. Thus, legitimate peripheral participation "is not merely a condition for membership, but is itself an evolving form

of membership” (p. 53). Apprenticeship is typically defined by tasks that are simpler than those of full participants, tasks that do not carry the responsibility that full participation bears. The examples of apprenticeship that they based their theory on suggest that a master–apprentice relationship is not necessary for participating in a community of practice; often that relationship exists primarily for the purposes of accrediting the novice rather than enhancing the learning. Although Lave and Wenger did not apply the principles of legitimate peripheral participation to the classroom, they did not dismiss the possibility that they could be applied (for critiques of theories of situated learning, see Anderson, Reder, & Simon, 1996; Kirschner & Whitson, 1997).

Theories of situated cognition offer a model of learning as socialization, or acculturation, into a community of practice and, through the concept of apprenticeship, a general conception of how that socialization occurs: By participating in the ways of doing that define a community, a newcomer learns its ways of knowing. But the theorists of situated cognition we have reviewed here do not explicitly address the place of writing in such apprenticeship activities. Brown et al. (1989) referred to the role that reflection and articulation can play in developing general conceptual knowledge from situated activity. Lave and Wenger (1991) mentioned the importance of discourse to learning, citing research suggesting that legitimate peripheral participation in a community of practice means learning to talk the way full participants talk. They also make a useful distinction between discourse about a practice and discourse within a practice, arguing that the former tends to characterize traditional classroom environments, in which teachers didactically talk about a practice and students end up mimicking that same way of talking. In the apprenticeship model, though, “the purpose is not to learn *from* talk as a substitute for legitimate peripheral participation; it is to learn *to* talk as a key to legitimate peripheral participation” (p. 109). Expanding *talk* to include writing gives us an indication of the potential value of writing to theories of situated cognition.

Our goal, then, is to investigate writing within the context of this theory of learning as socialization; specifically, we want to discover how writing in the disciplines connects learners to ways of knowing in the disciplines. The theory suggests that within those communities of practice in which writing is an activity that defines and is defined by the community, a key form of legitimate peripheral participation is to engage in the kinds of writing that full participants do. Engaging in such authentic activity, according to Brown et al. (1989), “is the only way they [learners] gain access to the standpoint that enables practitioners to act meaningfully and purposefully. It is activity that shapes or hones their tools.” But, they added, “how and why remain to be explained” (p. 36). In this study we shed some light on how.

Methods

We conducted our study at North Carolina State University, a large land-grant institution that emphasizes science and engineering. The participants were selected from students registered in fall 2000 for Biology 183, the second of a two-course sequence introducing life science majors to biology. The course was taught in the lecture–laboratory format typical of many lower-level courses in the sciences, one large lecture section whose students were divided among multiple laboratory sections of about 20 students each. The lecture section was taught by a professor of biology who also oversaw the teaching assistants who ran the labs (none of us participated as teachers).

In the labs, students did their experiments in groups of four. They wrote four traditional lab reports consisting of an abstract, introduction, methods, results, discussion, and conclusion. The first three reports were written individually, the last one collaboratively with their lab groups. All of the labs were related to concepts taught in the lecture. For the lecture, which provided three credit hours, the students' final grades were based on their scores from multiple-choice tests; students were not required to do any significant writing. For the lab, which provided one credit hour, their final grades were an average of scores on the lab reports and a lab practicum.

The 10 participants in the study were randomly selected from the official class roll of Biology 183; all student participation was strictly voluntary. Each student was interviewed at the end of the semester, using a protocol for individual semistructured interviews (Glesne, 1999). The interview protocol, which we developed and piloted in a different biology class during a previous semester, included questions about students' current and past experiences with lab reports, their processes for writing lab reports, their attitudes toward the report, and their views about the role of the report. (Interview questions are listed in the appendix.) The interviews were loosely related to another study (Carter, Ferzli, & Wiebe, 2004) that investigated the effects of *LabWrite*, an online instructional guide, on students' lab reports. But the interview questions were designed to elicit students' comments on their broader experience with, and attitudes toward, writing lab reports; *LabWrite* was never mentioned in the questions though some students referred to it in their responses. Our research complied with our university's human-subject regulations.

One of us, Ferzli, conducted and transcribed the interviews and divided the responses into 139 individual discourse units (one or more associated sentences), 86 of which were related to writing and learning. Another one of us, Carter, coded the 86 relevant responses, classifying them according to explicit statements of the relationship between writing lab reports and learning.

Our initial coding scheme consisted of 10 categories, but in subsequent readings of the data, we found that 4 of those categories could be folded into other categories. The final coding scheme comprised 6 categories:

1. learning by writing
2. learning by writing the genre
3. learning by enhancing learning behaviors
4. learning by using reports for future reference
5. learning in other contexts
6. learning in contrast to other modes of learning

Because this is exploratory research with a relatively small sample, and because a number of the students' statements could be placed into more than one category, we did not feel that quantifying the data would be appropriate. The data are further limited by their being based on retrospective student interviews that are not triangulated with other forms of data. Thus the results are not intended to be generalizable; rather, they offer preliminary answers to these questions: How does writing in a discipline contribute to learning in that discipline? What kinds of learning occur in the disciplines? How do students perceive the role of writing to learn in a discipline? Answers to these questions can guide further research into writing and learning in the disciplines.

Results

Our coding suggested six categories that could define students' statements of writing and learning in the discipline. The first five categories move from learning that is directly related to the act of writing the report to learning that is indirectly influenced by it. The sixth category consists of students' statements about how learning by writing lab reports differs from other forms of learning in the sciences. Each category is illustrated by excerpts from the students' interviews. In some instances we have combined two or more of the separate discourse units by which we divided statements in the transcripts to retain the students' complete thought on a particular way of learning. Some of the statements could be placed into more than one category; however, because we are not offering a quantitative analysis of the data, this overlap is not important. We chose samples from the transcript that would illustrate the concept of each category and provide a sense of the variation within the categories. The samples have been edited to limit distracting verbal tics, such as *like* and *you know*.

Learning by Writing

The first category, learning by writing, consists of statements in which students described ways that learning was encouraged by the act of writing itself. In these statements, students made a causal connection between the immediate operation of writing (e.g., “when I sit down and write” or “put[ing] it all into your own sentences”) and particular ways of learning:

- 1a. I feel that going to the lecture . . . I just don’t get everything, but then when I go to lab and I know that I have to write a lab report on that topic, I really feel that it all ties in really well, especially when I sit down and write the report. I mean, having to do a lab report forces you to sit down and learn. I mean, even if you don’t want to. (Student B)

- 1b. When you really put it down on paper, you have to put it all together, and somehow it has a way of making you understand everything a lot better. . . . It forced me to put all my thoughts together instead of having them all jumbled up because I know that when I was in the lab, even though I was trying to pay attention, and I was trying to learn it, it was all jumbled up for me. I don’t think that I was the only one in this situation. (Student B)

- 1c. I mean, writing the lab report really drills what you’ve learned back into your head because you have to put it all into your own sentences, and you have to go find references and all that, and cite material. When you’re writing down this is how it’s working and this is why, I think you’re furthering your understanding. (Student F)

- 1d. Well, it helps you, I mean, it did help me to look back at the lab because if I hadn’t written the lab report, I would have done the lab and never looked at it again. It makes you look back over at what you did and at least interpret what you did. (Student A)

In statement 1a, the student explicitly links writing and learning with the parallel phrases “sit down and write” and “sit down and learn.” The use of “forces” takes the link beyond simply the causal to the necessary. Specifically, writing the lab report led the student to learn a particular scientific concept by making stronger connections between the lecture in which the concept was taught and the lab in which it was applied. Thus the act of writing created a synthesis. In statement 1b, the same student describes writing the report as an act of ordering and clarifying “jumbled” thoughts about the lab. Again, the student presents the process in terms of necessity, saying that writing “forced” such an order. The student in statement 1c describes learning through writing

by using the metaphor of drilling, emphasizing the power of “put[ting] it all into your own sentences.” The physical act of writing what happened and why it happened enhanced the student’s understanding. Statement 1d describes how the act of writing invited the student to revisit the lab experience, not just to reflect on it but also to “interpret” it.

In all these cases, students demonstrated an awareness of something about the act of writing itself—an experience of synthesizing, ordering, reflecting, interpreting—that led to learning.

Learning by Writing the Genre

The second category, learning by writing the genre, consists of students’ statements that refer to specific features of the genre of the lab report as encouraging learning:

- 2a. You really understand the lab, you know, once you go back and really answer the questions. But . . . especially the introduction is probably one of the best parts about it because you learn not only about the experiment but about the things that go into it and that stuff. And the discussion is very important, too, because then you reflect back on the experiment itself. (Student C)

- 2b. With the lab report, you have to talk about the purpose in the introduction and what this lab has relevance to, what is relevant about this lab to the real world. And the materials and methods is what you actually did, and the results is what your results were, and . . . the discussion makes you go through and analyze your results and telling how that relates to your introduction and how it’s relevant to your world. . . . If you don’t understand any part of it, I think it really makes you think about everything, and you’re going to have a better understanding than just going in there and doing the lab. (Student G)

- 2c. [The lab report] is for paying attention to . . . whatever they were trying to study—like the specifics and the trends and the data or whatever would be shown better in the lab report. (Student D)

- 2d. [Responding to a question about the value of writing lab reports] I guess, just having to go back and interpret the results and straighten them and figure out why it happened the way it did. (Student A)

Generally speaking, the students showed that they were familiar with the parts of the lab report and how these parts shaped their understanding of the

lab experience. In particular, students in the examples cited the introduction as important for learning in that it provided a scientific context and sense of the purpose of the lab. They described the results as providing a way of making sense of the lab findings by discerning patterns in them. The value of the discussion is presented as inviting students to go back and interpret the results and put them in the context of the introduction.

Learning by Enhancing Learning Behaviors

The third category, learning by enhancing learning behaviors, comprises statements about how writing lab reports encourages learning by promoting learning behaviors that are not necessarily related directly to writing itself. In other words, having to write lab reports led students to engage in effective learning strategies they may not have otherwise employed:

- 3a. And I guess it sort of makes you read the lab manual better to figure out, well, this is supposed to work this way—maybe that’s the hypothesis, maybe that’s what’s supposed to happen, better than I guess something is going to happen, but I really don’t know. So you have to read the lab manual better. (Student D)
- 3b. Because I had to look up the words and I had to figure out what they mean, and what equipment and things we used that would be in the lab report and be in the results section. . . . I have a better understanding and I feel like I have learned, [become] more educated, because I really paid attention to the words and what they mean. (Student D)
- 3c. So I found out from that report that I really needed to . . . I really needed to pay attention more and even to what the instructor is saying because everything ends up being important when you’re writing the report. (Student B)
- 3d. I think it would be pretty much pointless to have a lab with no reports because—well, I don’t want to call it pointless. But you know that if you don’t have to write a report on a lab that you’re doing that you don’t have to pay attention as much or even write down all the observations you’re supposed to write down. So if it’s stressed that you have to write a report about it, then you’re going to pay more attention and be more observant. You’re going to understand it better. (Student C)

The common theme among these statements is that writing lab reports encouraged the students to attend more closely to the lab. In statement 3a, the student describes having to read the lab manual more carefully and to

think through the experiment before performing it in the lab—a strategy that the vast majority of lab instructors would agree is important for learning the concepts and procedures of the lab. Then in statement 3b, the same student notes that writing the lab report required paying more attention to the terminology appropriate to the particular lab as well as to the equipment used. In statement 3c, another student extends the theme of paying attention to include listening to what the instructor says, also a productive learning behavior. It is a telling assertion that having to write lab reports increases the importance of every detail of the lab experience. And in statement 3d, the student strongly expresses the learning value of writing lab reports by describing how they encourage students to take greater care in observing and recording their lab findings. Other students reported that writing lab reports prompted them to examine information more carefully, find out more about the scientific concepts of the labs, and ask questions during the labs.

Learning by Using Reports for Future Reference

In our interviews, students said that they have used or will use their lab reports as references for future learning situations. In the fourth category, we included statements in which students explicitly described referring back to their lab reports in other settings:

- 4a. But if I'm reading something and I'm kind of unsure about it and I remember it being in my lab report, I can go back and use that as a reference or whatever. I mean, I've done that. (Student B)
- 4b. One good thing . . . about it is that it's always something you can have to read later down the road after you've finished the lab. Like a reference for later in life or for an exam, especially for a lab practical. You'll have all the information you need right there written in your own words versus what's in the lab manual. So that's helpful because textbooks and manuals are written too systematically, and it's difficult to relate to it. (Student F)
- 4c. It may have been gone over in another lecture, not in BIO 183 but further on, and I could go back and look at how I wrote it and say, you know, that makes more sense than how they said it or something. (Student D)
- 4d. I think it is just a way to emphasize what you've learned, to show that you've understood what you've learned, and to have it as reference to reference back to it because higher-level courses build on this basic knowledge and you're going to need it as a foundation. (Student F)

In statements 4a through 4c, the students indicate a common theme regarding the use of lab reports as a reference: They describe formal sources of information—textbooks, lab manuals, and lectures—as unclear or difficult to understand and their own lab reports, in contrast, as clearer and more accessible. They describe their lab reports as potentially valuable references because having the information “in your own words” makes them more helpful. In statement 4d, the student demonstrates awareness that the lab reports written for this biology course could be used as a basic reference in more advanced courses in the same or a similar field.

Learning in Other Contexts

Some students describe how the lab reports they had written helped or would help them learn more effectively in other contexts in the university, or beyond. In this category, we placed statements that explicitly mentioned the link between students’ lab reports and other settings. This fifth category differs from the previous one in that students describe using their lab reports in ways other than as a reference:

- 5a. They really do help me for exams. I mean, when you do the research for the prelabs . . . you do the lab report, and then you do the test, and they all fall in line and they combine together. (Student B)
- 5b. And the information that I use for lab reports has really helped me on tests, and I really don’t think that if I didn’t have to write the lab reports that the tests would have been easy for me. (Student I)
- 5c. I guess writing a long lab report like that can only help you in other classes with all your other lab reports. . . . Having to write the lab reports in biology helped me to understand that I really have to pay attention in lab if I have to write a lab report. This helped me when I had to write my reports for physics. (Student B)
- 5d. This is some kind of basis for future lab reports, which will lead to graduate school and beyond. And if I ever have a chance to publish, then this is the starting point, the foundation to get there. (Student G)

In statements 5a and 5b, the students observe that writing lab reports has helped them perform better on exams covering related material. These students suggest that their performance on the exams was enhanced by their previous experience researching and writing about the scientific concepts

covered on the exams. In statements 5c and 5d, the students point to the way that writing lab reports in their biology class has led or would lead to writing better reports elsewhere. In statement 5c, the student describes how paying closer attention to biology labs, a behavior caused by having to write lab reports, carried over to physics labs. And in statement 5d, the student even traces the future value of writing lab reports in this class to a career as a scientist.

Learning in Contrast to Other Modes of Learning

The sixth category, learning in contrast to other modes of learning, contains statements from the interviewees describing how the learning associated with writing lab reports differs from, and is generally more effective than, other modes of learning they encountered in science education. The previous five categories have been characterized by a movement from the concrete act of writing to broader ways in which writing lab reports directly fosters learning science. Falling outside that taxonomical pattern, this sixth category offers data that more indirectly demonstrate the relationship between writing and learning in the sciences. This category is important because it reveals the students' awareness not only of how writing lab reports encourages learning but also of how writing lab reports contrasts with other modes of learning science. Their statements help us to understand better the value of writing to learn in this discipline:

- 6a. If you would just have to do the experiment, you don't learn as much. You don't take as many notes, and you just don't focus on that. You just sort of have to do it. And if you have to write something about it then you have to . . . learn all the details and specifically know how you did the lab, so you pay more attention to how you do it. (Student D)
- 6b. Having to write about it, you have to know a little more about it than just here's my worksheet and my results and here's my one-sentence conclusion. . . . If you generate your own information about it by writing, I guess I would be more likely to remember it than if I just filled in a worksheet or just turned in my results. Or, well, "I guess this is what this means. Here." But rather I have to sit down and think about this in order to write this paper. (Student E)
- 6c. If you have to explain something yourself and discuss it, then sure, you're going to learn it much better than just hearing about it or seeing it. . . . You don't do that in a regular class. You just memorize it for the

test. Anyone can memorize something for a test, but when you can sit there and explain what happened and relate it to variables and such and why this changed and that happened, then I would say that you're learning it better. (Student H)

6d. I think that the lab reports prepare you, and they help you learn more in more detail than what you're learning in lecture, and it kind of goes along with what you're learning in lecture so you do better on the test. And I guess you remember it more than you would with just a lecture. . . . But [in lecture] you're writing down what they say instead of what you're thinking and how they interpret it instead of how you interpret it. (Student D)

In these statements, students contrast the learning situation of writing lab reports to four other learning situations in the sciences. The first of these, doing a lab without having to write about it, was familiar to our interviewees because they were not required to write lab reports for all their labs in the Biology 183 course. In statement 6a, the student echoes what the students in statements 1d and 3d say: Doing a lab without writing a report is a poor learning experience. Writing encourages a fuller, richer engagement in the lab. In statement 6b, the student describes another practice, performing a lab experiment and only filling out a worksheet. This practice is becoming more common especially in labs associated with large-section introductory science courses for nonmajors but in other courses as well. The typical justification for having students fill out worksheets rather than write reports is that worksheets are easier for teaching assistants to grade and that nonmajors, especially nonscience majors, would derive little benefit from writing full lab reports. We suspect that most of the students in Biology 183 were familiar with worksheet labs because most of them would have taken the introduction to chemistry, which uses worksheets for nonchemistry majors. In statement 6c, the student differentiates learning through writing lab reports from the (short-term) memorization required to do well on science tests. Writing is a more effective mode of learning science, the student explains, because it engages students more fully in the experience of science, of scientific thinking. Finally, in statement 6d, the student contrasts two modes of learning the same scientific concepts, taking notes in a lecture and writing lab reports. The student considers writing the report to be a better learning tool because it encourages learners to construct their own thoughts and interpretations, a more powerful mode of learning than that of simply recording the thoughts and interpretations of the lecturer.

Discussion

The purpose of this study is to identify possible ways that writing in the disciplines encourages socialization in the disciplines. It is based on our contention that the common distinction between WAC and WID—writing to learn versus learning to write—understates the role of learning in WID. We have argued that the main difference between WAC and WID in terms of learning is not that WID emphasizes learning to write at the expense of writing to learn but that WID is founded on a conception of learning as socialization into the disciplines. The issue, then, is how such socialization takes place. Data from our interviews with students who had written a disciplinary discourse in a disciplinary setting point to an understanding of how writing may encourage learning in a discipline. These results are, of course, preliminary. They are based on retrospective interviews and a relatively small sample and do not incorporate a quantitative analysis—all of which limit their generalizability. We believe these limitations are acceptable, however, given the purpose of our study and the lack of research into how writing in a discipline encourages learning in a discipline.

We have used theories of situated learning to frame our study of socialization in the disciplines by considering writing as a part of an apprenticeship in a disciplinary community. To be considered an apprenticeship activity, writing lab reports must be considered legitimate peripheral participation (Lave & Wenger, 1991) or authentic activity (Brown et al., 1989) in a scientific community of practice. One critical issue, then, is whether the lab report is indeed *legitimate* participation, that is, whether the students are engaged in the discourse of full members of the community, best represented by the scientific journal article (Bazerman, 1988; Berkenkotter & Huckin, 1995; Journet, 1999). Freedman et al. (1994) showed that even in classes designed to reflect as closely as possible the writing of professionals in a field, the discourses of students and professionals are fundamentally different, given the significant differences in their contexts. Certainly the purpose and audience of the scientific journal article differ in important ways from the purpose and audience of the student lab report. We suggest, however, that it is what these two genres have in common that makes the lab report a legitimate apprenticeship genre: They share the structure of introduction, methods, results, and discussion, representing a shared way of knowing that is mirrored in other professional scientific genres, such as the conference paper, research proposal, proposal abstract, and poster.

Clearly more closely aligned with discourse within the community of practice than discourse about it (Lave & Wenger, 1991), the lab report provides students a way of participating in the scientific ways of knowing encoded in the genre while remaining on the periphery of the community of science. Students are relieved of the expectation that they must report original research to professional scientists so that, as apprentices, they can focus on mastering scientific ways of knowing. We would argue that apprenticeship genres such as the lab report could play a critical role in the socialization of undergraduates into disciplinary communities. In graduate school the focus of the apprenticeship tends to shift to the genres of full membership.

As an apprenticeship genre, lab reports appear to encourage socialization into the community of science. That is, they are a way of doing by which students participate in the ways of knowing of that community. Our question is, How does writing encourage this socialization? We realize that socialization into the disciplines is a complex process, much of which eludes our methodology; however, our study, though preliminary, provides a basis for speculating about possible answers to this question. One answer that we have just mentioned is that the genre of the lab report encodes a scientific way of knowing in its structure—a structure that defines and is defined by ways of knowing of the community. The lab report shapes the experience of the lab itself as a scientific experience. We suspect that most disciplines have discourses that can be identified as legitimate apprenticeship genres, such as the technical report, market analysis, literary critique, and social science research report. Other genres with less legitimacy in a discipline would tend to be less effective in encouraging socialization into the discipline. Take, for example, the literature review. Finding, reading, and summarizing the literature of a discipline can provide a good introduction to it. But this genre may be described as closer to discourse about rather than within a discipline. Although the literature review is a professional genre and some journals specialize in publishing literature reviews, it does not represent the ways of doing and knowing that are central to any particular discipline. And traditional school genres such as short-answer and fill-in-the-blank tests, book reports, summaries, and essays—all writing about disciplines—would be more likely to encourage socialization into the culture of school than of a discipline.

A second answer is that asking students to write in a way that is similar to the way full members of the community write encourages students to behave in the lab more closely to the way full members of that community would behave. Students' knowledge that they would have to write a lab report tended to influence their behavior before and during the lab; they acted less as students simply trying to get it done and more as scientists seeking to

understand the lab. We were surprised at the extent to which students reported that knowing they would be writing a lab report caused them to change their learning behaviors (e.g., to read the lab manual more carefully, pay closer attention to scientific terminology, become more observant during the lab procedure, take better notes). These behaviors made the lab experience itself more of a scientific apprenticeship. We believe that one reason students were aware of these changes in their behaviors was that the disciplinary activity of the lab is more transparent as an activity than are the more subtle disciplinary activities in other fields, such as reading primary and secondary texts for a literature course or analyzing economic data for a marketing course. But we suggest that having to write apprenticeship genres related to those activities could also have a positive effect on student behaviors. For instance, the prospect of having to write a literary critique may change the way a literature student reads texts; the same may be said for a market analysis and the way a marketing student analyzes economic data. Thus, by asking students to write these apprenticeship genres, we provide opportunities for socialization into the disciplines by encouraging them to enact broader ways of knowing associated with membership in the disciplines.

A third way in which writing the lab report encourages socialization into the sciences is that it provides a sense of meaning and purpose to the lab activities that they seem to lack without it, a meaning and purpose derived from the connection between the lab report and the scientific community. We had assumed that for students the lab would be the primary learning activity in the discipline and the report secondary. But our interviews suggested the opposite. Some students were dismissive of the lab, saying that without having to write a report, they would just do the lab and forget what they had done. One student said that doing the lab was pointless without writing a report. The lab report seemed to provide a *raison d'être* for the lab that was otherwise missing. This finding suggests that writing apprenticeship genres may hold a special place in the broader apprenticeship activity of the disciplines. All disciplines have characteristic ways of doing—performing a lab experiment, reading literary texts, analyzing economic data—that encourage certain ways of knowing in the discipline. Our study seems to indicate that the writing associated with these ways of doing—the lab report, literary critique, market analysis—carries with it the potential for turning those ways of doing into ways of knowing of the disciplinary community. Writing may be understood, then, as a special way of doing because it has the potential for catalyzing disciplinary activities into the ways of knowing of the disciplines, the critical link between doing and knowing (Carter, 2007).

A fourth form of socialization directly related to writing the lab report is that it provides a vehicle by which students are able to envision connections to a larger community of science. Students' statements in the fourth and fifth categories demonstrated that these life sciences majors were aware of a future in their disciplines and of the place of their lab reports in that future, as valued references and as sources of knowledge they could call on in other science courses and labs. Clearly, these students did not see the lab report merely as a graded exercise to be disposed of as soon as possible; rather, they saw it as a stake in their discipline, a link to a community of practice beyond their Biology 183 lab. We interpret this link as an indication of students' recognition of ways of knowing that transcend their present learning situation to encompass the larger scientific community that corresponds to their particular majors. We doubt that this sense of continuity, of shared ways of knowing across scientific contexts, would be inspired by classroom discourses that are not so clearly reflective of scientific ways of knowing, such as the multiple-choice exam, the lab practical, or even the fill-in-the-blank lab report. The lab report appears to act as a fulcrum by which students can lever their imaginations into other contexts in the sciences. We speculate that apprenticeship genres in other fields could also encourage in students a broader identification with disciplines as they participate in the shared ways of knowing that characterize those disciplines.

Finally, writing the lab report encourages socialization into the sciences by giving students the opportunity to write as scientists. This last form of socialization through writing the lab report is derived from the value, according to the students, of putting the lab experience into their own words. We were particularly struck by the students who said that what they had written had an authority for them that outweighed the usual authorities of the science classroom—textbooks, lectures, and lab manuals. This authority, we believe, led students to cite their reports as valuable references for the future and to state that writing lab reports was a more effective learning experience than other ways of learning in the sciences. We suggest, however, that this value comes not so much from their own words as it does from their appropriation of the language and thus ways of knowing of the scientific community. Lave and Wenger (1991) described the importance in an apprenticeship of learning to talk the way full members of the community of practice talk. One way to understand an apprenticeship in a discipline, then, is as an opportunity for newcomers to try on the ways of writing of the community, a way for them to develop their own authority within the community. An especially revealing finding from our study is

that the students were much aware of the distinction between discourse within and discourse about the disciplinary community (Lave & Wenger, 1991). Their valuation of the lab report over lectures, textbooks, fill-in-the-blank reports, and tests indicated this awareness. One source of this valuation, we suspect, comes from the students' sense of the authenticity of the lab report as discourse within the community of science in contrast to the other discourses, which were not so clearly connected to the community's ways of knowing. Apprenticeship genres in other disciplines would likely give students a similar sense of their own developing authority in those disciplines.

In this discussion of socialization in the disciplines, we have drawn on data from categories 2 through 6 in our results. Because the data from category 1, learning by writing, seem to be closer to a standard cognitive understanding of writing and learning than a social one, we address this category separately. Klein's (1999) extensive review of cognitive studies of writing and learning identifies three models for explaining how the act of writing itself causes learning. The first model, shaping at the point of utterance, explains how writers learn through the process of making tacit knowledge explicit by giving it semantic and syntactic form. The second, the forward-search model, explains how writers learn by using text they have created as a basis for revising, thus transforming ideas, and as a means of freeing up working memory to access more long-term memory. The third, the backward-search model, explains how writers learn by starting with broad, top-level goals and then generating rhetorical and content-based subgoals. By working through the rhetorical and content problem spaces, writers enhance their understanding of what they are writing about.

Our interviewees offered alternative explanations for how the act of writing generates learning: Writing the lab report highlighted connections between what they learned in the lecture and what they did in the lab, it created order in what was previously a "jumbled up" lab experience, and it provided the opportunity to revisit the lab and explain what happened in it. Thus, unlike Klein's (1999) models, which focus on writing processes that occur in the individual act of composing a text, our interviewees' explanations seem to focus on relationships beyond the text. This focus suggests that learning by writing disciplinary discourses in disciplinary settings depends less on the cognitive operations internal to the process of writing than on constructing meaning within a broader experience outside the text. But because the kind of learning students described in category 1 was not clearly directed toward participation in the ways of knowing in the sciences, we did not include it in our discussion of socialization.

Conclusion

We began this article with Ackerman's (1993) critique of the WAC assumption of a strong causal relationship between writing and learning, a critique we aimed at WID: How does writing in the disciplines encourage learning in the disciplines? But that question is difficult to answer without understanding in relatively concrete terms what it means to learn as socialization into a discipline. The theoretical framework of situated learning has provided us a way to conceive the lab report as an apprenticeship genre in the sciences and to describe five possible ways in which writing lab reports may encourage socialization into the disciplines. We hypothesize that other apprenticeship genres offer similar means of socialization into their disciplines.

It is important, however, not to forget that theories of situated learning are rooted in the critique of traditional educational practices, that is, teaching as the transmission of inert, decontextualized knowledge disconnected from doing (Brown et al., 1989; Lave, 1988, 1993; Lave & Wenger, 1991). This traditional model still dominates higher education. It is also a model that does not favor writing in the disciplines because writing is typically portrayed as being separate from knowing in the disciplines (Carter, 2007). But what if faculty in the disciplines reconceived the goal of education as helping students to grow as participants in the ways of knowing of their disciplines? Students would be understood not as outsiders but as fellow members of the disciplinary community, albeit on its periphery. Teaching would be understood as creating opportunities for students to learn by doing the kinds of activities full members do, though in a form appropriate for apprentices. And writing would be understood as the critical link between doing and knowing in the disciplines. Perhaps this process of reconceiving the goal of education begins with writing in the disciplines, helping faculty see the connections between writing and knowing in their disciplines. If that is the case, then there can be no doubt that writing in the disciplines encourages learning in the disciplines.

Appendix Interview Questions

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1. Think back to when you were writing the first lab report for Biology 183. What were some of your feelings at the time?
 2. How do you feel now about writing lab reports?
 3. Tell me what you like about writing lab reports.
 4. Tell me what you don't like about writing lab reports.
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(continued)

Appendix (continued)

5. Has writing lab reports helped your understanding of concepts you had to write about?
 6. Tell me what you think the role of the lab report is in school science laboratories.
 7. How did you come to form that perception?
 8. How about the role of the lab report in science laboratories? At the workplace?
 9. How did you come to form that perception?
 10. Did you feel prepared to write lab reports when you first came into the biology lab?
 11. Tell me about the instruction on lab report writing that you received in your biology lab.
 12. Tell me about how you wrote your lab reports for Biology 183.
 13. What did you find most helpful when you were writing the reports for Biology 183?
 14. How does your experience with writing lab reports in Biology 183 compare to previous experiences you've had writing lab reports in other science courses?
 15. Please comment on anything that you may have thought about during the interview or tell me anything you would like to add.
 16. Is there anything that I didn't ask you that you feel should have been part of the interview?
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