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ABSTRACT

The purpose of this paper is to examine how the epistemology of a discipline is interactionally accomplished, acknowledged, and appropriated in a university oceanography course. Drawing from sociological and anthropological studies of scientific communities, this study uses an ethnographic perspective to explore how teachers and students came to define particular epistemological perspectives through the everyday practices associated with teaching and learning oceanography. Writing in a scientific genre was foregrounded in the teaching of this university introductory course and demonstrated how, through discourse processes in classrooms about writing in science, knowledge construction reflects aspects of disciplinary knowledge derived from scientific communities. Analysis of the data examined how social mediators between science and education position the epistemology of the discipline of oceanography. Cultural themes woven throughout the course activities emphasized epistemological issues such as uses of evidence, role of expertise, relevance of point of view, and limits to the authority of disciplinary inquiry. Class discussions about writing in science became contexts for students to question cultural norms of science and school science activities. (Contains 61 references and 3 figures.) (Author/NB)

A naturalistic study of epistemology:

Oceanography constructed through oral and written discourse

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Abstract

The purpose of this paper is to examine how the epistemology of a discipline is interactionally accomplished, acknowledged, and appropriated in a university oceanography course. Drawing from sociological and anthropological studies of scientific communities, this study uses an ethnographic perspective to explore how teachers and students came to define particular epistemological perspectives through the everyday practices associated with teaching and learning oceanography. Writing in a scientific genre was foregrounded in the teaching of this university introductory course and demonstrated how, through discourse processes in classrooms about writing in science, knowledge construction reflects aspects of disciplinary knowledge derived from scientific communities. In our analysis, we examine how social mediators between science and education position the epistemology of the discipline of oceanography. Cultural themes woven throughout the course activities emphasized epistemological issues such as uses of evidence, role of expertise, relevance of point of view, and limits to the authority of disciplinary inquiry. Class discussions about writing in science became contexts for students to question cultural norms of science and school science activities.

A naturalistic study of epistemology: Oceanography constructed through oral and written discourse

In the ethnographic study we describe in this paper, we entered as participant-observers; we began by asking "what's happening here?" and found that the writing of science by students and the talking about writing by instructors (course professor and teaching assistants) led to fertile ground for examining how questions of knowledge construction, use, and representation are interactionally communicated in teaching and learning situations. Through an iterative ethnographic research cycle of posing questions; collecting, constructing, and analyzing data; and writing an ethnography; we focused on how the writing of a scientific genre in "Geology 4: Oceanography" (an introductory university course) foregrounded questions concerning disciplinary knowledge, thus making visible an epistemology of science. Our treatment of these epistemological issues began by identifying their importance to the participants and continued through the examination of the uses of everyday language (Wittgenstein, 1958). In the discussions of epistemology that follows, we provide a descriptive account of how educational processes reflect epistemological positions.

A naturalistic perspective on epistemological issues raises a number of theoretical concerns and possibilities (Duran, 1998). Ethnography and epistemology have not had a mutually informing history in their respective development of ideas. While some ethnographic perspectives make allusion to certain epistemological positions (e.g., phenomenology), epistemology has been a form of disciplinary inquiry, largely normative, and relatively independent of anthropological and other naturalistic studies (Kim, 1988). As a discipline, epistemology has been concerned with establishing the possibility for human knowledge and the origins, scope, nature, and limitations of this knowledge (Boyd, Gasper, & Trout, 1991; Sosa, 1991). Therefore, in any instance, the particular ways knowledge is constructed, portrayed, and legitimized, do not necessarily inform the larger theories of knowledge. Nevertheless, we argue that descriptive studies of knowledge-in-use in educational settings provide a means to examine the epistemological orientations and positions instantiated in teaching practices.

The Work of Knowledge Production and Representation: Epistemology Naturalized

In a seminal essay entitled "Epistemology Naturalized" Quine (1969) called for the study of epistemology in a new setting, under the jurisdiction of the natural sciences (i.e., those disciplines that study human behavior empirically). From this perspective, epistemology would be "naturalized" as it would be oriented to the descriptive study of cognitive processes. Since the time of Quine's essay, science studies from many disciplinary homes and perspectives (e.g., sociology of scientific knowledge, anthropology of science, rhetoric of science, feminist scholarship of science) have flourished, contributing to empirically-based understandings of the knowledge and practices of science (Jasanoff, Markle, Peterson, & Pinch, 1995; Kelly, Carlsen, & Cunningham, 1993; Roth & McGinn, 1997; Tuana, 1989). Throughout the development of science studies, two central issues for science education remain underexamined: the study of education as an institution of scientific communities, and the study of the epistemology of various disciplines as manifest through the actions of participants in educational settings. Therefore, the public presentation of science in educational settings provides a unique opportunity to examine how instructors acting as social mediators position the epistemology of a given discipline. This approach develops one line of argument following the "descriptive turn" (Fuller, 1992) in epistemology: the ways educational processes frame disciplinary knowledge through the mundane, everyday activities of accomplishing "education" in a scientific field.

Empirical studies of science-in-action (e.g., Latour, 1987) show that analysis of the inner workings of the construction of scientific knowledge evince the importance of the discursive and rhetorical work necessary to establish ideas as counting as science within a particular community (Bazerman, 1988). Similarly, educational studies informed by science studies have identified ways that disciplinary knowledge is constructed interactionally through discourse and interpretative processes (Kelly, Crawford, & Green, 1997; Kelly & Chen, 1998). For example, the evolution and transformation of inscriptions--representations of phenomena typically on computer screens or as printed material--as a cultural practice of scientists has come under study by educators concerned with understanding the public nature of knowledge in science (Roth & McGinn, 1998). These studies examine the social nature of the representation of knowledge and ways that communities make decisions about knowledge production, circulation, and discrimination.

In a recent review of methodological approaches for the study of the nature of science (NOS), Kelly, Chen & Crawford (1998) proposed a framework for the descriptive, empirical study of school science as everyday practice aiming to "understand how what is taken for science is accomplished through the everyday actions of students, teachers, texts, and technologies" (p. 26). In this review the authors found that few studies considered how an epistemology of a discipline was framed, construed, and shaped by actions of actors through everyday practice. However, empirical studies of the issues surrounding knowledge production and discrimination in science offer potentially new ways of conceiving of typically epistemological questions and problems. Lynch (1992), arguing from an ethnomethodological point of view, explained what is offered by such a perspective:

> Ethnomethodology's descriptions of the mundane and situated activities of observing, explaining, or proving enable a kind of rediscovery and respecification of how these central terms [of speakers of a natural language] become relevant within particular context of activity. Descriptions of the situated production of observations, explanations, proofs, and so forth provide a more differentiated and

> subtle picture of epistemic activities than can be given by the generic definitions and familiar debates in epistemology. (p. 258)

The study of the mundane and situated activities of scientists offers ways of broadening our understanding of what it means to learn science. By viewing science as culture and practice (e.g., conventionalized ways of knowing, speaking, acting, being), the relationships of knowledge-in-use of practitioners of a trade becomes relevant to formulations of activities for newcomers (Lave & Wenger, 1991). We draw on two studies of oceanographers to illustrate these points; this choice is strategic as oceanography is the discipline under scrutiny in our empirical analysis. The close examination of practitioners' actions has proven fruitful for both the study of the microanalytic work of accomplishing experimental tasks as well as for the study of negotiating ways of making such work possible. For example, in a study of life aboard an oceanographic vessel, Goodwin (1995) explained how becoming a member in the guild of oceanographers involved knowing how to observe and see events in a particular way. Goodwin explained that as an (uninformed) observer (i.e., anthropologist, non-oceanographer) he did not see a "nice feature" (folk term) noted by the oceanographers:

> The ability to see such an event is embedded within an endogenous community of practitioners, the work of which provides a guide for seeing--interpretative structures that locate particular phenomena as relevant and interesting--and tools and intellectual frameworks that make such phenomena visible in the first place. (p. 263)

Thus, this instance represented just one aspect of what it means to be a scientist, an oceanographer in particular. As explained by more fully by Kelly, Chen, and Crawford (1998):

> becoming a scientist involves coming to see the world in a particular way; coming to understand, use, and draw upon a common body of knowledge; coming to understand how to articulate an appropriate argument given certain contexts; and coming to know how to present oneself and one's data in socially and scientifically appropriate ways. Therefore, education in science can be thought of as contributing to a process in which novices are initiated into a community of practice. (p. 24)

While Goodwin's study examined the everyday practices of scientists on an ocean vessel, Mukerji (1989) considered the relationship of scientists to state interests in their research. Mukerji documented the multiple uses of discourse processes (both written and oral) and the importance of scientists appropriately mediating their discourse for given audiences, such as recruiting expertise (e.g., postdoctoral scholars) to a particular laboratory, using citations to form alliances, and positioning authors in the rivalries found at the forefront of science. Thus, the communicative system of doing science required a range of competencies. For example, scientists needed to know how to negotiate away some aspects of their intellectual authority, due to the interests of state funding agencies, while maintaining enough intellectual autonomy to maintain credibility in the scientific community. In other interactional contexts, they needed to know how to read and write in the stylized genres of science research journals, or how to demarcate their geographical space from other research groups when competing for the same funding. Thus, scientists in general, and oceanographers in particular, use a range of discourse processes that are employed to accomplish their work as scientists and that come to define the knowledge that counts within their discipline.

One rather unexamined discourse of science is the portrayal of the various disciplines to students, whether they are new initiates to a discipline, or outsiders with a need to know about the science in question. While studies of teacher discourse in science settings have touched on epistemological issues (Carlsen, 1991; Lemke, 1990; Moje, 1997), the central foci have typically been elsewhere. In this paper, we examine the portrayal of a discipline and how through this process the epistemology of the discipline is interactionally constructed, construed, accomplished, acknowledged, and appropriated in a university introductory science course. The study uses an ethnographic perspective to study the everyday practices associated with teaching and learning oceanography in a public university. Through the process of examining the presentation of a discipline in this university setting, we demonstrate how conceptualizing science as culture and practice contributes to our understanding of the relationship between knowledge construction through discourse processes in classrooms and disciplinary knowledge in other discourse communities. The analyses demonstrate how, in any given setting, what is taken as an epistemology of science is interactionally accomplished. Thus, one aspect of an epistemology naturalized is identified: how disciplinary knowledge is presented to students.

Educational Context

University oceanography provides a unique context for studying science education. As a research site, oceanography has features as a discipline that render it potentially fruitful. Oceanography receives less emphasis than other sciences in the official science curriculum in California's public secondary schools (California Department of Education, 1990). Therefore, while students enrolled in this course had a considerable amount of secondary school science, very few had extensive experience with oceanography. Most students enrolled in the course were first-year university students and the vast majority were not geological sciences majors (oceanography's disciplinary home at the university in question). In addition, unlike other sciences like physics where much educational research has documented students' preconceptions (or misconceptions or alternative conceptions) derived from previous experience (Clement, 1982; Dykstra, Boyle, & Monarch, 1992; Halloun & Hestenes, 1985), less is known about students' (mis)conceptions in oceanography. Furthermore, oceanography is an inherently multidisciplinary science, drawing from physics, geology, and chemistry and in interaction with a number of life sciences (Goodwin, 1995; Mukerji, 1989).

The particular course under study also offered a number of unique features. The course functioned both as a terminal course for non-scientists as well a course designed to attract geological science majors. The class consisted of approximately 200 students who attended 3 lectures (offered by the course professor, third author) and one 2 hour lab session each week (led by graduate student teaching assistants). The course addressed many scientific and environmental topics of importance for political decision making and counted as a "writing intensive course" required of undergraduates at this university. This oceanography course was described as the study of "how the earth works, covering the formation of the earth and its physical features, the seafloor, ocean composition and currents, the atmosphere, and the climate." The professor's course goals included teaching students to think as a scientist, increasing students' scientific literacy, and increasing participation in the earth science major. A central focus was on "scientific thinking" that was geared to help students understand about science and become informed citizens. In support of these goals, CD-ROM technology has been created to provide students access to a rich earth data set used by practicing geoscientists.

The CD-ROM software gave students "point and click" access to real earth data. It also incorporated a management module ("Class Master"), homework answer entry (with automatic grading), and game problem modules. In addition, the students were provided with a conventional paper lab manual complete with instructions for the various section exercises. The data module provided students with enough raw earth data to solve many problems associated with plate tectonics. Plate boundary types (quakes, volcanoes, elevations, heat flow) and plate motion could be determined (island ages/hot spots) with this technology. Students accessed movies and still graphics illustrating views or facts about particular locations. More advanced studies could be conducted on slab dip and by studying more complex plate boundary configurations. More information about the CD-ROM may be found at http://oceanography.geol.ucsb.edu/.

Research Approach and Methods: Oceanography Constructed Through Oral and Written Discourse

Classroom-based ethnographies from various theoretical traditions have incorporated discourse analysis into the theoretical and analytical work of studying cultural practices in school settings (Erickson, 1992; Green & Wallat, 1981; Mehan, 1979). Discourse processes have been identified as central to culturally shaping events in classrooms and other activity systems (Bazerman, 1997; Green & Dixon, 1993). The approach we describe focuses on examining cultural actions, artifacts, and discourse processes through which group members (e.g., members of a classroom community, members of a research laboratory) construct social situations and signal to each other ways of being a group member in routine everyday events (Kelly & Chen, 1998; Kelly, Crawford, & Green, 1997).

Discourse analysis allows researchers to understand and represent how cultural knowledge (e.g., science) is interactionally accomplished through the moment-to-moment interactions of students, teachers, texts, and technologies. From this perspective, common practices and commitments (e.g., epistemological commitments, see Strike & Posner, 1992) of a disciplinary community (or "intellectual ecology" following Toulmin, 1972) are not pre-defined, abstracted, and isolated from that community. Rather, this view suggests that a social epistemology is constructed through discourse and interpretative processes of members of a group as they affiliate over time and build patterned ways of interacting with each other, with the environment, and with other communities. Discourse processes constructed as patterned activities across settings within and across communities may become cultural practices (e.g., the experimental research article as a writing genre in science, see Bazerman, 1988) that interact with and subsequently influence the construction of new situated discourse processes as they are invoked by members of a community.

As a team of ethnographers[2] we analyzed videotapes of lectures and small group sessions, student products (tests, labs, papers) and reflective essays written by the students. Analysis of the data was based on a set of analytic procedures drawn from an ethnographic research framework (Kelly, Chen, & Crawford, 1998; Kelly & Crawford, 1997; Kelly, Crawford, & Green, 1997) following a logic-of-inquiry (Gee & Green, 1998) shown in the ethnographic research cycle depicted in Figure 1. Through our data collection processes, initial observations, informal interviews, and reviews of the classroom artifacts, we identified the writing of a "technical paper" (folk term (Spradley, 1980) used by the course instructors to refer to a paper written in a scientific genre) as a central cultural practice constructed through "key speech events" (Gumperz & Cook-Gumperz, 1982) in the social construction of "Geology 4: Oceanography." The technical paper was the students' midterm assignment in which they were required to use geological data to support an argument for plate tectonics. This writing task was spoken of often by the instructors (course professor and teaching assistants), foregrounded in the "laboratory manual" accompanying the course, and was identified by the instructors as a central reason for student use of the interactive CD-ROM database technology. Therefore, as ethnographers of this community, we used this identification of the "writing of a technical paper" as a basis for our selection decisions regarding the videotaped records.

We reviewed the videotapes for weeks 2 through 10 of each lecture of the course professor and of all laboratory sessions of two teaching assistants, noting the instances when the participants spoke of, made reference to, or implicated the "technical paper." These videotaped segments were collected on a compilation tape for more thorough analysis. Each episode was labeled with a descriptive cover term. A catalogue table noting the episode cover term, date, time, speaker(s), and short description was constructed. To situate these events in the course, we constructed a timeline of these episodes over the course of the 10 week academic quarter (see Figure 2.).

The analysis of these videotape episodes consisted of mapping classroom events in increasingly greater detail at various levels of specificity (Erickson, 1992; Green & Wallat, 1981; Kelly, Crawford, & Green, 1997). Instructional conversations have an episodic nature to them, marked interactionally by the members of the classroom (Kelly & Crawford, 1996; 1997; Lemke, 1990; Mehan, 1979). Thus, as researchers, we identified potential boundaries of activity and reviewed the videotaped records to create time-stamped transcripts of the actions and discourse of the participants. This approach utilized the interactional markers to segment a conversation for analysis purposes and, in doing so, defined a set of units for analysis of varying degrees of specification. In Figure 3, we show three levels of analysis (phase units, sequence units, and transcribed talk) used in creating an event map.

A <u>phase</u> of activity represents concerted and coordinated action among participants, reflects a common focus of the group, and can be identified by the content of the actors' talk (Green & Wallat, 1981). For example in Figure 3 the phase unit is labeled "Goal of midterm paper: Do what scientists do." The representation of this phase unit includes line numbers; time (from time-stamped videotape records); sequence units (see below); and research notes and "transcribed talk." In this case the professor of oceanography is delivering a lecture to a large class (approximately 200 students). He is providing a rationale for his assignment of "writing a technical paper" as a course midterm assignment. The phase was introduced with the professor orienting the class to the topic: "There's a lot of possible ways you could go on this midterm paper" (Figure 3, lines 101-102). This cued the students, but also us as researchers, as to the onset of a new phase in his lecture. The interactionally marked end of the phase involved the professor saying "OK uh waves" as he walked away from the open space of "explaining science" in the middle of the lecture platform, to the more "content oriented" podium where he had his overview slides for his lecture.

Within each phase, participants structure conversations and cue each other through their interactions. As researchers we used these cues to mark cohesive or thematically-tied interactions, each labeled as a sequence unit. To identify these sequence units, as for the phase units, we considered the thematic content of the speakers' talk as well as cues to contextualization (e.g., intonation, stress, phrasing, pause structures, physical orientation, proxemic distance, and eye gaze (Gumperz, 1982, 1992)). For example, the sequence units comprising this phase unit labeled "Goal of midterm paper: Do what scientists do" are represented in column 4 of Figure 3; that is, the professor's description of what scientists do was comprised of a set of sequences of talk, labeled by us by topic: "struggle of scientists," "personal experience of not understanding what the data means," "actions students should take," and "identifying and explaining a problem."

In the far right hand column of Figure 3, research notes are represented in italics and transcribed talk from the professor's lecture are represented in quotation marks. This form of representation allows a researcher to get a sense of how a particular segment of talk fits into a larger set of actions and discourse processes. In this case, the professor can be seen as presenting certain practices of oceanography as a discipline. He explained that science is a struggle (lines 106-107), the difficulties he has faced doing fieldwork (lines 108-112), and that students should not feel alone or dumb if they do not understand right away (lines 113-114). At time 00:02:51 he began a sequence concerned with identifying and explaining a (scientific) problem. In this case, like some of the others, a direct quote is included in the research notes. By including the quote, the researcher can read the particular way that the notion of identifying a problem in science was conversationally accomplished. The professor suggested that "Part of doing science is to figure out kinda (winnow) out what can I explain and what can't I explain" (lines 121-123). In this case the professor offered insight into the practices that constitute doing science from his perspective. He continued, “What's an interesting problem or what's an interesting thing to explain or what uh you know when when a scientist does research, one of the talents you have or has to be developed is knowing first off what's an interesting problem to study” (lines 123-126). In these examples, the professor helped shape an epistemology of his discipline by drawing from his personal experience as a scientist and offering suggestions about how to think about doing science.

In sum, interpreted through discourse analysis, this lecture episode can be seen to present to students a particular portrayal of scientific practices and dispositions. We completed similar analyses with event maps for all the videotaped records selected for detailed analysis (27 episodes totaling approximately 2 hours). Through this process we began to identify common themes and patterned practices. In order to systematize these initial findings we constructed a set of domain analyses. Spradley defines a cultural domain as “a category of cultural meaning that includes other smaller categories” (p. 88). Domains are comprised of three elements: a cover term, included terms, and a semantic relationship that specifies the ways that the included terms are a set within the broader category denoted by the cover term.

Recently, the use of domain analyses has come under criticism by linguists (e.g., Gilbert, 1992) and anthropologists (e.g., Lave, 1988) concerned with uses of language. Gilbert (1992) questioned the assumptions about language informing such analysis, arguing that the construction of cultural domains by researchers presupposes language used by particular cultural groups as having static, transparent, and discrete meanings. He further argued that use of domains by researchers fails to appreciate the socially negotiated nature of meaning (p. 45). Similarly, Lave (1988) noted that cognitive anthropology risks reifying fluid and ever-changing negotiated meaning. Her concern was about a potential overspecification of culture by language. The rationale and use of domain analysis for this study is not to specify the discrete and static meanings of the participants' language, as if that were possible or even suggested by cognitive anthropologist such as Spradley (1980).

Rather, as described by Coffey and Atkinson (1996, p. 90), we aim to use this analytic strategy to identify the patterns and systems of the everyday language of "Geology 4: Oceanography" as a mechanism to understand the cultural knowledge as interpreted through discourse processes (both oral and written) of this particular social group. We took an approach to this analysis following Emerson, Fretz, and Shaw (1995):

> the ethnographer is concerned not with members' indigenous meanings simply as static categories but with how members of settings invoke those meanings in specific relations and interactions. (p. 28)

Through analysis of the event maps (like that portrayed in Figure 3), through multiple viewings of the videotape record, and through analysis of the written "laboratory manual" (cultural artifact), we identified and constructed 10 cultural domains. In each instance, we attempted to use as many folk terms as possible in order to capture as best as possible the indigenous meaning of the participants. For the purposes of cross reference and cataloguing, we noted the speaker(s), date, and time on the compilation tape. This allowed us to review the original data and make comparisons across instances. This approach is consistent with critical issues for microanalysis of interaction identified by Erickson (1992): identification of the full range of variation and establishment of the typicality of each instance across the range of diversity.

After completing the domain analyses, we grouped the domains into three broader categories: those focused on writing in science, those focused on scientific practices, and those focused on social responsibility and science. These were not entirely mutually exclusive. See Appendix for complete listings of cultural domains. Four domains were included as being concerned with writing in science: ways to write in science, ways to distinguish scientific and technical writing, reasons for writing as a scientific practice, and kinds of student concerns about writing scientific (technical) paper. Four domains were grouped as centrally concerned with scientific practices: kinds of scientific practices identified by the social mediators, ways to distinguish observation and interpretation in science, characteristics of doing the work of scientists, and kinds of scientific norms (and counter norms) identified by the social mediators. Two cultural domains were considered under social responsibility and science: kinds of social, political, and economic ramifications of science and attributes of socially responsible use of science/scientific knowledge. In summary the 10 domains, organized into four broader categories, can be represented as follows:

Domain categorical summary:

- Domains concerning writing in science:
  - ways to write in science
  - ways to distinguish scientific and technical writing
  - reasons for writing as a scientific practice
  - kinds of student concerns about writing technical paper
- Domains concerning scientific practices:
  - kinds of scientific practices identified by the social mediators
  - ways to distinguish observation and interpretation in science
  - characteristics of doing the work of scientists
  - kinds of scientific norms (and counter norms) identified by the social mediators
- Domains concerning social responsibility and science:
  - kinds of social, political, and economic ramifications of science
  - attributes of socially responsible use of science/scientific knowledge

As an example of the ways a cover term denotes a broader category of included terms, we will present two of the included terms that were grouped *as a characteristic of* (semantic relationship) "doing the work of science/work of scientists" (cover term). (We refer readers to Appendix for complete set of included terms for all domains.) These examples are taken from the phase of activity represented in Figure 3. Starting on line 115 the course professor presented his view of "doing science as scientists do." We included this in the domain analysis, using the phrase "turn over and struggle with concepts, talk with others" as this was paraphrased from his description. Another entry for the domain "doing the work of science/work of scientists" was taken from the section of the laboratory manual titled, "scientific writing and communication." The included terms were taken from a sentence that read, "Real science involves dealing with messy inconsistent data, figuring out the best explanation from a choice of competing and sometimes conflicting possibilities, and arguing with other researchers who may prefer completely different interpretations of the same data." These two examples, and the others included in the domain, were grouped for analytical purposes and summarized in the organization of domains. The meaning of each included term(s) cannot be understood merely by reviewing these summaries. Rather, the summaries were analytically useful for us as researchers as we identified broader themes cutting across different events and texts throughout the course.

Results: Identification and Description of Cultural Themes

As class members participated in common activities and oriented to the task of writing the "technical paper" they came to define sets of beliefs and assumptions about science, scientists, and the work of doing science, including the writing of science. These activities led the course instructors and students to make public a set of assertions about how science was construed in this course. Through their actions, and oral and written discourses of science, the participants established patterns in the ways they went about accomplishing the work of constructing "Geology 4: Oceanography." By examining our cultural domains, we identified these recurrent patterns in the participants' actions. These patterns are considered cultural themes by anthropologists such as Spradley (1980) who defined a cultural theme as "any principle recurrent in a number of domains, tacit or explicit, and serving as a relationship among subsystems of cultural meaning" (p. 141). The ethnographer's role is to make explicit these cultural themes of the group under study through consideration of the ways culture is comprised of a system of meaning integrated into a larger pattern.

In reviewing the domain analyses and the primary data sources, we considered recurrent patterns in the ways the instructors and students spoke of science and of writing, plus the connections between the two. Through these analyses, the mediational role of the instructors who brought knowledge and practices from their scientific communities to the students became apparent. This mediational role made apparent to us as researchers the ways that the discipline was being framed. In articulating their experiences and knowledge of scientific communities' knowledge and practices, the instructors served as social mediators between oceanography students and oceanographers (Kelly & Green, 1998). We identified three themes associated with these social mediators' portrayal of science. In addition, we identified one theme constructed from students' inquiries about social mediators' portrayals of science. We now turn to our description of the cultural themes and how they cut across the different domains.

The first cultural theme constructed from social mediators portrayal of science can be stated as: Written knowledge is discursively shaped through negotiated meanings of rationales, procedures, and norms. Across events of the course, and as represented in the cultural domains, there was evidence of the discursive work necessary to construct the writing of science in particular ways. The instructors and students needed to talk about writing in science through recounting personal experiences, through exemplars of scientific practice, and through preparatory experiences (such as writing observations at a local beach), among other means, in order to achieve some level of intersubjectivity. Descriptions and examples, explanations and confusions, questions and responses offered means for the writing of technical paper to become a scientific practice from both the instructors' and students' perspectives.

Three points of confluence for the discursive shaping of written knowledge were rationales for writing in science, procedures for writing science, and norms governing scientific activities associated with writing. Students were offered reasons why writing is important in science and why learning to write scientifically is useful. For example, in order to provide motivation for the uses of the interactive CD-ROM database technology, the instructors described how writing was central in efforts to persuade agencies and individuals of the importance of one's scientific research and secure funding for continued research. For example, in the lecture of October 25 the course professor, explained his personal difficulties writing science eventually suggesting that "You know you really think a lot of how to communicate your ideas when you're asking for money." In addition, other issues of audience, such as using texts to persuade other scientists of the validity of one's work through uses of evidence, were presented as central to scientific activities. Thus, the negotiations with state funding agencies described by Mukerji's (1989) study of the field of oceanography and the particulars of recognizing and describing instances of events in science described by Goodwin's (1995) study of oceanography aboard a vessel were evident in the ways the discipline of oceanography was portrayed to students.

A second example of discursive shaping of written knowledge concerned the particular procedures for writing a technical paper in science. The students were given a template with various sections, each with an accompanying description about what would count as an instance of "introduction," or "observation," etc. The format of a technical paper was presented in the course laboratory manual and was to include sections labeled: abstract, introduction, methods, observations, interpretations, conclusions, figures and captions, references[2]. Students were instructed to use diagrams, figures, and other data representations (i.e., inscriptions, Roth & McGinn, 1998) as evidence for their scientific argument. The particular convention of uses inscriptions as intertextual links (Bloome & Egan-Robertson, 1993) was evident not only in this study, but across many studies of scientific activity where the uses of inscriptions are central to intersubjective understandings

(Roth & McGinn, 1998). An example from this course of the disciplining of writing through the use of inscriptions was offered by Earl, one of the teaching assistants, who explained to his students the relationship of ship track lines and the sea floor. telling them that "This is what geologists do." The disciplining of student writing to include inscriptions in their arguments, and the students' questions and concerns about such use, is a representative case of how disciplinary practices were communicated through discourse processes.

A third way that written knowledge was shaped was through consideration of norms of scientific communities. Scientific writing was presented as requiring justification, citation, and use of inscriptions. These conventions were portrayed as essential elements to writing science. Another teaching assistant, Karen, explained to her students, "make sure you do cite all your references. If you take information from your oceanography text, or these [holds up nearby books] ... Make sure you cite them in the appropriate form." As the uses of citation were offered as normative goals, students could be seen as questioning how these norms would be manifest in the details of their writing. Although for this paper we did not complete an extensive textual analysis of the students' papers, their classroom conversations oriented their writing toward adherence to these conventions.

The second cultural theme constructed through social mediators' portrayals of science can be stated as: <u>Writing is a means to distinguish science as disciplinary inquiry</u>. Both in formal written documents and spontaneous discussions with the students, the course professor and teaching assistants used contrasts to signal the epistemological differences defined by their discipline. One primary means to distinguish science was to draw attention to differences in uses of evidence across audiences. A point of contrast was with the differences between arguments made by scientists and those of a famous radio talk show host. In this case, the course professor suggested that for issues such as global warming, the scientific community had multiple voices and differences of opinion. While scientists were portrayed as having some evidence for global warming, it was suggested that other scientists had different interpretations and that the position of the professor should be taken as just one position: "I'm giving you a certain viewpoint of information. And what I'd like to teach you uh if you come away with anything from this class is recognize that I have a viewpoint and don't trust it. Find other people.... But but find other viewpoint. Compare them. And then you're gonna make your decision." As a point of contrast, the professor read from The Way Things Ought to Be (Limbaugh, 1992) demonstrating the insinuative language and strength on conviction:

> Mount Pinatubo in the Philippines spewed floors [flourocarbons] more than a thousand times the amount of ozone depleting chemicals in one eruption than all the fluorocarbons manufactured by wicked diabolical and insensitive corporations in history. Mankind can't possibly equal the output of even one eruption from Pinatubo, much less four billion years worth of them. So how can we destroy ozone?

The professor treated Limbaugh's claims as worthy of consideration and offered a point of view on the current scientific evidence concerning the atmospheric effects of the Mount Pinatubo eruption, citing a 1993 article in Science (Minnis, Harrison, Stowe, Gibson, Denn, Doeling, Smith, 1993). The contrast was not to show differences in the inherent validity of the respective assertions (i.e., scientists got it correct, Limbaugh got it wrong), rather the example demonstrated the differences in the critical stance of the observers: scientists consider evidence in light of a multitude of factors recognizing the limitations of their interpretations, radio talk show hosts less so.

A second way writing provided a means to distinguish science as disciplinary inquiry concerned comparisons and contrasts of "technical writing" required in science with other forms of writing. The first class assignment was an observation exercise at a local beach. In framing this activity in the laboratory manual, the course professor made comparisons with a courtroom trial. The comparisons served to show how, much like in a courtroom, the students were to "paint a big picture" and support this with the presentation of evidence. These comparisons framed writing observations in science as an activity of persuasion, rather than a telling of indubitable facts. Technical writing is described as a genre that uses figures, tables, and pictures in an effort to lend credence to an observer's case. The use of scientific writing as a specific genre was similarly invoked by a teaching assistant, Karen, in her attempt to assist the students' understanding of the norms for writing in science. She compared science writing to "English major type style" and in another segment asked the students to "compare what is the differences between say an English paper writing you know or a like you're making short story (or something) between scientific writing. What are the differences." Later in the transcript, Karen explained her view that scientific writing required adherence to a specific format, is prepared for a specific audience, and is concerned with the subject matter of science (i.e., the students' paper topics).

A third way in which writing served to distinguish science as a form of disciplinary inquiry was the use of observation/interpretation distinctions. In the description of technical writing presented in the laboratory manual and in eight different videotaped episodes from class sampled for analysis, the course instructors drew distinctions between observation and interpretation. Observations were portrayed as the "raw input" and "just the facts." Observations were explained as generally quantitative in nature; including details such as lengths, directions and geological features; and what "everyone would agree on" (cf. Quine, 1969). Interpretations were portrayed as more personal, as derivative of observations, as explaining observations, and as supported by observations. Although the students were provided with examples and the distinction was discussed in numerous occasions, this distinction remained difficult for them to make (see the fourth cultural theme described subsequently).

As ethnographers, the case of observation/interpretation distinctions represents an example of how insider knowledge (of scientists) can be impenetrable for newcomers (students) and how it is often learned through practice, rather than stipulative definitions (Lave & Wenger, 1991). At first pass a clear separation of observation and interpretation may seem difficult to make in any definitive manner, especially given arguments from philosophy of language about meaning in use and its connections to different purposes and "forms of life" (Wittgenstein, 1958).. Yet, from an ethnographic point of view, the scientists used "observation" in particular ways to count as a particular discourse practice. Thus, in order to do science as our participating scientists sought to do science, students needed to understand the indigenous meaning of observation and know how to use it appropriately. Similarly, the scientists portrayed interpretation as differing from observation and marked this difference as socially significant. Therefore, part of the process of coming to know how to think like an oceanographer (in this case) was to understand how scientists made such distinctions and subsequently how to write these into a technical paper with scientific data.

The third cultural theme constructed through social mediators' portrayals of science can be stated as: <u>Citizens have a responsibility to understand the importance and limitations of science including an awareness of sources of knowledge, uses and limits of expertise, and norms for practicing science</u>. One way this theme was manifest was in the talk and actions classified in the domains (see Appendix) concerned with the social, political, and economic ramifications of science and the socially responsible use of scientific knowledge. However, this theme can be seen in other discourse processes grouped in other domains. The political ramifications of science and technology were tied in the classroom conversations to appropriate uses of knowledge by scientists and citizens. Examination of the laboratory manual as a cultural artifact identified how oceanography was explicitly connected to, and seen as impacting, public policy. Numerous examples of this were brought up in the conversations among the teaching assistants and students. Local examples such as the impact of the construction of seawalls on the coastal environment were used to show how science can contribute to debates in the public forum. Cross national issues such as large scale fishing and residence time for artificial gases were used to explore how science contributes to environmental degradation. However, the teaching assistants were careful not to over simplify. They tied such issues to the complex interests of a society at large and to the particular interests of scientists who want research jobs.

A second way the theme of citizen responsibility for understanding and using scientific knowledge was manifest involved discussion of issues of expertise, point of view, audience, and limits to knowledge. Although the oceanography instructors described science as grounded in evidence as opposed to unsupported beliefs, they were careful not to canonize science and scientists. The students were asked to consider multiple points of view, to be suspicious of unsupported arguments from any source, to identify sources of information and authors' points of view, and to be skeptical of any one person's position, including the course professor. In addition, the teaching assistants mitigated against simplistic epistemic distinctions between science and other ways of knowing by identifying ways bias and sources of funding influence the construction of scientific knowledge. For example, while Karen made the distinction between quantitative and qualitative observations, favoring quantitative for "scientific" observation, her position was not one of ultimate faith in numbers. In discussing the science of fish counts and their relationships to industry, she cautioned about what numbers say:

> It's hard ta-it's you hafta [have to] take numbers and data with with a grain of salt. You hafta [have to] look at how they might be skewed, uh and with the numbers you know a lot of thi--with this, um stu-you know with the studies that are done there's a lot of estimation because it's hard to go run around the ocean and count fish.

Thus, in sum, the picture painted of scientists and the ways they practice their craft was a complex one without clear cut answers. The complexity of the portrayals of science led us to consider how the students reacted to this complexity and in particular, how they sought to appropriate those scientific practices necessary to complete their writing assignment of a technical paper following a scientific genre. This leads to our fourth cultural theme.

The theme constructed from students' inquiry about social mediators' portrayal of science can be stated as: Talking about writing is a way for students to question cultural norms of science and school science activities. Analysis of participants' discourse reveal that the task of writing a technical paper as a cultural practice in science was unfamiliar to many of the Geology 4 students. Their confusion and uncertainty about the technical paper could be seen through the mutual exchanges of dialogue with their instructors and each other during weekly discussion sections. Students questioned a range of issues related to scientific writing, including topics such as the purposes of scientific writing, procedural aspects of constructing texts that count as scientific, ways of representing research methods embedded within a larger argument, and ways creativity was consistent with the disciplined ways of writing in science. The examples below draw from the summaries of discourse processes presented in the student concern about writing technical paper domain in the Appendix.

The purpose of writing a scientific research paper of the sort described by the instructors was not immediately recognized by the students, with the exception of the obvious reason that this is what was required to receive course credit. The intellectual purpose for writing a technical paper in science posed problems for many students. This may reflect the diversity in the various disciplines comprising science, each of which embodies cultural practices specific to a relevant community of knowers. There are multiple purposes for writing in science (Kelly & Chen, 1998; Mukerji, 1989) which are not necessarily mutually exclusive of one another (e.g., as a means for interpreting data, to persuade funding agencies to allocate grant money, for the advancement and distribution of knowledge). Understanding the purposes for writing a technical paper required cultural knowledge for which the students only began to understand through their experiences with the course and course instructors. Therefore, the discourse around and about the writing of science by the students and instructors provided a means for exploring how and why scientists need to write to accomplish their everyday tasks.

Other student questions about writing a technical paper involved the construction of the actual texts, such as whether or not to use a title page or footnotes, what information to include in the methods section, how to include pictures in the text, and what word processing program to use when typing up the reports. Although at initial glance, these questions may appear to be trivial or tangential to the substantive issues of competently communicating knowledge through writing in science, we provide a different view. We interpret student inquiries of this sort as reflecting their conceptions about scientific writing. Students' questions about the writing procedures reveal their understanding of the multiple contingencies involved in writing a technical report. Analysis of participants' discourse showed that students view scientific writing to be different than other types of writing. The talk about writing showed that students' previously known practices from other writing contexts were not transferable to science writing. For example, the use of footnotes and title pages were discouraged for the scientific genre expected in this course. The questions about footnotes were not just procedural detail, although they were often brought up for the purposes of understanding the writing procedures. Rather, structural features such as use of footnotes and associated uses of parallel texts, do more than frame the form of the knowledge; such features shape what knowledge counts as science and how it can be represented (Bazerman, 1988).

Students' also posed questions about how to write descriptions of their research method. As described previously, the course instructors offered a complex picture, one showing the need for rigor in science, but also one that recognized the role of bias and point of view. In providing such a view of the complexity of science, the problems facing students regarding method may have been magnified. For example, the recommended "methods" section in the technical paper required descriptive writing; some students recognized the need to include specific information, but were unsure as to what kind of information to include. Their unfamiliarity with having to support their claims with data was suggested through students' questions about how to use figures in the text of their reports.

A final example of how talking about writing among the course participants offered students means to question the cultural norms of science and school science activities is found in the discussions concerning creativity and its place in scientific writing. In this case, the analysis of the data suggested a discrepancy between how Earl (TA) and Bill (Professor) viewed creativity in scientific writing as compared to how Karen (TA) perceived it. Throughout the presentation of writing technical papers, the course professor continually emphasized the need to be "straightforward and clear," but that authors needed to "capture their [readers'] imagination and interest." Earl expressed a similar view, using the notion of creativity by telling his students that "technical writing is a real artform" and that one needs to be concise in her or his descriptions. From their perspectives, there is a certain level of skill and creativity in scientific writing. On the other hand, Karen made it explicit in her section that scientific writing is not creative, when compared to "English paper writing" for example. She described to her students that they should get "practice in writing in a scientific way," a way that is different from short stories of English papers that are usually more creative. Therefore, scientific writing was presented as involving creativity in order to express oneself in an appropriate manner relevant to the scientific community, but the writing itself was not to be creative in the sense that the descriptions should be fictional or decorative. Talking about writing therefore provided a means for students to understand the cultural practice of technical writing in science.

Discussion

Our ethnography provided a means for us to document how the epistemology of oceanography was constructed, portrayed, and construed through oral and written discourse in an introductory university course. The details of the mundane everyday activities of teaching and learning about writing in science provided many examples of how epistemological issues run through many educational events. This course may have been unique in its explicit emphasis on knowledge use and display by students and teachers, rather than display by teachers and assumed appropriation by students. Nevertheless, the emphasis on writing as a scientific practice and its relation to values in science provided fertile ground for exploration of education and epistemology, issues to which we now turn.

Educational Issues

The themes woven through the discourse processes of this university oceanography course provided the students with particular visions of science. Through discussions centered on writing in science, the course participants framed an epistemology of their discipline as one that considered the socially constructed nature of science (e.g., issues of funding, audience, economic and political ramifications), expertise (e.g., considering speakers' roles in framing arguments), evidence (e.g., supporting conclusions with an evidential base), and responsibility (e.g., citizens' role in the use and understanding of scientific knowledge). This is an important dimension for university (and other) science teaching: The discourse processes, the ways that science is spoken of, provide a means for communicating the substantive content of science as well as communicating messages about science (Carlsen, 1991; Cunningham & Helms, 1998; Kelly & Crawford, 1997). The importance of this dimension of science teaching can be illustrated through comparisons with other discourse analytic studies showing science to be portrayed as unassailable facts and laws of nature (Cochran, 1997; Moje, 1997). For example, through ethnographic analysis of a university organic chemistry course, Cochran (1997) found that reliance of lectures and texts as sources of information led to the production of school science that promoted ways of succeeding in the course over ways of understanding the principled knowledge of the discipline. Science, in this case organic chemistry, was positioned as a discipline comprised of content and product, with verifiable, objective answers.

The positioning of writing science in oceanography in relation to other disciplines and other discourses answers one of our original questions concerning ways that ethnographic studies of classroom practice inform understandings of disciplinary knowledge. As a site for knowledge construction and re-presentation, university science represents a location for examining how disciplines portray themselves both to potential new members as well as to likely outsiders of the community of practicing scientists. In this case, the practice of doing science was portrayed as connected to a multitude of values and commitments. The scientists identified norms for conduct in science, but also offered insight into the actual "ways things get done." The emphasis on the importance of the use of evidence was similarly balanced by descriptions of making the best interpretation, given the contingencies of the particular situations. These events, constructed through discourse, reveal ways the discipline interprets itself through the eyes of practicing scientists -- university scientist (third author) and geoscience graduate students -- and the ways these interpretations are communicated to others.

Epistemological Issues

Our examination of the discourse processes of a particular university science course led to considerations of the uses of knowledge. The epistemological implications of this study need to be specified through the identification of two notions of epistemology. The first notion is of *an* epistemology of science (e.g., of oceanography) as reflected in particulars of the presentation of knowledge in a university course. The second is epistemology as a field or discipline concerned with the origins, limitations, and justification of knowledge. We provided a research methodology and a particular example of the first notion. However, Quine (1969) was referring to the second notion, epistemology as a field of inquiry, when he proposed it become a branch of the natural sciences.

The first notion of epistemology is one that can be characterized through empirical evidence. It is unremarkable to suggest that teaching methods, discourse processes, and scientific conventions entail certain epistemological assumptions. Ways knowledge is presented and represented; modeled and appropriated; constructed, deconstructed, and reformulated are underwritten by certain beliefs and ways of doing business that presuppose notions of evidence, inference, reference, and theory. Therefore, our anthropological perspective on the presentation of science to new initiates specifies aspects of epistemology that can be only known through empirical evidence (Lynch, 1992). This case provides an example of how epistemological issues are embodied in the discourse of scientists and students.

The second notion of epistemology requires serious consideration concerning the usefulness of empirical investigation. It would be presumptuous of us to suppose that any one empirical study would resolve long standing issues concerning the nature of knowledge. Nevertheless, the descriptivist turn in philosophy lends some credibility to consideration of studies of knowledge in use. Boyd (1992) suggested that programs of research in the philosophy of science (typically treated as "philosophical packages" that include notions of semantics of theoretical terms, nature of explanation, metaphysics) need to adhere to the same kind of rigors as the sciences of its subject matter. Boyd's naturalistic recommendation on philosophical method offered a view of the interdisciplinarity suggested by such a perspective: "philosophical packages should be thought of as including, in addition to distinctly philosophical doctrines, suitable versions of the findings of the various other disciplines with which philosophical inquiry overlaps" (p. 163). Thus following Boyd, epistemology as a field of inquiry, and as related to science in particular, would need to interact in a coherent manner with empirical investigations of the natural and social worlds. Educational settings provide one of many sites for such naturalistic investigations: The description by scientists of their scope of inquiry, their justification schemes, the limits of their knowledge, among other issues, provides a means to compare their explanations and portrayals of knowledge with their uses of knowledge in their daily work (not explored in this study).

Epistemology and Education

Identification of definitive demarcation criteria of science from other ways of knowing eluded the positivists -- science could not be shown to be based exclusively on empirical content absent of metaphysics (in the positivist pejorative sense). Developments in science studies, particularly the strong theory-dependence of scientific methods identified in philosophy (e.g., Kuhn, 1996; Boyd, 1985), and the problems of experimentation identified in sociology of science (e.g., Collins, 1985; Knorr-Cetina, 1995), make clear distinctions between science and other knowledge difficult and potentially ideological (Toulmin, 1982). Furthermore, educators such as Lemke (1990) have pointed to the portrayal of science in schools as epistemologically unassailable as a reason for students' alienation from the subject matter. Yet, taken across multiple instances, scientific communities produce knowledge that is more instrumentally reliable (i.e., yielding accurate predictions about observable phenomena, see Boyd, 1991) than just anyone's personal opinion, regardless of the relative popularity of each on commercial radio. Science teachers are thus faced with the task of socializing students to particular practices, of enforcing certain criteria for uses of evidence, and of identifying and acknowledging the limits to scientific knowledge. All this is to be accomplished while considering students' ideas, valuing their point of view, and respecting them as persons (Strike & Soltis, 1992).

To teach anything that might reasonably count as science, that is, to provide opportunities for students to understand the communal knowledge and cultural practices necessary to act in socially appropriate ways, educators need to make certain epistemic distinctions, lest students view just any idea from a popular charlatan as epistemologically secure as relatively well-confirmed scientific theories. Our argument is that the epistemological position of science in the discourse of education can be better understood through naturalistic studies that document the ways science is portrayed in school and provide examples from which normative goals can be set and reframed. Thus, to have faith in the instrumental reliability of scientific knowledge is not to adhere necessarily to a discourse of hegemony; rather it is to assess the relative contribution science can make to the pragmatic needs of members of society given varied purposes (Rorty, 1991).

Conclusion

In this paper we have developed a line of argument related to the interactional construction of scientific practices. We have provided one example of how, through systematic methodological procedures, perspectives on the portrayal of an epistemology of science, conceived by course instructors and constructed jointly with students through written and oral discourse, can contribute to an understanding of how science is characterized in educational settings. By bringing to the fore certain aspects of science and ways of doing science, the instructors framed their discipline and offered their students a means to explore the norms and practices suggested in these pedagogical activities. However, the limits of the value of this study are clear. The epistemological positions of any small number of scientists may not reflect and need not inform a full range of issues for normative theories in epistemology.

Footnotes

1. As the third author created and taught the course, he was purposefully not involved in the ethnographic analysis. His contributions to the educational research were made after the completion of the domain analyses and the identification of the cultural themes.

2. An alert reader will notice that the general structure of this educational research paper, following the conventions of the American Psychological Association (APA) publication manual, varies only slightly from the scientific technical paper described to the students in their laboratory manual. For a review of the epistemological orientation of the APA manual, see Bazerman, 1988.

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Figure 1. Representation of the logic of inquiry for study. Shown are the kinds of research cycles of inquiry processes, not a replication of exact procedures.

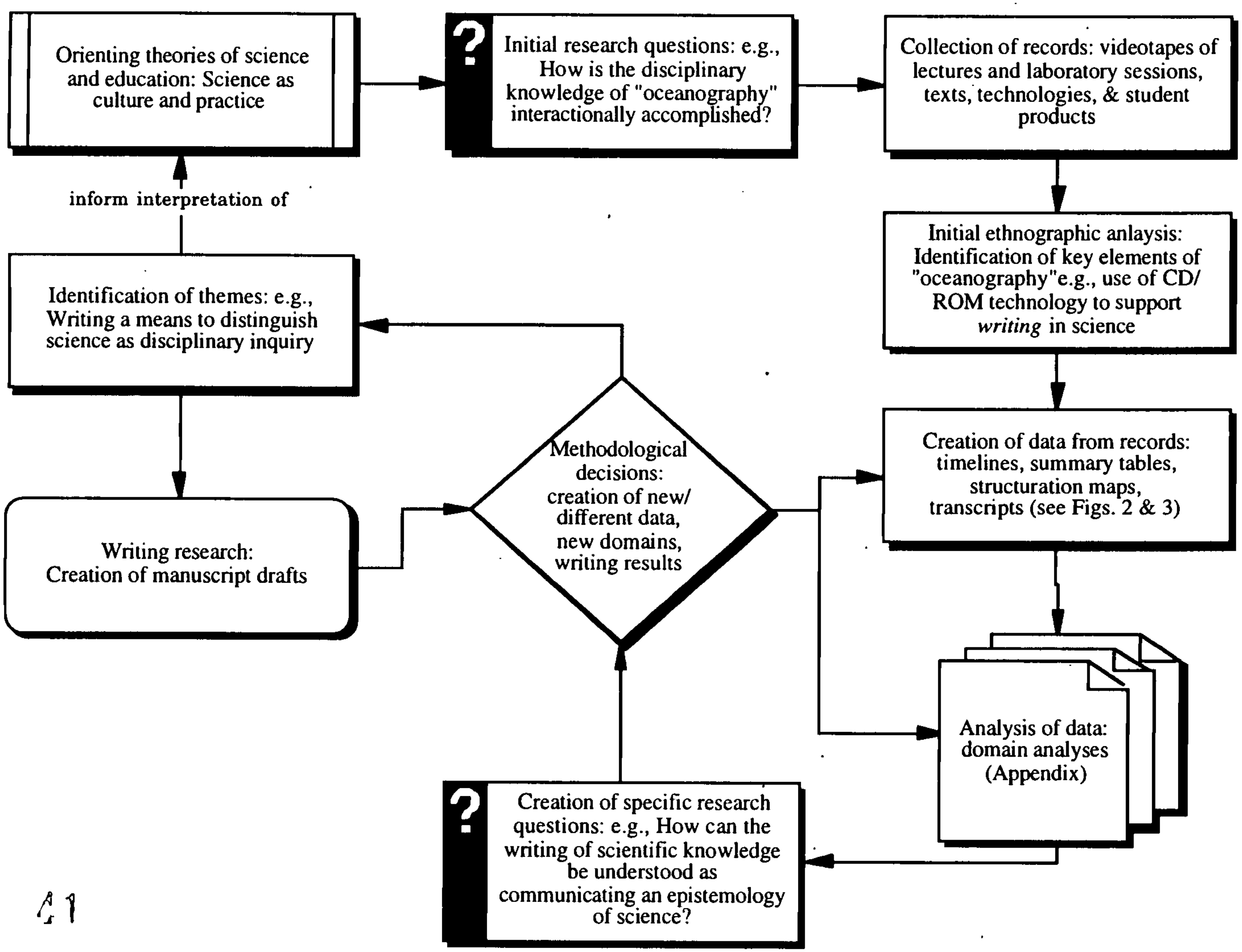

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Figure 2. Timeline situating episodes chosen for detailed analysis over the course of "Geology 4: Oceanography." Included in this table are the video segments identified for detailed analysis, the date the episodes took place, a cover term naming each episode, and a short description.

VIDEO SEGMENT	DATE	EPISODE	SHORT DESCRIPTION
		Week 1: Negotiating entry - - no videotaping	
		Week 2: Scientific writing and communication	
1	10/12	Students working in groups	TA_1 explains how to do a peer group evaluation. Uses observation process of scientific method as analogy.
2	10/12	Qualitative vs. quantitative observations in science writing	TA_1 explains beach assignment as observation exercise: qualitative data contrasted with "numbers."
3	10/13	Observation & writing	TA_1 contrasts "English paper" with science writing. Intros. idea of genres of written discourse. Starts with observations: suggests qualitative vs. quantitative differences, importance of audience.
		Week 3: Maps and profiles	
4	10/17	Observation/Interpretation & writing	TA_2 starts with student's writing, looks at observation/interpretation distinction.
5	10/17	Doing science -- Geology	TA_2 uses real data of ship track lines, makes explicit "what oceanographers do", i.e.. they try to find features.
6	10/20	Reading and writing lab notebook	TA_1 stresses need to make outline of the midterm paper before writing, as is recommended in the lab manual.
7	10/20	Citation & credit: using other's work	TA_1 discusses sources for the paper. Credit must be given for data source.
		Week 4: Exploring the deep	
8	1023	Technical writing: "What scientists do"	Prof explains importance of writing. Uses examples from personal history as scientist, scientific problems, data, and doing science.
9	10/25	Writing, using data, role of audience	Prof explains writing process, importance of revision and consideration of audience.
10	10/25	Power of written language	Prof uses (mis-)quote to valorize writing and power: "pen is mightier than the sword."

Figure 2 (continued, pg 2 of 3) Timeline situating episodes chosen for detailed analysis over the course of "Geology 4: Oceanography."

VIDEO SEGMENT	DATE	EPISODE	SHORT DESCRIPTION
11	10/27	How to make an observation & interpretation	TA_1 suggests a cause and effect relationship for the observation/interpretation dichotomy. One is needed for the other; "use observation to make interpretation."
Week 5: Sediments and sediment transport			
12	10/27	Map as observation	TA_1 brings up the crucial question of how to find data. Purpose of using "tools" is to find evidence for plate tectonics. Data then become part of the process for making this argument. The necessity of "proof" is invoked here.
13	10/27	How to display data in the paper	TA_1 discusses layout of "technical paper." Tries to make explicit how data should be organized to make argument.
14	10/27	Mechanics of writing science	TA_1 discusses the "details" of the technical paper: illustrations, references, citation form, footnotes.
15	10/27	More mechanics of writing science	TA_1 addresses students' software and documentation questions, how to reference map points and use coordinates.
Week 6: Waves and beaches - - no reference to technical paper			
Week 7: Earth's heat budget			
16	10/31	Nature of the midterm paper	TA_2 compares technical paper with journal article, magazine and Ph.D. thesis. Here graphics are good, but content is better, according to TA_2.
17	11/03	What geologists do with rocks	TA_1 explains sediments and their impact on the coastal environment.
18	11/03	More reasons for studying rocks	TA_1 describes that the movement of rocks pertains to oceanography; also the human impact on coastal environment..."that's what geologist's do."
19	11/15	Social/political use of scientific data	Prof takes issue with Rush Limbaugh's use of scientific authority in political discourse.
20	11/17	Sources of data: Mt. Pinatubo & Rush Limbaugh	TA_1 makes argument about natural sources of atmospheric gasses and human produced gasses: chlorine in the atmosphere. Limbaugh's data as flawed and a cautionary tale.

Figure 2 (continued, pg 3 of 3) Timeline situating episodes chosen for detailed analysis over the course of "Geology 4: Oceanography."

VIDEO SEGMENT	DATE	EPISODE	SHORT DESCRIPTION
Week 8: No theme identified *(shortened week)*			
21	11/20	Writing as a product: grades	Prof talks about Rush Limbaugh and the media in general; wants students to be skeptical of information they hear.
Week 9: World's fisheries			
22	11/28	Consideration of sources of written knowledge	TA_2 raises question: source of articles determine their validity? Expresses personal view of persuasion.
23	11/28	Funding in science	TA_2 raises issue of data objectivity and bias in science due to funding sources (corp. and gov't.) Modern science is characterized as "not a gentleman's science."
24	12/01	Responding to grading	TA_1 discusses writing as a product: used for evaluation. Grade appeals are also discussed.
25	12/01	Point of view in applied scientific problems	TA_1 has students work in groups to take positions and to research data to make arguments in environmental application of scientific data.
26	12/01	Critical evaluation of scientific data	TA_1 raises questions: How valid is data in the public sphere and political debates? How many studies are needed to make policy?
27	12/01	Fair grading and model papers	Prof talks about "fair" grading of papers and recommends that students go see their TAs for model/exemplar papers.
Week 10: Coastal marine biology- - no reference to technical paper			

Figure 3. Representation of different levels of discourse analysis. Shown are: line numbers for presentation and discussion, phase unit noted with cover term, time stamps from compilation video dub, sequence units, and research notes and comments.

line #	phase units	time	sequence units	research notes & comments/ "transcribed talk"
101 102 103 104 105	Goal of midterm paper: Do what scientists do	00:00:05	Reference to lab notebook on how to write a technical paper	*Begins with:* "There's a lot of possible ways you could go on this midterm paper." *Professor describes his balancing act between too much information and too little information; enough information to let students know professor is expecting, but not too much so that it becomes "fill in the blanks."*
106 107		00:00:52	Struggle of scientists	*Scientists go through a progress of struggle:* "trying to make sense out of what seems like chaos a lot of times."
108 109 110 111 112 113 114		00:01:10	Personal experience of not understanding what the data means	"So NSF has given us ah 80 grand or something. We've gone out, done field experiments, measured earthquakes for a couple of months, and we look at it and 'oh boy' and you start looking at it. you start, 'well let's try this.' you start looking at it and plotting things up and trying to make some consistency out of it. Then looking at this." *Professor says for students not to feel alone or dumb if don't understand right away.*
115 116 117		00:01:54	Actions students should take	*Professor mentions need to turn over and struggle with concepts; talk with others; discuss in sections; in the process of "doing science" as scientists do.*
118 119		00:02:20	Earthquake data	*Professor indicates that students will be analyzing current, real data.*
120 121 122 123 124 125 126 127 128 129 130 131		00:02:51	Identifying and explaining a problem	"There's another part of science that you need to know about is you can't explain everything." "Part of doing science is to figure out kinda (winnow) out what can I explain and what can't I explain. What's an interesting problem or what's an interesting thing to explain or what uh you know when when a scientist does research, one of the talents you have or has to be developed is knowing first off what's an interesting problem to study. Second off, whether studying it, and what data you can take can actually solve that problem or get some new information on that problem. So there's a lot of problems in the world uh that that are unsolvable you know, sort of classic problems you might not want to tackle."
	Onset on new phase of activity focused on the waves.			Professor walks back to podium saying, "OK uh waves."

Appendix: Domain Analyses related to the epistemological framing of oceanography

Domain paradigm:

cover term			
semantic relationship	indexed by:		
included terms:	spkr (cnxt)*	date	time

* with speaker (spkr) = s (Student), Karen (TA), Earl (TA), Bill (Professor) ; context (cnxt) = lecture (L), laboratory session meeting (S), lab book text** (LB), CD technology (CD)

** Information taken from the lab book includes page numbers. These included terms were located preceding the events of the class because the publication of the lab book precedes the events taken from the lectures and laboratory session.

Domains are read as "included term," "semantic relationship," and then "cover term." For example the first instance of the first domain would be read as:

"Thinking like scientists, i.e., learning how to access information and use knowledge to make informed decisions," *is a kind of* **Scientific practice identified by social mediators**

Scientific practices:

Scientific practice identified by social mediators			
is a kind of			
included terms:	spkr (cnxt)	date	time
thinking like scientists, i.e., learning how to access information and use knowledge to make informed decisions	Bill (LB, p. 1)		
thinking like scientists, i.e., acquiring data, thinking about the data, and writing up the results	Bill (LB, p. 25)		
arguing with other researchers with different interpretations	Bill (LB, p. 37)		
presenting the best data and interpretations, allowing for and making rebuttals of scientific work	Bill (LB, p. 37)		
poking holes in others' work	Bill (LB, p. 37)		
commenting on another's written work	Karen (S)	10/12	00:22:54
collecting quantitative observations and using numbers	Karen (S)	10/12	00:24:36
presenting and interpreting data (not necessarily perfect or correct)	Earl (S)	10/17	00:14:04
identifying and using data inscriptions (geologists--track lines)	Earl (S)	10/17	00:15:46
finding features (oceanographers)	Earl (S)	10/17	00:16:41
collecting and making sense of data	Bill (L)	10/23	00:01:10
persuading agencies to support your scientific work	Bill (L)	10/25	00:04:54
informing and interacting with other disciplines (anthropology)	Bill (L)	12/21	01:17:42

Observation and interpretation*			
is a way to distinguish			
included terms:	spkr (cnxt)	date	time
observations include making estimations, drawing sketches, being quantitative	Bill (LB, p. 19)		
observations are data that happens without the interpretations	Bill (LB, p. 28))		
qualitative observations are not very useful in technical writing, quantitative observations are	Bill (LB, p. 28)		
interpretations take individual observations and use experience, insight, and knowledge to explain them	Bill (LB, p. 29)		
interpretations are backed by one or more observations	BP (LB, p. 29)		
observations are raw input, interpretations making	Bill		

sense of them	(LB, p. 29)		
observations are "just the facts" (possible great debates about meaning)	Bill (LB, p. 30)		
description involves what everybody would agree on, interpretation is more personal	Sf (S)	10/12	01:06:30
observation involves looking in a different (specific) way	Karen (S)	10/12	00:20:42
scientific observations are quantitative	Karen (S)	10/12	00:23:28
observations can be quantitative, using numbers, as opposed to abstract description like in a poem	Karen (S)	10/13	00:10:59
observations include details of features rather than label (i.e. volcano)	Earl (S)	10/17	00:13:36
descriptions include details such as features, lengths, directions	Earl (S)	10/17	00:14:29
knowing the meaning (transform fault) of data inscriptions (purple line) is good observation	Earl (S)	10/17	00:16:29
observations support interpretations	Karen (S)	10/27	00:30:37

* Note: Professor's examples of observations are on p. 28; interpretations p.30.

Doing science/work of scientists			
is a characteristic of			
included terms:	spkr (cnxt)	date	time
acquiring data, thinking about data, and writing up the results	Bill (LB, p. 25)		
dealing with messy data, inconsistent data, figuring out the best explanation from competing possibilities	Bill (LB, p. 37)		
process of struggle, make sense out of chaos	Bill (L)	10/23	00:00:52
turn over and struggle with concepts, talk with others	Bill (L)	10/23	00:01:54
know what is an interesting problem to study	Bill (L)	10/23	00:02:51
persuading agencies to support your scientific work	Bill (L)	10/25	00:04:54
dealing with new data gathered by the scientist and interpreting the unknown	Karen (S)	10/27	00:42:38
studying the history of rocks and movements (what geologists do)	Karen (S)	11/03	00:50:14

Scientific norms or counternorms (CN) identified by social mediators			
is a kind of			
included terms:	spkr (cnxt)	date	time
CN: conflicts in data: in real world (unlike textbook) data rarely agree perfectly with	Bill (LB, p. 29)		

interpretations as data may have errors etc.			
honesty: refrain from over-interpreting data or exaggerating, and include all data	Bill (LB, p. 29)		
trust factor in science suggests openness and honesty in reporting	Bill (LB, p. 30)		
using multiple data sources for a study	Bill (LB, p. 30)		
referencing data, text, and figures in technical writing	Bill (LB, p. 34)		
considering the reputation and the quality of peer review in making judgments of credibility	Bill (LB, p. 37)		
using references and citing work appropriately	Karen (S)	10/20	00:27:40
using citations to data sources (CD-ROM)	s? & Karen (S)	10/27	00:38:49
using citations to all sources and in appropriate form	s1&s2 & Karen (S)	10/27	00:39:13
using citations to all sources and in appropriate form	Karen (S)	10/27	00:41:03
writing a methods section so others can replicate	Earl (S)	10/31	00:47:18
CN: Scientists (course professor) have a viewpoint that should not be trusted	Bill (L)	11/15	01:08:24
science turns into politics, relationships with monetary interests	Bill (L)	11/15	01:12:08
CN: scientists' research interests tie to economics, importance and (hopefully) the truth	Earl & s? (S)	11/28	00:58:10
CN: "gentlemen science" not really characteristic of modern science which has "big interests"	Earl (S)	11/28	00:59:01
CN: scientific questions defined by funding sources	Earl & s? (S)	11/28	00:59:25
use of multiple studies to booster conclusions	Karen (S)	12/01	01:05:26
use of multiple studies to booster conclusions	Karen (S)	12/01	01:06:02
CN: individual scientist and funding resources	Karen (S)	12/01	01:06:32

Social responsibility and science:

Social, political, economic ramification of science			
is a kind of			
included terms:	spkr (cnxt)	date	time
scientific results have an impact on public policy, especially when the environment is concerned	Bill (LB, p. 38)		
impact of seawalls and drudging on the coastal environment	Karen (S)	11/03	00:50:47
understanding the complexity of science	Bill (L)	11/15	01:11:35
consideration of residence time for natural and artificial gases in atmosphere	Karen (S)	11/17	00:52:40
relationship to jobs and state interests	Earl (S)	11/28	00:56:01
complex interests/responsibilities of	Earl & s?	11/28	00:56:50

scientists/citizens	(S)		
scientists' research interests tie to need to make a living	Earl & s? (S)	11/28	00:58:10
scientific questions defined by funding sources (also counternorm)	Earl & s? (S)	11/28	00:59:25
large scale fishing (read scientifically-based) may lead to depletion of fish	Earl & s? (S)	11/28	01:00:13

Socially responsible use of science/scientific knowledge			
is an attribute of			
included terms:	spkr (cnxt)	date	time
making informed decisions about environmental issues and economic needs	Bill (LB, p.1)		
understanding that scientists will disagree about issues	Bill (LB, p. 37)		
knowing the difference between good and bad science by considering alternative views.	Bill (LB, p. 37)		
evaluating science as reported to the public	Bill (LB, p. 38)		
being suspicious of unsupported arguments in the popular media (ex: Rush Limbaugh)	Bill (L)	11/15	01:07:08
considering multiple viewpoints, sources of information	Bill (L)	11/15	01:08:39
consideration of evidence (science) vs. unsupported assertions mixed with balderdash (Limbaugh)	Bill (L)	11/15	01:10:02
understanding the complexity of science	Bill (L)	11/15	01:11:35
sorting through reasonable opinions and not believing the course professor (or anyone else)	Bill (L)	11/15	01:13:05
being careful in reading, being aware of misinformation	Karen (S)	11/17	00:53:24
being aware of the source and possible motivations of authors/information	Earl (S)	11/28	00:54:00
identifying bias in writing	Earl (S)	11/28	00:55:03
taking numbers and data with a grain of salt	Karen (S)	12/01	01:04:48

Writing:

Write in science			
is a way to			
included terms:	spkr (cnxt)	date	time
considering the audience and communication of topics	Bill (LB, p. 26)		
condensing information for the reader's easy assimilation of information	Bill (LB, p. 32)		
having other people read your work	Karen (S)	10/12	<00:17:04
communicating different observations	Karen (S)	10/12	00:17:51

conforming to a particular format	Karen (S)	10/12	00:18:55
"	Karen (S)	10/27	00:34:30
communicating knowledge observations, and interpretations	Karen (S)	10/13	00:12:38
writing multiple drafts	Earl (S)	10/17	00:15:19
separating extraneous information from supporting details	Earl (S)	10/17	00:14:51
considering the audience in communicating ideas	Bill (L)	10/25	00:05:52
writing is a process that undergoes changes and modifications	Bill (L)	10/25	00:05:52
revisiting written work for modifications	Bill (L)	10/25	00:06:24
recognizing and utilizing the interplay of data collection and writing	Bill (L) Bill (L)	10/25 10/25	00:07:16 00:07:51
(using citations) but not footnotes	Karen (S)	10/27	00:42:00
using coordinates in technical papers (when acquiring data)	Earl (S)	10/31	00:46:53
reviewing well written (student) papers) as exemplars	Bill (L)	11/20	01:14:16

Scientific/technical writing			
is a way to distinguish			
included terms:	spkr (cnxt)	date	time
comparing to uses of evidence in court cases	Bill (LB, p. 19)		
following a specific (but variable) format	Bill (LB, p. 25)		
using figures, pictures, sketches	Bill (LB, p. 31)		
using maps, symbols, legends	Bill (LB, p. 33)		
noting differences with writing English papers	Karen (S)	10/12	00:18:37
comparing to writing in English major type stuff	Karen (S)	10/13	00:10:24
using section subheadings	Karen (S)	10/27	00:34:30

Writing as scientific practice			
is a reason for doing			
included terms:	spkr (cnxt)	date	time
getting money, selling products, publishing in scholarly journal, persuade others	Bill (LB, p. 25)		
persuading agencies to support your scientific work	Bill (L)	10/25	00:04:54
persuading interested parties and outsiders	Earl (S)	11/28	00:55:03

Student concern about writing technical paper			
is a kind of			
included terms:	spkr (cnxt)	date	time
identifying science writing as particular and "not creative"	s1 & Karen (S)	10/12	00:18:26
purpose and uses of the CD-ROM technology for the writing task	s? & Karen (S)	10/27	00:31:19
(lack of) separation of observation and interpretation	s1 & Karen (S)	10/27	00:33:21
	s4 & Karen (S)	10/27	00:34:30
understanding method for determination of grade	s1 & Karen (S)	10/27	00:34:06
presenting observations with their respective interpretations	s5 & Karen (S)	10/27	00:35:28
using within paper reference	s5 & Karen (S)	10/27	00:35:50
using separate paragraphs for each interpretation or geographical area	s5 & Karen (S)	10/27	00:36:13
using pictures in text	s4 & Karen (S)	10/27	00:36:34
using analyzed area for an observation	s5 & Karen (S)	10/27	00:36:58
using examples appropriately	s5 & Karen (S)	10/27	00:37:15
using citations to data sources (CD-ROM)	s? & Karen (S)	10/27	00:38:49
using footnotes	s? (S)	10/27	00:42:00
understanding the main purpose of the paper	s? (S)	10/27	00:42:38
using computer software to write the paper	s? (S)	10/27	00:43:56
using citations to data sources (CD-ROM)	s? & Earl (S)	10/31	00:44:28
using computer software to write the paper	s? (S)	10/31	00:45:09
knowing what information to include in the "methods" section	s? & Earl (S)	10/31	00:44:41
using reference points and maps	s? & Earl (S)	10/31	00:46:15
using a title page in the technical paper	s? & Karen (S)	11/03	00:48:30
using computer graphics (value of)	s? & Karen (S)	11/03	00:49:37

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