

Acquiring Expertise in Discipline-Specific Discourse: An Interdisciplinary Exercise in Learning to *Speak* Biology

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Abstract: This article reports the results of a study with 70 senior undergraduate biological science majors enrolled in a required course on *Writing and Speaking in the Biological Sciences*. Students enrolled in this course were expected to develop oral scientific presentations of their research projects that exemplified the norms of speaking in the biological sciences. Rather than gathering information from experts or providing explicit instruction on the conventions and structure of this particular genre, we surveyed the students enrolled in this class about their self-perceived communication challenges. Students overwhelmingly identified general issues of organization and concerns about delivery as their primary challenges and communication workshops were developed to address these concerns. According to the reports of the biology faculty who evaluated these students' presentations and grade data for the oral component of this course compared to previous sections of it, students demonstrated significant expertise in enacting a highly discipline-specific oral communication task. We attribute these students' ability to successfully deploy such discipline-specific discourse to their own tacit knowledge of their field combined with instruction in both the disciplines of rhetoric and biology.

I'm not a biologist. So when asked to develop communication workshops for biology majors on speaking in the biological sciences, I was unsure how to proceed. As director of the Communication Lab, I had a similar uncertainty with other recent requests to provide instruction for chemistry and engineering majors about speaking assignments in genres specific to their disciplines. In those instances I attempted to consult with the professors requesting these workshops about their students' speaking abilities and the norms and conventions of the genre students were expected to enact. For this request, however, I wanted to experiment with a different approach. I decided to consult with an often-overlooked group—the "audience" of students being required to perform the communication task. In this case, the audience was 70 senior biology majors who were enrolled in multiple sections of a required course on *Writing and Speaking in the Biological Sciences*.

Most practitioners of communicating in the disciplines programs rely on a top-down model—gathering information from experts about the norms, genres, and what counts as good communication in a particular field (Darling & Dannels, 2003; Dannels, 2002; Dannels, 2001) and then interacting with students only after decisions about their communication needs have already been made. Rather than relying upon these methods, we began this study by surveying senior biology majors about their self-perceived communication abilities and communication challenges, even though the oral requirement for this course was a highly discipline-specific scientific presentation.

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Consequently, because we relied upon the accounts of students rather than traditional experts and because we did not research the norms and conventions of *speaking like a biologist*, this study represents a departure from the standard methods for exploring discipline-specific expertise and communicating in the disciplines.

We chose to rely upon the self-reported communication abilities and challenges identified by our audience of senior biology majors as our starting point for three reasons. The first reason for relying on students' accounts was in response to recent communication in the disciplines research suggesting that what "experts" may identify as critical communication skills for a particular discipline or situation may not adequately address students' perceived communication needs and the communication challenges that they actually face. For example, in a study that sought to develop a teaming, writing, and speaking module for a capstone chemical engineering design course that included students from chemical engineering, computer science, industrial engineering, economics and food science, researchers found that their assumptions about what students needed to learn was incompatible with the students' perceptions of their actual communication challenges (Dannels, Anson, Bullard, & Peretti, 2003). In this case, the kinds of oral communication expertise emphasized were determined by a group of specialists who attempted to give these students what they believed they would want and need. Since this did not comport with the students' experiences, they were largely dissatisfied with the course content and emphasis. Frustrated with the process, they failed to understand the significance of the writing and speaking instruction in the context of their work and felt that the communication material emphasized did not address the communication challenges they actually encountered.

The second reason that we conferred with students was to test the assumption that consulting with "experts" or identifying discipline-specific communication norms and conventions is a necessary preliminary step in instructing students who are attempting to acquire oral competence in their discipline. Like many other colleges and universities, our communicating across the curriculum program is relatively new with very little faculty release time to promote it. Since time constraints precluded us from conducting field observation, interviewing, or researching norms or conventions of discipline-specific discourse in advance of multiple requests for communication instruction from various departments, we were interested in experimenting with other methods for promoting students' opportunities to acquire oral communication competence in their discipline.^[1] Our research gave us a means to examine other approaches to developing communication curriculum for students trying to acquire and demonstrate oral competence in discipline-specific discourse (Pratt, 2002).

Finally, we were interested in students' self-reports because we perceived these students as *legitimated sources* and, in fact, *fledgling experts*. As senior biology majors, these students had already acquired a level of expertise as biologists through ongoing study and exposure to the culture of their discipline and the specialized world view that enculturation entails (Kuhn, 1970). Through course work, texts, lectures, labs and internship experiences, and general interaction with biology faculty and biological science peers, these students had presumably learned a great deal about their discipline and its culture. For example, they were familiar with the kinds of questions that are important to biologists and how biologists construct them, what kind of phenomena one should pay attention to and what one should ignore (Hall, 1996), how to study and approach biological data (Toulmin, 1958) including knowledge about the "language game" and communicative tools of biologists (Wittgenstein, 1968). Throughout their experience of majoring in biology, these students had been exposed to multiple examples of discipline-specific discourse. We presumed that they brought that knowledge, though perhaps tacitly, to this course on writing and speaking in the biological sciences in which they were expected to produce written documents and oral

presentations that exemplified the norms of writing and speaking in their discipline—a kind of knowledge they would soon be required to demonstrate in the "real world." In this sense, our research brought together the expertise of communication and biology faculty as well as the emerging expertise we presumed our students had acquired.

Writing and Speaking in the Biological Sciences

A course on Writing and Speaking in the Biological Sciences is required of all senior biology majors. Each section is a small class of 10—13 students taught by one of two biology instructors. During the entire semester, students research, write and talk about the primary scientific data on a particular biological "problem" or "controversy" that they have selected from a list of current biological issues. The following topics are illustrative of the questions students studied: "The direct mutagen effects of non-ionizing radiation associated with the use of cellular phones" or "Whether prion diseases propagate by conformational information or by transmission of genetic information."

As a part of selecting a topic, students are assigned the role of a professional biologist such as that of a researcher with the Food and Drug Administration or the National Institute of Health. In this role each "biologist" is to study the primary scientific data on the problem and make a professional recommendation about it to a particular audience such as a government funding agency or group of physicians. In their oral presentations students are required to present the primary scientific data surrounding the biological problem, use the primary scientific data as the evidence for supporting their resolution or recommendation, use scientific language appropriate to the field of biology, and use PowerPoint as a visual supplement. Consequently, both the written documents and oral presentations for this class were highly discipline-specific insofar as they represented what is commonly accepted as a specialized perspective and language game along with the conventions for speaking about science in the field of biology.

Initially, students developed a written document that examined the primary scientific data surrounding their research question and developed a recommendation based on it. Students took this research paper through two draft revisions in conjunction with feedback from their biology instructor. Students were then asked to begin to translate the written document into an oral presentation.

While the oral requirement for this course had been in place for several semesters, the biology instructors had been very dissatisfied with the quality of the oral presentations.^[2] In previous classes biology instructors had devoted a two-hour class session on how to organize an oral scientific presentation. Students then presented their work on two occasions—an initial presentation and a revised final presentation. However, biology instructors found that most students "had difficulty using the language of science and talking about the primary data," "lacked confidence about the material and how to present it," and that their presentations "lacked focus," and were "poorly organized and too long."

In an effort to improve the quality of the oral presentations, the instructors for this course approached the Communication Lab director to provide two two-hour workshops for students on "translating a written scientific document into an oral scientific presentation." The biology instructors believed that more specialized communication instruction was necessary and that they were not equipped to provide it. In addition, biology instructors also scheduled a one-hour workshop with faculty from the Center for Instructional Development & Design on the use of PowerPoint, a required component of each oral presentation.

Research Questions

We were primarily interested in the following two questions: 1.) How would these senior biology majors describe the oral communication challenges that they faced? 2.) How would instruction designed to directly respond to students' self-reported communication challenges provided by communication faculty affect their ability to enact a discipline-specific oral communication task?

Methodology and Data

Participants

During fall 2003 and spring 2004 when this study was conducted, six sections of Writing and Speaking in the Biological Sciences were offered with a total of 70 students. There were very few class absences and the number of students participating in the surveys and communication workshops for this research ranged from 66 - 68 senior biology majors.

Initial Survey

An initial survey was developed by the Communication Lab director and administered to students in advance of the two communication workshops. The purpose of this survey was to determine students' previous instruction in oral communication, the extent to which they engaged in various kinds of public speaking activities, their perceived strengths and weaknesses in oral communication, and what they wished to learn about oral communication in the forthcoming workshops. Table 1 lists the questions on the initial survey.

Table 1. Initial Survey

#	Question	Response Options
1	What communication courses or workshops have you taken?	
2	Please indicate how often you participate in speaking situations such as meetings, presentations (in class or other), discussions (in class or outside organizations), teaching, tutoring, sales, tours, etc., on a weekly basis?	Infrequently (once a week) Sometimes (2-4 times per week) Often (5 or more times per week)
3	On a scale of 1-10, how well do you understand the process of putting a talk together?	Likert Scale 1=Not at all 10=Understand very well
4	On a scale of 1-10, how comfortable are you in speaking in front of either a small or large group?	Likert Scale 1=Very Anxious 10=Very Comfortable

5	On a scale of 1-10, how would you rate yourself as a speaker?	Likert Scale 1=Needs Improvement 10=Excellent Speaker
6	What aspects/issues/questions about giving a talk would you like to see discussed in next week's workshop? Be specific about what you want to learn.	

Initial Survey Data

The first two questions on the initial survey dealing with prior communication instruction and the frequency of engaging in various types of oral communication were analyzed quantitatively. *Of the 68 participants completing this survey, 49 had never taken any type of course or workshop in communication.* In addition, only 16 of the 68 participants engaged in oral presentation/communication activities on a regular basis.

For questions 3, 4, and 5, students were asked to respond by circling a number on a Likert scale that corresponded to their level of understanding, comfort, or competence about speaking in public. For all three questions, 1 represented the low end of the scale and 10 represented the high end of the scale. The mean responses are reported in Table 2.

Table 2. Mean Likert Scale Responses to Initial Survey Questions 3, 4, and 5

Question	Mean Response Fall Classes	Mean Response Spring Classes	Overall Mean
3. On a scale of 1-10, how well do you understand the process of putting a talk together?	6.6	6.4	6.5
4. On a scale of 1-10, how comfortable are you in speaking in front of either a small or large group?	5.5	5.9	5.7
5. On a scale of 1-10, how would you rate yourself as a speaker?	5.7	5.6	5.7

Responses to question 6 were grouped into thematic categories with two major themes of "organization" and "delivery/dealing with nervousness" as the dominant communication challenges students perceived as needing to be addressed in their communication workshops. Of the 43 students who responded to the question by identifying a particular topic they wished to explore, 18 identified some element of organization and 25 identified delivery or speaking anxiety issues. Students were very clear in their comments about the challenges that they perceived and what they needed to learn. For example, regarding organization, students commented: "making message clear," "organization process in presentations directed towards biology," "how to decide what's important," and "how much detail to present."

Students were also explicit in identifying delivery, including speaking anxiety, as primary challenges. The following comments were typical of what students identified as needing to learn: "how to keep the audience interested," "how to talk to the audience," "whether to talk with your hands," "how to sound confident," "how to relax," "how to give a talk without my heart pounding and voice shaking," and "how to be effective and not look nervous." In their comments organization and delivery/speaking anxiety were the themes throughout this survey that emerged as the dominant challenges for students.

As the data show, the results of the survey were strikingly similar for all six sections of biological science students. This seemed particularly compelling since students completed the surveys in class without advance knowledge or any discussion of the survey.

Oral Communication Workshops

Two two-hour workshops were developed in response to this initial survey. The first workshop focused on organizing a presentation and the second on delivery, which included speaking anxiety.

Workshop One - Organization

The first workshop was comprised of two parts. In part one, the Communication Lab director provided an overview and discussion of the initial survey results and an introduction to the study of oral communication and what it means to "think communicatively." The rationale behind the initial survey that students completed was explained as an attempt to understand and analyze our *own* audience, a cornerstone of any effective presentation. The survey data and the themes that they had identified as their dominant challenges—organization and delivery and nervousness about speaking in public—were discussed. Essentially, the students had set the agenda and the content for the workshops.

When discussing the initial survey data that they provided about their speaking anxiety, the relationship between knowledge, practice, and ability was emphasized, as was the fact that almost none of them had ever taken a course or workshop in oral communication or experimented with various forms of it on a regular basis. It was suggested that with instruction and practice their knowledge and confidence would increase and their anxiety would decrease.

In introducing students to what it means to "think communicatively" the study of oral communication was situated and explained as a distinct discipline. Students were advised that to think communicatively would require a shift in the central goal of their research. It was no longer a question of what they had learned and discovered, but rather how to orally communicate that scientific knowledge for a particular audience. It was emphasized that a part of the successful conduct of science was being able to *communicate* one's findings and insights. Students were asked to consider their research from a communication perspective, in other words, to engage a different kind of critical thinking process that focused on rendering and translating complex information into an oral genre.

Students were then introduced to key elements of working with organization such as specific purpose, discovering main points, and arranging and supporting their main ideas. Their written comments from the initial survey were re-introduced to illustrate how the critical thinking process of organizing information for oral presentation and inventing categories or main ideas from a complex set of data works. Responses to the initial survey were written on the board to illustrate how one discovers the relationship among complex sets of information and how, as a result of their

many different comments, the *categories* or main ideas of "organization" and "delivery" had been abstracted.

In part two of this workshop students were divided into small groups of approximately seven students and a communication instructor. At this point in the course students were close to completing a second draft of their written document and had been asked to bring an outline to the Communication Lab based on this current draft. Despite the presence of a written outline, students struggled to verbalize the specific purpose and main ideas developed in their papers. In a manner similar to the content in the first written drafts, they provided too much detail for some ideas and very little for others. The Communication Lab instructor used guiding questions to lead students to begin to explore ways to organize this complex material for oral presentation. Students received feedback from the communication instructor and their classmates about suggestions for discovering, developing, and organizing their main ideas. Biology faculty attended but did not participate in these sessions. In concluding this first workshop students were provided with various handouts on organizing a presentation, and the university's speaking across the curriculum web site was provided as another supplemental resource. Students were asked to revise their outlines prior to the next meeting. Essentially, these biology students had been introduced to some of the core elements of classical rhetorical invention—the relationship to audience and the critical thinking process of organizing, arranging, and supporting material for an oral genre. Other core elements of rhetoric and thinking communicatively were the focus of the next workshop.

Workshop Two—Delivery

The second communication workshop conducted by the Communication Lab director focused on delivery. Information, handouts, and exercises on delivery and speaking anxiety were provided. Delivery was discussed as a range of nonverbal behaviors and students explored how to identify specific behaviors associated with aspects of their delivery that they wished to improve.

Speaking anxiety was also discussed as a very common experience. It was emphasized that instruction in communication, experience speaking, and ongoing practice were the critical factors in reducing it. Because students were beginning to become adept with constructing and supporting the main ideas for an oral presentation, they were asked to organize and deliver an impromptu presentation on "a place that we all should visit." Students were asked to construct a thesis statement with two or three main points with support for each point. The director of the Communication Lab provided an oral presentation that modeled the assignment. This exercise gave students another opportunity for group practice and feedback on organizing and supporting main ideas for an oral presentation, illustrated the competence they had already acquired in organizing a talk, and demonstrated the ease with which individuals can stand and speak about something they genuinely understand. The range of topics was broad and engaging. Students asked each other questions about their topics and the Communication Lab director commented on the organization and delivery of each presentation. Throughout the session, the ability these students had already acquired was highlighted, and the formula that instruction plus practice facilitates expertise was strongly emphasized. Even highly reluctant speakers were able to stand and deliver their presentations.

Before concluding the session, the revised outlines were quickly reviewed. The outlines no longer replicated their papers but were now organized into the main ideas or major findings that they intended to present. Students showed an effort to organize material to fit an oral genre. Verbalizations were more direct and to the point. Specifically, nearly all students had developed a thesis statement that explicitly stated the most relevant material of their research in main points with support that was restricted to these main ideas. Students were again encouraged to be well

organized, to practice, and to contact the university's Communication Lab for individual assistance if they felt they required additional help with their research presentations. Nine students contacted the Communication Lab director. Five of these students had questions that were answered via email. The other four students made an appointment with the Lab director to discuss some aspect of their presentation or to do a "run-through" in advance of presenting their research in class. [3]

Initial and Final Presentations - Speaking in the Biological Sciences

Students delivered their oral presentations on two occasions. The biology faculty graded each presentation with the final presentation weighted more heavily. The initial presentations occurred after both communication workshops and the PowerPoint tutorial. The initial presentations were videotaped and each student was required to review his/her presentation and develop a concrete plan for improving it in conjunction with general guidelines provided by the director of the Communication Lab. Communication instructors did not attend the presentations or review the videotapes. However, students did receive extensive written and oral feedback from the biology instructor who graded the presentations as well as oral feedback from their peers.

The biological science instructors gave the initial oral presentations mixed reviews. While some were "convincing scientific statements and well organized," many "had too little science," "used biological language awkwardly," and some "lacked a clear thesis," "exceeded the allotted time," and "rambled."

Biology Faculty Assessment of Final Presentations

Final presentations took place approximately three weeks after the initial talk.

Biological science instructors found very marked improvement in the organization, clarity, use of scientific language, confidence and delivery of the final research presentations, noting considerable improvement over the final oral presentations in previous versions of this course. Biology instructors found this improvement to be the case especially for the average or 'C' student. For example, "the number of 'C's' dropped by nearly half (from 29% to 18%)" in one instructor's section of this course. For all sections of this course, "the number of 'A's' increased from an average of 7% to 24%."

One of the two instructors teaching sections of this course provided the final oral grades for students over a three-year period. This data, reported in Table 3, lists the percentage of students receiving a 90% or better final oral grade. This data is reported in conjunction with the number of presentations and the availability of instruction from communication faculty.

Table 3. Final Oral Grades over Three Year Period

Semester	N	Presentations	Comm Faculty	Percent of Students receiving 90% or better
Fall 02	11	1	No	20
Sp 02	14	1	No	
Fall 03	24	2	No	41
Sp 03	31	2	No	
Fall 04	23	2	Yes	61

Sp 04	15	2	Yes	
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Follow-up Survey

A follow-up survey was administered in the final class session of each section of this course. Its goal was to assess whether students perceived their speaking abilities differently than in the initial survey, especially in relationship to the primary communication challenges that they had initially defined as needing to be addressed. The survey was administered in class without any advance notice or opportunity for discussion. Table 4 lists the follow-up survey questions. [4]

Table 4. Follow-up Survey Questions

#	Question	Response Options
1.	What do you feel were the strengths of your <i>FINAL</i> presentation?	
2.	What areas of your <i>FINAL</i> presentation were weak?	
3.	On a scale of 1-10, how important was the opportunity to review and critique a videotape of your presentation to the quality of your <i>FINAL</i> presentation? Comments?	Likert Scale 1=Not Important 10=Very Important
4.	On a scale of 1-10, how clearly do you feel that you communicated your message (i.e., rate how well you organized your <i>FINAL</i> presentation)? Comments?	Likert Scale 1=Very Disorganized 10=Very Well Organized
5.	On a scale of 1-10, how comfortable did you feel in delivering your <i>FINAL</i> presentation? Comments?	Likert Scale 1=Very Uncomfortable 10=Very Comfortable

Follow-up Survey Data**Strengths**

Almost all of the 66 students who completed the follow-up survey listed several areas of strength in their final presentations. The themes of organization, confidence about understanding and talking about the science, knowledge of the topic, and confidence in delivering their presentations dominated their comments. Table 5 summarizes students' characterizations of the strengths in their final research presentations.

Table 5. Responses to Follow-up Survey Question 1

Question	Themes	# of Students Expressing Theme	Sample Quotations
1. What do you feel were the strengths of your <i>FINAL</i> presentation?	Statements of Confidence in Organizing Ideas	33	"transitions," "it flowed well," "was able to narrow it down to specific points that were better supported," "clear," "organization," "I feel my final presentation effectively condensed my paper into a few main points," "the main strength of my presentation was organization," "I felt that I was more prepared in
	Statements of General Confidence and Improved Delivery	39	
	Statements of Confidence about Presenting Scientific Data	9	

		<p>delivering my speech and that it was more organized."</p> <p>"I was calm and spoke clearly and slowly," "less nervous," "addressed class in confident tone," "more comfortable," "more confident," "confidence," "I think I battled back the nervousness," "much less nervous," "ease of talking in front of class," "eye contact & confidence," "talked slowly."</p> <p>"good knowledge of materials," "data,"</p> <p>"knew the material well enough to talk about it," "I was confident about the material that I was presenting," "presented the data well," "greater comfort with the material," "explained slides well," "knowledge of the slides," "confidence in the ability to get across my major points."</p>
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In addition to written comments about various dimensions of increased confidence, follow-up question 5 provides a comparison with the initial survey on the change in students' self-perceived level of anxiety and comfort in delivering their final presentations. Table 6, which illustrates this data, shows a 2 point increase on the Likert scale from an average of 5.6 in the initial survey to 7.7 in the final survey. Perhaps more telling is that 17 students recorded scores of 5 or below (tending toward feeling very uncomfortable) in the initial survey, while only 4 such scores were recorded in the final survey.

Table 6. Mean Likert Scale Responses to Follow-up Survey Question 5

Question	Mean Response Fall Classes	Mean Response Spring Classes	Overall Mean Final Survey	Overall Mean Initial Survey
5. On a scale of 1 -10, how comfortable did you feel in delivering your FINAL presentation?	7.6	7.7	7.7	5.7

Final survey question 4 on *organizing the final presentation* provides some information on how students' self-perceived ability to organize a talk changed during the course of the semester. While

final survey question 4 on organization is not precisely comparable to the initial survey question on *the process of putting a talk together*, the data provide some insight into the change in students' self-perceived abilities and confidence in organizing an oral presentation—a major deficit they initially identified as needing to be addressed. The overall Likert scale score increased from 6.5 to 8.2 in the pre- and post-surveys respectively (Table 7). Scores of 5 or below, reflecting a poor knowledge of how to construct a talk, comprised only 3% of the students in the post- survey analysis, but were 25% in the pre-survey responses.

Student responses to follow-up question 4, along with their specific comments on the organizational strengths of their final presentations, stand in strong contrast to their initial perception of their ability to construct a talk. The fact that students emphasized that learning how to organize a presentation was essential to their ability to do so seems simply stating the obvious. Nonetheless, students are often asked to complete an oral assignment without any instruction in how to do so. In addition, when students are graded on an oral assignment, they often do not receive explicit feedback about the strengths or deficits in a presentation, therefore they never really understand what was done well or poorly. In terms of both reticent and non-reticent speakers, Kougl's findings (1980) continued to represent the norm for the students in our study, nearly all of whom had little to no previous instruction in oral communication and high levels of uncertainty about how to organize and deliver a talk. According to Kougl:

Students often report that they received no training in oral communication skills, although they were frequently graded on how well they spoke. Even when they received a high grade, confidence did not result. Since they were unsure of what they had done to deserve the grade, they feared that they would not be able to repeat. They were left with the impression that good oral communication is a matter of luck and best avoided when possible. (p. 235)

Table 7. Mean Likert Scale Responses to Follow-up Survey Question 4

Question	Mean Response Fall Classes	Mean Response Spring Classes	Overall Mean Final Survey	Overall Mean Initial Survey
4. On a scale of 1 - 10, how clearly do you feel that you communicated your message (i.e., rate how well you organized your FINAL presentation)?	8.4	7.9	8.2	6.5

Weaknesses

Of the 66 students responding to the follow-up survey, eight could not identify any weakness in their presentations. Among those students who did comment, various aspects of delivery were the most commonly identified. Table 8 summarizes students' characterizations of the weaknesses in their final research presentations.

Table 8. Responses to Follow-up Survey Question 2

Question	Themes	# of Students Expressing Theme
What areas of your FINAL presentation were weak?	Speaking too quickly	24
	Use of Fillers	5
	Poor Eye Contact	6
	Overreliance on Notes	7
	Nervousness	8
	Poor Transitions	5
	Weak Science & Data	5
	Poor Use of Visuals	4
	Difficulty with Q & A	4

Interestingly, the initial communication challenges that students identified as needing to be addressed surfaced infrequently in the follow-up survey. While "nervousness" remained a lingering concern for some students, "It doesn't matter how many times I present, I still get nervous," "Still very nervous," the majority of students now identified speaking too quickly because of time constraints as the primary weakness of their final presentations. Concerns about organizational issues were virtually absent in the follow-up surveys.

Discussion

Organizing an effective presentation, speaking anxiety, and effective delivery are general oral communication challenges and are not particular to the field of biology. However, these were the challenges our audience of students reported as needing to be addressed. In preparing our workshops for them we did not research the biological sciences, nor did we attempt to identify the conventions and norms of the specialized genre they were expected to enact. Nonetheless, based on students' self-reports, the reports of the biology faculty who evaluated their oral presentations, and final grade data for the oral component of this course compared to previous versions, the students in our study were able to acquire proficiency in a discipline-specific genre without first identifying its conventions or receiving explicit instruction about it. Given the general nature of our communication instruction, how do we explain these students' success in learning to speak biology? We believe that several interdependent factors, specifically the knowledge of biology that they had already acquired combined with instruction in the disciplines of rhetoric and biology, best account for their ability in acquiring expertise in speaking like biologists.[5]

Even though the overwhelming majority of students in our study did not initially see themselves as knowledgeable or competent in the area of oral communication and had no previous instruction in it, we believe that they had considerable knowledge about the field of biology, including its discourse. As seniors, it seems quite plausible that these students knew, for example, a great deal about what kinds of questions biologists ask, what kinds of data are important to notice, and how biologists conceptualize and talk within their discipline through their exposure and enculturation as biology majors.

Socialized into the culture of a discipline, one is consistently exposed to discipline-specific communication norms and genres, often internalizing these conventions without realizing it (Hall, 1966) and developing a knowledge about how to deal with more complex, specialized problems or tasks that is tacit (Dretske, 1988). Because varieties of tacit knowledge are utilized and expressed in various ways, we tend to "know more than we can tell" (Polyani, 1958/1974, 1995). Nearly all of these senior biology students would soon be practicing professionals or continuing graduate study in the field and most likely brought such tacit knowledge of the way biologists communicate to this intensive course on writing and speaking in their discipline.

However, even though the students in our study had already acquired a significant degree of knowledge about the discipline and language of biology, they lacked explicit instruction and practice in how to deploy this language. Their problem was essentially rhetorical insofar as they were unaware of how to distill the biological knowledge they had acquired.

Facing essentially a rhetorical problem, these students were provided with specialized instruction in the discipline of rhetoric which we called "thinking communicatively." The introduction of this specialized instruction provided a mechanism and framework for students to begin to think about their biological problem within an oral communication structure and form—something that, according to their initial self-reports, was a mystery to most of them.

Whether speaking to the literati or to a general audience, the oral form requires a speaker to condense and structure complex information into cogent oral messages for presentation to a particular audience, place, time, and purpose. Within this context, to think communicatively requires a speaker to get to the root of complex data and material and to invent ways to organize and deliver it—a kind of rhetorical knowledge that Aristotle referred to as *techne* (Dunn, 1993).

Like the Chinese brush painter who observes and grapples with her subject until she recognizes its essential components and then synthesizes these dimensions into a simple and distinct visual genre, the *art* of rhetoric requires a speaker to discover the essentials of a topic for synthesis into a distinct oral genre that includes a specific audience, place, and moment in time. Asking students to "think communicatively" changed the focus of their thinking towards the discipline of rhetoric and how to identify the essential findings of their research, varieties of evidence needed to support it, and how to organize and deliver this material for an audience. As a result, the primary goal of the course shifted. It was no longer about what the students had learned, but how to tell what they had learned. Having examined the science in order to make a recommendation regarding their research questions, they were then faced with the communicative problem of how to structure the science and deliver that science for oral presentation. In this process students grappled with oral communication issues that have been one part of the specialized content of the study and practice of rhetoric since ancient times. In short, in developing their arguments students were working with classic canons of rhetoric and the range of techniques that suggests.

However, it was not just instruction in rhetoric, but rather instruction in the disciplines of rhetoric *and* biology, that provided the framework for these advanced students' success. The biology instructor provided expertise in guiding students away from expressing ideas using general language and toward the use of appropriate scientific terminology. The biology instructor also provided specialized feedback on how to evaluate the actual "science" surrounding each student's research question and how to identify misconceptions in explanations of biological mechanisms, processes or interpretations of scientific data.

In regard to the first issue, students enter the course knowing and recognizing scientific terminology but have limited practice using it. They are uncomfortable with its use in both the written and spoken formats. A lecture by biology faculty, occurring after the submission of the first written drafts,

addresses common scientific expression problems. For example, in early drafts students seem content to mention that a particular treatment had an "increasing or decreasing" effect on some variable. Thus, for example, at this stage the statement "pesticide usage decreases tadpole survival" would be typical. While the statement may be true, it is only hearsay in the absence of the actual data, a level of significance and a proper citation. In later drafts such statements are supported with the inclusion of the data and significance level, "tadpole survival was significantly ($p \leq 0.05$) decreased by 50% in the treatment group receiving the highest (50mg/L) dose (Smith et al. 2003)."

The second area in which the biology instructor provided a specialized disciplinary role was in clarifying scientific misconceptions in student writing and speaking. Although these are senior biology students with nearly all of their biology requirements completed, they may show only a partial understanding of concepts or technical procedures. Controversial data can be explained by subtle differences in experimental design, species, chemical or statistical analysis about which these students have limited knowledge. Students often express their confusion in conferences with the biology instructor about some part of a study or the complexity of a certain mechanism they would like to include in their argument. For example, in student papers regarding which human hormone might be the best candidate for development as an anti-obesity drug, students often avoid discussing relevant background material on the process of normal human appetite control. In student-instructor conferences they reported that appetite control was a complicated process and was too detailed to include in their papers. But it was necessary information for students to understand in relationship to the research question and necessary information for a reader or listener to have in order to follow the arguments about which hormone would work best. Instructors suggested that information be gathered into a table that summarized common ideas such as the anatomical origin of each hormone, its chemical class, and its mechanism of action. This provided a quick reference for the reader, an exercise in table construction for the student and a visual aid that could be included in their oral presentations later in the course. The ongoing creation, feedback, and revision of written drafts and ongoing talk with the biology instructor about the material resulted in improved comprehension of the science that was reflected in an improved ability to write and speak about biological processes. After submission of their final drafts and oral presentations, students frequently commented on the importance of talking with the biology instructor in comprehending the science surrounding their research questions.

The data from this study support other research which suggest that general communication knowledge and the critical thinking such knowledge entails can be applied in ways relevant to discipline-specific discourse. For example, in acquiring fundamental areas of communication knowledge, organic chemistry students improved their ability to engage in discipline-specific communication. Even though the conventions of oral communicative expertise vary among disciplines, this research suggests that when students acquire knowledge in fundamental communication principles, they are able to apply this knowledge in discipline-specific ways (Zohar & Nemet, 2002; Tien, Roth, Kampmeier, 2002; Palmerton, 1992). Our study reinforces this observation and also highlights the power of interdisciplinary instruction combined with students' own abilities in facilitating expertise in discipline-specific discourse and, in that process, examining and understanding the basic units of their discipline more comprehensively--a phenomenon described in communicating across the curriculum as both learning to speak and speaking to learn.

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Notes

[1] We use the concept of discipline-specific discourse simply as a way of referring to a specialized language game used by members of a particular discipline. The oral requirement for the students in our study necessitated that they demonstrate oral competence in a very specialized role, perspective, and language game. We were interested in exploring the assumption that one needs to first identify the conventions and norms of such specialized discourse as a preliminary condition for teaching students who are attempting to acquire and demonstrate competency in it.

[2] While this current paper reports the findings of our study on improved oral competence, the primary biology instructor with whom we worked initially introduced the oral component as a means of improving the written scientific document. Introducing the oral presentation was in response to the consistently high number of students' evaluation comments citing feedback in one-on-one conferences with instructors where they could talk about the biological issue and its science as the most important factor in improving their final written document. Since talking and feedback seemed to facilitate student learning, the oral component was introduced to provide students with another opportunity to talk about the science and hopefully improve the quality of their scientific writing.

[3] While the availability of individual tutoring through the Communication Lab posed yet another new variable, so few individual students (approximately 7%) utilized this additional resource that its implications seem insignificant to the overall findings.

[4] In addition to the follow-up surveys that communication faculty conducted and reported earlier in this paper, in spring 2004 the biology instructors for this course conducted their own follow-up survey to identify what students perceived as the most and least helpful sessions and assignments. Twenty-three out of the 38 students completing this survey identified the oral communication workshops as among the most useful while none of them identified it as among the least useful.

[5] It is important to note that the students in our study had the benefit of a highly supportive learning environment, including small class size, small group feedback and synergy, opportunities to practice, and highly involved biological science instructors. However, these factors had been in place for several years prior to the introduction of the oral communication workshops and PowerPoint tutorials.

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