Making Visible the Behaviors that Influence Learning Environment: A Qualitative Exploration of Computer Science Classrooms

Lecia J. Barker and Kathy Garvin-Doxas
ATLAS Institute Evaluation and Research Group, University of Colorado, Boulder, CO, USA

ABSTRACT

The authors conducted ethnographic research to provide deep understanding of the learning environment of a selection of computer science classrooms at a large, research university in the United States. Categories emerging from data analysis included (1) impersonal environment and guarded behavior; and (2) the creation and maintenance of informal hierarchy resulting in competitive behaviors. Both of these categories describe patterns of recurring communication taking place in the classroom learning environments. We identify particular and recognizable types of discourse, which, when prevalent in a classroom, can preclude the development of a collaborative and/or supportive learning environment. Alternative communication choices, both explicit and implicit, can lead to a more balanced and supportive climate for learning. An example of a successful effort to alter traditional patterns of interaction, without compromising the quality of learning, in a higher education astrophysics class is presented.

1. INTRODUCTION

Computer science faculty today face many pressures to integrate collaborative and cooperative learning approaches in courses, increase active participation by students in classes, and increase the participation of under-represented groups in computing. The pressures are many and varied and derive from many sources, such as the emphasis on team work by the Accreditation Board for Engineering and Technology, the Joint IEEE Computer Society/ACM Task...
Force in the “Model Curricula for Computing,” and industry (cf., ABET Accreditation Commission, 2003; IEEE/ACM Joint Task Force, 2001). In addition, learning environments with opportunities for collaborative work or peer learning are thought to be more appealing to student members of underrepresented groups (Agogino & Linn, 1992; Blake, 1998; Felder, Felder, Mauney, Hamrin, & Dietz, 1995; García & Giles, 2000; Strenta, Rogers, Russell, Matier, & Scott, 1994). As one of the processes underlying the competitive, rather than collaborative nature of computer science classrooms (Button & Sharrock, 1996), a “defensive communication climate” works against the achievement of these goals.

Education is essentially a communicative activity. Educational researchers in the socio-cultural tradition have long been convinced that language, verbal, non-verbal, and paraverbal, mediates the way and the degree to which students construct knowledge (Coll & Edwards, 1996; Edwards & Mercer, 1987; Forman & Cazden, 1985; Hicks, 1996; Jadallah, 2000; Lemke, 1993; Mercer, 1995, 2000; Spears, 1996; Vygotsky, 1978; Wells, 1999; Wertsch, Del Rio, & Alvarez, 1995). In this paper, expanded from a conference paper presented at SIGCSE 2002 (Barker, Garvin-Doxas, & Jackson, 2002), we focus on the communication climate we observed in several computer science classrooms at one large, public, research university. Although we believe the behaviors made visible through our analysis has special impact for females, they certainly impact the learning experience of both female and male students. Below we present learning environment and communication climate as theoretical constructs, describe our research methods and results of data collection and analysis, and discuss the implications of the communication patterns we observed in computer science classrooms. Following this, we describe an astrophysics professor’s efforts to personalize a large lecture course, showing one way of shifting the balance from a defensive toward a more supportive communication climate.

1.1. The Learning Environment
When the study of the learning environment is used as a means of describing learning situations, it improves our understanding of various influences on learning outcomes. In particular, by understanding influences at the level of concrete behavior, one can more easily determine appropriate interventions for changing the environment. A learning environment comprises “all of the physical surroundings, psychosocial or emotional conditions, and social or cultural influences” present in a learning situation (Hiemstra, 1991, p. 8).
Both the physical and the social aspects of a learning environment influence student participation and satisfaction (Fulton, 1991) and are believed to affect the learning of the people who function in them. These effects can be positive or negative (Vahala & Winston, 1994). In fact, learning environments have effects beyond learning to include socialization, particularly when certain patterns of interaction occur across many classes in a curricular program. Students and faculty come to expect and to see as normative some actions and not others (i.e., what one should or should not do). For example, when students’ seats are bolted to the floor facing a lectern, student collaboration can be inhibited. If, in combination with this physical influence, instruction is almost entirely lecture-based, students can come to resist different teaching methods such as student-led discussion or small group work (e.g., Waite, Jackson, & Diwan, 2002).

Part of the learning environment is the social climate, which is influenced by socially and culturally grounded beliefs about appropriate class activities, relationships, and roles; traditional and emerging beliefs about trust, authority, status, and hierarchy; the personalities and behaviors of individuals; implicit and explicitly stated beliefs held by the instructor; typical patterns of interaction; and the nature of messages embedded in assignments and official documents (Fulton, 1991; Hiemstra, 1991; Knowles, 1970, 1984; Murphy, 1997; Tead, 1958; Vosko, 1991). While the learning environment exists in social space, it is rarely explicitly stated nor are its features static. Instead, the learning environment is negotiated through student-student and instructor-student interaction, and its characteristics, in turn, have a socializing effect (Rorty, 1999). Communication patterns are key, since it is by creating shared understanding that teaching and learning occur. Communication patterns that become typical provide not just information, but represent and maintain social order, implying and prescribing the way things are done or should be done – and who can do them – “around here” (Burke, 1966; Goffman, 1959; Mead, 1934).

In educational settings, communication functions to create shared meaning through the transmission of information (e.g., lectures, discussions), yet it has much more subtle functions as the vehicle for the development of roles, relationships, norms, and beliefs. Patterns of communication are influenced in large part by how the teacher and students view authority, appropriate forms and content of talk, and their roles within the learning environment (Hiemstra, 1991; Knowles, 1970). These patterns may be negotiated in higher education, but most frequently adult students enter into the learning situation with
preconceived notions grounded in years of socialization. One of the major influences on interaction and communication is what is known as the communication climate (Gibb, 1961).

1.2. Communication Climate

The communication climate, like all social aspects of learning environments, is negotiated, maintained, and changed through all modes of communication (verbal, non-verbal, and para-verbal), both explicit and implicit. That is, what one infers from the routine, patterned interactions that take place in a particular environment become one’s beliefs about appropriate roles, activities, etc. Gibb (1961) developed a descriptive theory about communication in large and small groups based on 8 years of coded observations and analysis of recorded human relations training sessions in industrial, educational, military, and community settings. This theory can be helpful for describing classroom communication climates, such as whether students feel comfortable asking questions. Gibb found that groups develop communication styles that become habitual and normative; these are characterized along a continuum from defensive to supportive.

As social beings, we necessarily concern ourselves with others’ perceptions of us. To understand these, we draw inferences (wrongly or rightly) from others’ speech and behaviors as representing their attitudes and beliefs about us. Unfortunately, we sometimes do not get the opportunity to test the accuracy of our inferences by asking what someone said or did to make us believe in a certain way. Instead, we respond to what we think others mean, potentially initiating a spiral of defensive behavior. When defensive communication becomes habitual in a social context, it engenders a “defensive climate.” Distrust of others becomes the norm, resulting in a social environment privileging competition over cooperation.

In evaluating a program where collaborative learning is an objective, it is important to understand whether communication patterns are resulting in a defensive climate, since this would hinder success. A great frustration encountered by teachers interested in enhancing student learning is the inability to elicit students’ questions when the students clearly need further explanation of a concept (Chi, de Leeuw, Chiu, & LaVancher, 1994; Graesser, Millis, & Zwaan, 1997; Graesser & Person, 1994). In the interest of conveying content knowledge, professors often overlook the need to create a communication climate that works to support the level and type of learning we expect as an outcome. Students feel free to ask questions in class only in a supportive
Gibb characterized six overlapping categories of speech as creating defensiveness in people (see Fig. 1). First, speech that is interpreted as evaluative or judgmental often creates defensive reactions; criticism implies both status differences and that the person being evaluated is substandard. For example, in response to hearing the average grade on a test, a student might announce, “my dog could’ve done that!” If the professor laughs and even extends the joke (implying approval), and if this type of behavior becomes routine, the climate may become one where only the most high-achieving students feel comfortable disclosing their progress for fear of being cast as inadequate rather than valuable and competent. Second, speech seen as intending to control can lead to resistance; the implication is that the speaker privately believes the listener makes inadequate behavior choices. Third, people become distrustful when they perceive that others are using deceptive strategies to achieve their goals rather than acting openly. That is, people begin to wonder about another’s possible hidden agenda when they feel manipulated. Fourth, individuals protect themselves against others whose behavior suggests they lack concern or empathy for the individuals as humans with needs; it may be seen as a rejection of the self as deserving to be treated well (i.e., as opposed to being treated as a second class citizen). Fifth, when people communicate their superiority either implicitly or explicitly, feelings of inadequacy are aroused (e.g., drawing attention to the mistakes of others). Finally, when people communicate certainty in a dogmatic fashion, they also tend to communicate inflexibility or a low tolerance for disagreement, which can lead to others withholding or even hiding their true thoughts, opinions, and ideas for fear of being perceived as wrong.

**Fig. 1. Communication climate (Gibb, 1961).**
These categories are not mutually exclusive and form a continuum, with the categories of speech found in supportive climates at one end and those observed in defensive climates at the other. There will always be elements of each type of climate in any social setting, but in most cases, the balance tends to swing more toward one end than another. When recurring interactions lean more heavily toward the defensive end of the continuum, it can interfere with normal interactions, particularly in a learning setting, since people can become preoccupied with image management and maintaining their integrity with respect to fellow students. Over time, and through multiple similar interactions, a predominantly defensive climate works to constrain social interaction and to create and maintain a classroom environment that presents many challenges to those who teach. A learning environment with a more supportive communication climate is desirable in terms of making it possible for students to articulate their understandings of concepts and participate actively in class. After hundreds of hours of observation, we began to associate a defensive climate with computer science classes we observed.

2. METHODS

Below we present the method, data, and analysis by which we characterized student-student and student-teacher interactions within the computer science learning environments we studied. We then describe patterns that became evident across courses we observed and discuss ways to shift the balance from defensive to supportive grounded in lessons learned from our analysis of an astrophysics program.

2.1. Ethnographic Inquiry

A well-accepted qualitative research method in anthropology, communication, history, geography, sociology, and other academic traditions (cf., Denzin & Lincoln, 1994; Thomas, Chataway, & Wuyts, 1998), ethnographic inquiry is the practice of “representing the social reality of others through the analysis of one’s own experience in the world of . . . others” (Van Maanen, 1988, p. ix). The ethnographer is often an outsider to the group or is precariously perched between one group and another, attempting to capture the details and meanings of interaction from the perspective of members of the target group. As ethnographers who conduct research in higher education classrooms, our aim is to understand and articulate the shared, yet often unspoken, rules,
beliefs, and values produced communicatively by students and instructors and
which surround and influence their everyday teaching and learning practices.
The conclusions drawn from ethnographic research are not intended to be
generalized. Rather, they are used by analogy: the findings are applicable in
other settings only when the reader sees similarities between the essential
features of the description provided and his or her own experiences and
situation.

Understanding requires that we as researchers enter the classroom and alter
it with our presence; further, any interpretation is accomplished through our
subjectivity and historicity. Nevertheless, as Gadamer (1989) points out,
attempting understanding is worthwhile, since even a scientific statement is a
response to a question and implies values, and we cannot change the fact that
one always has presuppositions and privileges certain values when one asks
questions, makes statements, or attempts to understand the lived experience of
others. Gadamer also argues, however, that the interpretive researcher must go
beyond simply stating research conclusions, but must make a special effort to
ensure that data gathering is done reliably and that analysis be conducted
dialectically.

Ethnographic research is not judged by the same criteria as quantitative
studies; instead, ethnographic research is judged by its credibility (Lincoln &
Guba, 1984). To achieve credibility, a researcher needs “prolonged engage-
ment, persistent observation, and triangulation” (Lincoln & Guba, 1984,
p. 301) in order to improve the probability of producing credible findings. Our
research team, consisting of the authors, a colleague with Ph.D. in educational
research methods, three doctoral students (sociology, communication, and
political science), and two masters students (anthropology and communica-
tion), spent more than 348 hr in 13 computer science courses over a span of
four sequential semesters (two academic years) (see Table 1). We triangulated
by collecting participant observation and interview data as well as by
analyzing artifacts (e.g., syllabi), student records, and demographic data, all
typical data for ethnography.

Participant observation aims to describe in writing, “what people do, what
people know, and the things people make and use” (Spradley, 1980, p. 5). Field
notes become the empirical data that are interpreted through constructs
generated from the data as well as the inevitable subjectivity of the interpreter.
That is, for example, as outsiders to the computer science classroom setting, our
expectations for classroom interaction likely caused some behaviors and actions
to stand out and may have caused us to miss others. Most data gathered focus on
conversation (oral discourse), because it is in conversation that people work to create and maintain the implicit rules and beliefs operating in a social situation: what is and is not acceptable practice is made available in participants’ conversational actions, in their accounting for their actions, and their commenting on or reacting to the actions of others. For example, if a professor tells students that he gives extra credit for “good questions” during lecture, but only records students’ names when they provide correct mathematical equations, students are likely to infer that this professor’s working definition of “good questions” is “accurate statements of mathematical details.”

Interviewing participants can answer questions that observation cannot answer (e.g., perceptions) and can be used to validate analysis. One must also examine artifacts, since understanding their meaning and how they are used may make visible other data or analytical categories and thereby strengthen the analysis.

Discourse from observations, interviews, and in artifacts is best interpreted through an understanding of the social context in which it takes place.

Table 1. Class Observation Details.

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2000</td>
<td>Intro to programming (2 sections w/different instructors; 10 labs and 27 lectures, 2 special study sessions) “Town Hall” meeting of students, faculty</td>
<td>48</td>
</tr>
<tr>
<td>Spring 2001</td>
<td>All-level multi-disciplinary project for educational projects (9 lecture/lab sessions) Data structures (14 lectures, 3 labs) Principles of programming (12 lectures, 9 labs) Upper-division multi-disciplinary design course (20 lectures, one student group meeting) All-level multi-disciplinary project for community clients (28 lecture/lab sessions)</td>
<td>9</td>
</tr>
<tr>
<td>Fall 2001</td>
<td>Intro to programming (29 lectures, 19 labs) All-level multi-disciplinary project for community clients (22 lecture/lab sessions) Cognitive science (16 lectures)</td>
<td>55</td>
</tr>
<tr>
<td>Spring 2002</td>
<td>Algorithms (19 lectures, 5 labs) Intro to java programming (14 lectures, 12 labs) All-level multi-disciplinary project for community clients (16 lecture/lab sessions)</td>
<td>21</td>
</tr>
<tr>
<td>Total hours</td>
<td></td>
<td>348</td>
</tr>
</tbody>
</table>
(Potter & Wetherell, 1987). The conclusions the researcher draws are based on complex, multi-layered interactions and the interactants’ responses to them; that is, responses in the form of communicative behaviors reveal participants’ interpretations of the meaning and salience of the interaction. Analysis includes identifying recurring themes and patterns within the data by noting and discussing the frequency and importance of certain activities, the content and form of interaction, and other features of the social context; discussing each analyst’s coding schema; and iteratively re-examining the data using the mutually-agreed codes. For example, suppose students asked three questions in a particular class on a particular day, yet two questions were really statements seeking only confirmation rather than new information. This does not make a case for any particular interpretation and the observation should be considered anecdotal. Yet if a similar proportion of student questions asked across several classrooms over several semesters is of the same type, or if certain other behaviors frequently accompany such a question (e.g., leaning back in the chair and spreading out one’s arms), we might infer it is meaningful and mark it as a patterned form of interaction that needs to be examined in the context of other evidence related to these interactions. Such recurring themes and patterns are not anecdotal, but documented in the field note evidence. Accompanied by corroboration from other sources, pattern identification allows us to build a series of stories that demonstrate the values, beliefs, and assumptions people reveal when their behaviors and interactions are considered in the larger, cultural context.

2.2. Data Collected
Over the course of the 2000–2002 academic years, we collected three types of data: artifacts (e.g., records and documents), participant observation, and interviews and other accounts of setting members. Artifacts included (1) student demographic and academic achievement records, used to better understand the students’ preparation and backgrounds; and, (2) class documents (e.g., syllabi), used to understand the written policies of the programs and how the programs describe and present themselves to the outside world. Student academic records were analyzed using the Statistical Package for the Social Sciences version 11.0 (SPSS) and artifacts were analyzed using discourse analytic methods.

We observed 13 courses over four semesters, a “Town Hall” meeting, and special study sessions, for a total of 348 hr (see Table 1). We also were invited to and attended a day-long faculty retreat on cheating. The extensive field
notes recorded: number of students present and when they arrived, gender, and appearance; physical layout of classrooms and seating choices of students by gender; descriptions of interaction (student-student and student-instructor interaction) and interactants (male/female; major). Often, direct quotes from students and teachers were recorded. Field notes focus on what happened, when, and with whom and provide an initial opportunity to identify recurring patterns and themes and to develop research questions. Fieldnotes were typed and systematically documented and filed; the resulting thousands of pages of text were bound as “books,” organized by course. An excerpt of a classroom observation is shown in Figure 2.

We conducted formal interviews with faculty and students and informal interviews with students during, before, and after class periods. Our team conducted 37 formal interviews with computer science students over the course of the two years and six interviews with the computer science advisor. Formal interviews were either tape-recorded and transcribed verbatim or recorded in writing as much as possible during and after the interview.

---

<table>
<thead>
<tr>
<th>Observer: Lecia Barker</th>
<th>Instructor:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course: Data Structures</td>
<td></td>
</tr>
<tr>
<td>Date: 2-15-01</td>
<td></td>
</tr>
<tr>
<td>Number of Males: 8</td>
<td>Number of Females: 9</td>
</tr>
<tr>
<td>Seating Arrangement:</td>
<td></td>
</tr>
<tr>
<td>M F</td>
<td>F F</td>
</tr>
<tr>
<td>F F</td>
<td>F M</td>
</tr>
<tr>
<td>M F</td>
<td>M M</td>
</tr>
<tr>
<td>L M</td>
<td>M M</td>
</tr>
</tbody>
</table>

Observation:

<professor> talking about things to be discussed today.
Writing topics on board. They are up to Chapter 6
- Delete—all versus destructor
- Debugging with printscreen, etc.
- Recursion of trees
- Software reuse (iterator) (template)
- Stacks

<professor>—here's what I would do (strongly implies that there are other approaches, but this is probably best) ... would give each node a unique ID.

(Shows them a good way to write that bit of code; works backward: the piece of code needed, the problem associated with it, then the extra code needed to keep program from crashing every time a string is null)

Male arrives.

<professor>—... show you a more sophisticated application of that idea
(Writing code on board)(Diagram)

<professor>—Does anybody know or care about fractal geometry?
(No response)
<professor> laughs and explains what one is, drawing on board, has smile while doing (perhaps is intrinsically interesting to him) Shows how a tree is a fractal. That's, each node can break into 2 more nodes.

<professor> handed out page of code. Printed with green and blue and black.

<professor>—here's what I would do (strongly implies that there are other approaches, but this is probably best) ... would give each node a unique ID.

(Still talking about the tree—"It’s binary... if you’re proving things by induction...")

Four Females are writing, maybe Five.
No Males are writing. —WHY?

Fig. 2. Sample field notes (edited to fit selection).
Meaning emerges as part of the interview process as interviewers attempt to clear up ambiguity and interviewees apply their own meanings to questions. Mishler (1986) argues that social scientists often make problematic assumptions with respect to interview questions: that the interviewer is always asking the same question of each respondent and that those questions have the same meaning for each respondent. To increase our ability to arrive at valid interpretations, interview questions are transcribed verbatim, rather than appearing as they do on interview protocols. An interview excerpt is shown in Figure 3. Informal interviews were used to validate (or invalidate) hunches or clear up confusion on our part. These occurred on a regular basis and are too numerous to count.

2.3. Data Analysis and Corroboration
Both authors read through selected data and engaged in generating the coding categories through continual discussion and negotiated agreement. Later, we coded the observation data in terms of the broad categories and subsets identified through the coding process. For example, in each classroom observation document (i.e., by date of observation), descriptive statements such as “no one is talking to each other,” “no one responds to professor’s question” or “professor points to student, doesn’t use name” were coded. Using the identified examples, we developed a narrative to share with professors and students in
order to understand the degree to which our interpretations of classroom climate were valid.

We worked to corroborate our data collection in several ways. Two computer science professors (the department chair and the chair of the undergraduate curriculum committee) were part of the project group and participated in regular semester meetings to comment on and guide findings and queries. In addition, we shared our findings with the computer science faculty both in writing and orally, eliciting commentary. For example, we engaged in occasional email exchanges asking about some particular pattern or event we may have noticed and we sent out the shorter conference paper version of these findings (Barker et al., 2002) via email to elicit reactions. We held a half-day workshop to present and discuss our results, during which the majority of computer science faculty members came in and left as their schedules permitted. Our professional research assistant took detailed notes of their comments and questions. The faculty did not seem surprised at what we told them, asking instead what they could do about improving climate, without compromising the instruction they were providing and given issues such as plagiarism and differences in student ability in introductory courses. We conducted formal and brief informal interviews with students and faculty to ask if what we were seeing made sense. Finally, we presented our initial findings at SIGCSE, a computer science education conference, in 2002. There, and later in email, many students and faculty have told us that our description resonated with their classroom experiences.

3. FINDINGS

3.1. Records Review

Our review of student records showed us that female CS majors enter the major with significantly less mathematics preparation than males, as judged by their Scholastic Assessment Test mathematics scores (SAT; a nationally-administered examination required by most institutions of higher education in the U.S. designed to predict first-year college success); this is consistent with other studies (Dorans, 2002). In spite of these differences in mathematics exams, we found no statistically significant difference between males’ and females’ academic achievement, except in the third (junior) year, when females’ grades were slightly higher than males’. We also discovered that about 10–11 percent of students switch out of the CS major prior to
graduation, and although women drop out at a higher rate than men, the difference between males and females was not statistically significant (attributable to low statistical power, the small number of women for making the comparison, even across a six-year study).

3.2. Syllabi Analysis
While it is hard to know whether the incidence of cheating is on the rise or the tools for catching cheaters have become more sophisticated and readily available, cheating remains a significant problem in universities and colleges; one study shows 75 percent of students saying they have cheated at least once (McCabe & Drinan, 1999). Cheating devalues the validity of assessments as well as public perception of what a student really learns in a program. The department under study has worked hard to combat cheating, using software that both grades and evaluates the potential of plagiarism of programming assignments and setting strict policies with respect to cheating. While intended to solve a very real and possibly growing problem, the way that plagiarism is presented to students contributes to a belief that solitary work is preferable to working with other students.

In analysis of syllabi for the introductory CS courses, we found that collaboration with other students was equated with plagiarism, in some ways very explicitly. That is, a written section in several syllabi entitled “Collaboration” defined an instance in which it is acceptable to talk to other students about assignments (“high-level coding issues”). Following this, however, was a list of several instances in which one “MUST NOT” talk to other students about assignments. These would be considered cheating and students would receive a failing grade. In addition, those syllabi also warned students that if they received any help from anyone else (a tutor, another student), they must note who assisted them and with what particular line of code. However, in no cases that we were able to discover, did teachers explain clearly the fuzzy line between high-level and low-level code nor exactly how students should cite help. We believed that these written policies were difficult to interpret for a first-semester freshman; as a result, they were acted upon by introductory students as if peer-peer and student-tutor interactions as a means of helping students understand difficult concepts were simply to be avoided.

Our interpretation of this language and its meaning as interpreted by students was later supported in discussions conducted with CS students. For example, one female student explained that she never worked in the
department computer labs because, “it just isn’t safe because someone might copy your code and then you will be accused of plagiarism.” In an interview about an experimental course where students were placed in learning teams, a male student said, “my friend that took this class last year – and they didn’t do the group format – I would just watch him absolutely struggle with this because they couldn’t really get help from anybody because that would be considered cheating.” Thus students came to believe that learning in computer science is something that is done alone.

3.3. Impersonal Environment and Guarded Behavior

Although observation data fell into a number of different categories, here we focus on those related to the communication climate that characterized the social learning environment in these courses. Interpersonal relationships usually begin with learning a person’s name, then learning more about a person’s interests through self-disclosure. The social environment of most of the computer science courses we observed can be characterized as impersonal, an environment in which it is easy to remain relatively anonymous and socially distant. In observations, it was rare to hear the name of a student in class or any personal information beyond that learned or guessed by appearance and other obvious facts (e.g., only CS majors are allowed in this class, so one can infer that all students enrolled are CS majors).

In only two courses were students required to introduce themselves to the class; in only one of these did student names continue to be used by the instructor. In fact, instructors rarely used students’ names, even at the end of the semester. Instructors sometimes called on students according to their clothing, such as “the woman in the red shirt.” When names were used, it seemed surprising, leading us to wonder if the student and professor knew each other from extra-classroom interaction. Sometimes a professor would call on a student by name, adding, “I’m calling on you only because I know your name.” In other words, he didn’t know others’ names, though this occurred more than two months into the semester. Further, field notes from the computer science courses are characterized by identifying students as “F1” (first female), “M2,” “red hair.” As observers, we try to remember names so that we can track individual behavior, but the lack of name use made this difficult. Non-use of names was not a function of class size; only one of the seven CS courses observed had enrollment greater than 30, and classes were regularly attended by many fewer. In fact, when we had a CS faculty member read through an earlier version of this paper, one professor told us that her students reacted with
suspicion whenever she used their names, saying for example, “why do you know my name!?”

Self-disclosure is sharing information that others would not usually know or discover without being told. This information is not necessarily private or sensitive, but can be as bland as telling a classmate you went to a basketball game the night before or that you did not study for the test (or both). Self-disclosure functions to cement interpersonal relationships by helping people predict behavior and deepening mutual trust (Derlega, 1993). In observations of lower-division CS courses, it was rare to hear a student disclose personal information related to anything other than work (a serious and important topic), even in the limited before-class chitchat. Indeed, one instructor repeatedly disclosed personal information such as his love of music and hiking, but students typically remained silent, violating an unspoken norm in American culture: self-disclosure is reciprocal (Derlega, 1993). Yet students rarely responded to instructors or even spoke much in class, suggesting that the social environment was very guarded.

We believe that this guardedness results from a combination of the impersonal environment maintained by lack of opportunity to get to know one another, professors’ explicit beliefs that students should work alone (implied in syllabi and elicited in interviews), being graded by a computer program rather than getting personal feedback from a human, and fears of being accused of (or caught) cheating. Contributing to or resulting from this guardedness were the lack of or very subdued chatting before class, students sitting apart from one another, non-response to instructor queries, silence when the instructor paused or erased the board, and lack of typical questions (e.g., “what was the average grade on the test?”). These observed behaviors were also influenced by other issues, such as fear of being exposed as “not smart.”

3.4. Informal Student Hierarchy

Hierarchy and status, whether equal or unequal, are characteristics of every social situation and relationship (Burke, 1966; Watzlawick, Beavin, & Jackson, 1967). Hierarchy may be formal or informal, or have elements of both. Formal hierarchy occurs when certain persons have the authority and duty to govern the actions of others, such as in teacher-student relationships. Informal hierarchy is created through the acquisition and display of status by participants in a social situation and is relevant to the values shared by members (Berger, Cohen, & Zelditich, 1972). Individuals learn the values of
groups in subtle ways, primarily through interaction, and present themselves as belonging to a group through the expression of shared values. One way that they make a bid to be treated as having higher status is for them to publicly (e.g., in regular class meetings) talk in ways that suggest they excel at the kind of skills, knowledge, or other “social capital” required for functioning in that social context. Persons with low status experience more negative emotions than those with high status (Tiedens, 2000) and participate less (Weisband, Schneider, & Connolly, 1995).

In computer science classrooms, status is informally accorded to those who display their ability to write “elegant programs,” display ability to reason well (frequently defined as mathematical reasoning), or provide other needed information. In classes, who belongs and where they belong in the informal hierarchy were negotiated throughout the semester in the courses we observed. Even on the first day of class for first semester freshmen, the process of identifying who belongs and who does not would begin. One professor explained to his class that the course had no prerequisites and that all levels of experience, “never programmed, a bit of programming, and rocket scientists” are all in the same course. Thus all students belong. The instructor further defined the “rocket scientists” by saying that they often compete to do more and to out-do one another. He presented as example a student who designed a complex game for his final project, saying, “Did it help his grade [to go beyond the assignment]? No, but he had fun.” So smart people are competitive and take extra time on projects. In one course, the professor demonstrated a possible project for the final component of the course (an extension of the peg-board game) and asked “[who in the class] thinks it’s a cool one?” When all of the students raised their hands, he said, “Good, because if you don’t think it’s cool, you’re in the wrong class. This is about as good as it gets.” Thus, the types of people who belong, their status, and typical behavior of different types of belonging are set up and defined early on.

Setting up hierarchy and status can help students to understand success factors in the major. For example, a professor compared two versions of the same code, telling the class, “don’t hesitate to write code like this [indicates the beginner’s version], but eventually you’ll write code like this [indicates the more compact, efficient version].” However, problems can arise when students confuse the source of knowledge that can lead to high status: intelligence versus experience. This is especially problematic for those with less experience, a group to which most female CS students belong. Students with
programming experience are frequently referred to as “smart,” both explicitly and implicitly. For example, one instructor announced, “we have people in this class who have never programmed and some who have created game software. By the way, we have [TA] jobs for smart students like that.” A professor described a computer scientist as “a very smart person, who knows how to create software.” The notion that being experienced at programming meant that one was smart was repeated across many early classes, so it was no surprise that students came to think of technical knowledge as superior to other types of knowledge. For example, in a multi-disciplinary course, an undergraduate CS major who worked with a group of non-majors said, “I tried to make sure that ideas from non-technical people could be heard by not making judgments.” This patronizing statement implies a self-perception of intellectual superiority, that he felt he was qualified to judge them but held back; we knew from records analysis, however, that the two students to whom he was referring were high-achieving double majors who were, in addition, seeking a multimedia certificate. If “smart” implies experience in programming, then computer science students may have some difficulty accepting other kinds of knowledge as equally valid. What is more, novice computer science majors with little experience may wonder whether they are indeed “smart” or may avoid disclosing their lack of experience to others for fear that they will be labeled as “not smart.”

Over time, students become aware of whether they belong as well as where they fit in the CS social hierarchy. That is, they are developing their identity as “computer scientists” – or not – through interaction with each other, their instructors, and TAs. Prior to the deadline for the first assignment for a junior-level course, one undergraduate TA spent the entire recitation session telling students how ‘easy’ the assignment would be: “You won’t have any problem with [the assignment]. It will be simple.” When a student asked, “did you already do this project?” the TA replied with a wave of his hand, “No. I spent about an hour putting together [this presentation for class] and I’ve written five languages commercially – this is all scraps to me.” Only 26 out of more than 80 students received passing grades on the assignment. Likewise, in a lower-division course, the instructor repeatedly told the class that “this test is a slam dunk; you’re all going to get 100 percent.” Those on the lower end of the 87 percent mean grade must have wondered, like the 54 students who failed the assignment above, whether they belonged or were “smart” like the other computer scientists (i.e., experienced students). Being told assignments are easy, yet finding them hard, can lead to self-doubt and fear of revealing one’s
inadequacy. And when two-thirds of the class fails an assignment, surely the problem lies with the instruction, not the students.

Most people prefer not to be at the bottom of a social hierarchy. We observed several computer science majors, all male, with the exception of one female with programming experience, engaging in behaviors that could be interpreted as bids for status. These projections of self image function to reinforce hierarchy in the classroom. For example, a male freshman made a point of telling one of us about his web design business and extensive programming experience. He explained his presence in the introductory class by saying that he did not want to place out of it so that he could have a more ‘relaxed’ semester. He said all of this before being reminded that the researcher wasn’t another student in the class and was later overheard sharing the same information with other students in the class. Such accounting for his presence could be seen as an attempt to position himself above other students in status. In many classes, students asked questions that did not appear to be seeking information, but to be displays of their own knowledge. Students would use question forms such as, “You can do _____, right?” and “Isn’t it true that ____” or “But doesn’t it work [this way] in Java?” These were intoned not as questions, but as statements.

The strategy seemed to persuade at least some of their peers that they knew a lot. In a recitation, an older female student said to a male student, “why are you taking this class? From what you said the other day, it sounds like you already know this stuff.” Later in the semester, the same male student asked the professor, “but isn’t there another way to program that operator?” The instructor agreed and called on the student to explain to the rest of the class. The student did not articulate an explanation, but instead said, “that’s what I get for opening my mouth.” Interestingly, when we tested our belief that students were posturing in discussions with three CS professors, all laughed and agreed that students often “show off” like that. To people who consider themselves to be outsiders to the CS classroom, however, such posturing seems unusual. Most students we observed, however, remained silent, effectively avoiding notice by their peers.

Some students would demonstrate their knowledge by pointing out mistakes in syntax on professor’s slides or on work written on the blackboard. Students frequently interrupted lecture with comments like, “Shouldn’t ‘expression’ and ‘term’ be the other way around?” or “you’ve made a mistake in ______.” In informal interviews, instructors acknowledged that being precise is essential in programming, yet they felt that students who publicly
challenge their knowledge and who point out minor mistakes on slides interfered with lectures simply to make the point that they were experts. Worse, these professors felt that such attention-drawing strategies distracted others from the real point of the lectures, focusing too much on details and not on concepts. However, professors’ reactions to such challenges and displays of knowledge often validated, rather than discouraged, the behaviors.

When students pointed out errors, professors consistently either offered accounts for having made a mistake (e.g., “that comes from doing things at the last minute”) or attempted to make light of the mistakes in a way that indicated embarrassment (e.g., “obviously, I believe in text readers”). After a series of such corrections, one professor began finding his own mistakes as he lectured and jokingly corrected them ‘live’ “so [that] people who have me next time will benefit from these debugged slides.” These accounts for mistakes can be seen as attempts to mitigate the dispreferred behavior and also function to acknowledge the students’ right to point them out. Consider alternative responses: the professor could say, “You’re right. But these slides are meant to help me convey theoretical information, not programming code, so those details aren’t important here. How about coming to my office hours to debug my slides?” We saw no such response, which could be used to preempt a climate of criticism. Over time and in conjunction with other similar messages (e.g., a grading system that penalizes students a full 80 percent of their grade if the program doesn’t compile, regardless of the correct planning and steps indicated in their programs), reactions we observed indicated to students that it is not really okay to make trivial mistakes – especially not in public – and that judging others’ knowledge and abilities and defending your own are expected and acceptable behavior.

4. THE CREATION OF A DEFENSIVE CLIMATE

The interactions described above combine to create, maintain, and reinforce a learning environment characterized by a defensive communication climate, as discussed by Gibb (1961). No single person and no one class created a defensive climate, nor did we see significant patterns of all the types of defensive communication that Gibb identified. Only a series of interactions over extended periods of time leads to such a climate. It is important to note that the faculty members who allowed us in their classes are actively seeking ways to encourage interaction in their classes and to re-enfranchise those students who
are underrepresented in the major. Still, the types of interaction we saw in most of these courses, impersonal communication, guardedness, and jockeying for superior status, lead to and lend their support to the creation and maintenance of a defensive communication climate which works against these goals.

The impersonal environment and guarded behavior we describe is characterized by neutral, as opposed to empathetic, communication. The depersonalization of students through failure to use their names and an environment that discourages self-disclosure can be perceived as a lack of concern for others, intended or not. This violates the normal human desire to be perceived as important, as someone for whom others are concerned. This is a particularly salient desire for women, in that they tend to define themselves in terms of their relationships to others, as opposed to men, who often define themselves in terms of their occupational contributions to society (Gilligan, 1982). The neutral and impersonal nature of many of the practices in the CS courses observed can unintentionally and indirectly communicate rejection rather than acceptance and therefore fail to recognize the value of the individual. This neutral communication style is further supported when teachers repeatedly tell students that what they’re learning is “easy.” In doing so, they implicitly deny the legitimacy of students’ concerns and fears about mastering what they perceive to be new and difficult material. Again, women are particularly sensitive to this sort of rejection and denial of their concerns (Tannen, 1999); further, women are more likely to enter the computer science major with less experience.

Much of the system of informal hierarchy described here stems from communication that emphasizes superiority rather than equality. Clearly, the problem of unequal preparation in introductory computer science courses contributes to the problem. When students with and without programming experience attend the same lectures and do the same assignments, one group will be challenged and the other bored. This is a particular problem in departments with limited resources for creating bridge courses or advanced introductory courses. However, equating students experienced with programming to being “smart,” implying that one must think that extending programs like the peg board game is “cool,” and describing students who compete to do more and to out-do one another as “rocket scientists” (i.e., “smart”) function to reinforce a social order defining certain types of people (those without experience) as not belonging.

Not all CS majors have time to “extend a game” nor the desire. As Margolis and Fisher (2002) show, women (and we believe many men) enter
computer science with the desire to apply what they learn to create solutions to human activity (e.g., education, medicine, business). The identification of those who belong as being “smart” and competitive seems to lead to a competitive environment where many students attempt to demonstrate their superiority, not just in the private execution of their assignments, but in the way they present themselves to their peers and challenge their teachers publicly. In the absence of early opportunities to learn what other students really know, given the fear of cheating and of displaying one’s lack of experience, other students remain silent and alone. On top of this, student behavior contributes to a communication environment in which teachers and students are at risk for and often expect a kind of public criticism that tears down: mistakes are cause for embarrassment. Once again, these communicative practices can be discouraging to women, who tend to exhibit fewer of these behaviors and who are often more cooperative in their approach to social interactions. While we endorse public critique when handled well (i.e., “constructive criticism”), a learning environment should be a place where making a mistake is an acceptable action.

5. CREATING SUPPORTIVE CLIMATE: AN EXAMPLE FROM ASTROPHYSICS

Many specific communicative and interaction behaviors can encourage a supportive communication climate and discourage a defensive climate. It is clear that hierarchical structure (and its implications for communication) is an important element of any educational environment. Although students may have been socialized to expect distance from their professors and fellow students such as those in the CS program we discuss here, it is possible for a professor to build and encourage more supportive interaction through the regular use of student’s names and other behaviors that reduce the social distance between students and the authority in the classroom as well as make the value of students as individual learners clear. Below, we offer a short anecdote taken from research author Garvin-Doxas has conducted in space science classrooms on the same campus.

Until about 5 years ago, little attention was paid to the improvement of teaching and learning in this program, since the department’s mission is to conduct world-class research, and this forms the basis of tenure and promotion decisions. Even today, those professors who work seriously on their teaching
are in the minority. In addition, the students who enter the undergraduate program, even as non-majors, are socialized similarly to the CS students in the program we described above. This prior socialization and anticipation of a certain sort of learning environment, one characterized by anonymity and competition, is in large part a result of students’ negative experiences in science and mathematics courses from much earlier in their educational history.

Just recently, a professor in Astrophysics decided that she wanted to have a better, more personal connection with the students in her large lecture course. She wanted them to talk to her and to each other in class when she gave them assignments using computer simulations. Garvin-Doxas suggested, among other things, that the professor learn students’ names or, at least, many of them. The professor decided to take “mug-shot” style photographs of students in groups of three (i.e., frontal shots with name plates below their chins). These photos were taken during the second week of the term. Though unplanned, waiting in line to have their photographs taken gave students time to become acquainted outside the classroom environment. Interestingly, although the students were not required to sit with the two students with whom they were photographed, many did. A by-product of the professor’s taking the trouble to learn students’ names (even in a large class) was that when students began to engage in collaborative activities, they had already gotten to know one another, making it easier to collaboratively complete an in-class assignment.

At each lecture section, the professor spread the photos out on a table in the front of the room to help her identify the students. Then, rather than have the teaching assistant return papers to students, the professor would walk around the room looking for each student, beginning just prior to class time and ending about 2 min into the class session. Three weeks into the term, she knew the names of all but a few students (those with irregular attendance). In informal interviews, students said that they were initially embarrassed at how silly they looked in their pictures, but that since everyone looked equally silly, it no longer bothered them. In fact, without being specifically asked, several said with surprised wonder that they did not mind the photos because they had helped the professor to learn students’ names. The professor moved around the classroom, even during lectures, so she was not always physically distanced and separated from students, both of which affect interpersonal relations.

These students experienced a more supportive learning environment than those described in our CS data. In this communication climate, it was
preferable (or required) for students to work together on assignments rather than to work alone; the climate encouraged them to articulate their understanding of concepts to their peers and also to their professor. Finally, the implicit message sent by the professor about the importance of knowing their names and apparent desire to be relationally closer was that students are human beings who deserve to be treated with dignity. The examples here, learning student names and less physical distance from students, are relatively simple behaviors to initiate, and require forethought, organization, and small amount of resources for camera and film. The investment is small relative to the return of making the learning environment more supportive, like a community.

It is important to note that the professor did not lower her expectations for the quality of student work nor did she have to spend time using “touchy-feely” activities to bolster students’ confidence. Student confidence was bolstered by virtue of an improved learning environment, in which they were not allowed to feel anonymous and in which they could more accurately judge their own progress in comparison to their peers. That is, peers’ knowledge was not a mystery. In computer science courses, the lack of discourse among students and the self-presentation as knowledgeable on the part of some students meant that they could not make this judgment accurately. In the astrophysics course, those students who failed very likely knew that they honestly did not belong in the discipline, either because they were not willing (or able) to spend the time studying or because the subject matter was too hard – but not because they believed other students’ unchecked one-upmanship.

We present this example as a means of illustrating the sorts of things that teachers can do to change the learning environment and develop a more supportive communication climate. There are many other ways to achieve the sort of result the Astrophysics professor did. Awareness, a conscious effort, and consistency are the main ingredients for success.

6. CONCLUSION

We have provided in this paper an ethnographic description of defensive climate as created and maintained in many of the computer science classrooms we observed. These data were collected at only one university, in a selection of classes in one computer science department. It is not our
intention to claim that the description here can be generalized to all computer science classrooms. Nevertheless, the results of the study have been termed unsurprising by many computer science faculty members from other universities, suggesting that such climates are not unusual. To the extent that the reader sees essential similarities in his or her own classrooms and the descriptions we have presented, the analysis presented here may be valuable for permitting reflection about how to improve communication climates.

Our intention is to allow faculty to recognize specific behaviors on the part of their students or themselves leading to defensive climate, so that they might eliminate these from their own classrooms. As Gibb (1961) points out, defensive communication is endemic to most traditional learning environments. We believe that even though some students might enter the major with tendencies toward competing, when their behaviors are not actively discouraged, a defensive climate flourishes. While instructors do not desire nor alone create defensive climates, it is they who have the power to change it. To meet the demand for IT professional collaboration skills, increase student participation in classes, and increase the participation of under-represented groups, it will be necessary to be cognizant of the ways in which the dimensions of communication climate can shape students’ beliefs about appropriate behavior not only in individual classes, but throughout their academic careers and into their professional careers. Using techniques that allow students to articulate their genuine knowledge to each other, without decreasing academic rigor, as did the astrophysics professor described above, may create climates in which a larger variety of students feel that they can safely learn.

ACKNOWLEDGEMENT

This material is based upon work supported by the National Science Foundation under Grant No. 0090026.

REFERENCES


