Importance of Gender Homophily in the Computer Science Classroom

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The number of women earning bachelor's degrees in computer science (CS) peaked at 15 126 in 1986 but plunged to 7063 by 1995. Since then, the number has increased slightly to 10 474 in 2000 [18, tab. 2-22]. Yet, a survey of incoming freshman in 2002 revealed that only 3.2 percent of women planned to major in CS, compared to 14.6 percent of men [17, p. 2-6]. Although a growing number of women earn master's degrees in CS (from 2786 in 1995 to 4868 in 2000), there is a marked decline in the number of women earning doctoral degrees (from 186 in 1995 to 155 in 2001) [18, tabs. 2-24, 2-26].

The problem of disproportional representation of women in the CS discipline in post-secondary education has become a major concern [2], [28]. In recent years, scholars have identified a number of possible factors that affect the enrollment and retention of female students in CS programs. These factors include exposure to computers and gender socialization [27], gender bias in software design [8], motivational differences [13], differences in learning strategies and behaviors [10], [24], negative attitudes toward women in CS programs [6], and masculine CS culture [12].

This study explores how particular communication behaviors influence women's experience of the CS classroom in the United States. In particular, it investigates the correlation between students' perceived gender similarities with others in the CS discipline or homophily [23], their feelings about the closeness and openness of communication between people or immediacy [21], the resulting presence or absence of a supportive communication classroom climate, which is understood as a set of systemic entities whose presence and dimensionality may be inferred from students' and teachers' perceptions of psychosocial attributes of the classroom social system [32], and finally, their intention to remain in the CS program.

Teacher immediacy has been posited to have a linear relationship with increased student learning [20]. The more students feel they can communicate openly with their instructors, the better they are likely to do in learning outcomes. Although student involvement in the learning relationship with the teacher has been studied to some degree [15], student-to-student immediacy has not been adequately theorized in the literature. The dynamic of student-to-student immediacy may be of particular interest in a field of study such as CS, which has a strong, male-dominated classroom

ting has been identified [14], [19]. Feelings of interpersonal familiarity and acceptance by peers can mitigate general anxiety in the classroom [25]. However, despite the existing research on communication climate in the educational setting, no studies have connected teacher-immediacy, peer-immediacy, and homophily to conceptualize an overarching classroom communication climate. It is our proposition that all three must be measured in conjunction to understand the formulation of classroom climate and its effects on female students.

tions of higher education that were designated as Minority-Serving Institutions (one historically Black university, two Hispanic-serving institutions, and one tribal university). These students were in their second and third years of CS study. All interviews were conducted by Roli Varma, principal investigator on the project, to ensure that data collection was consistent. Random sampling was used to select subjects with sufficient numbers of women and men. However, purposive sampling was used when the numbers of women and men majoring in CS was small (e.g., Native Americans). The sample size of 66 students included 35 females and 31 males. The sample was ethnically diverse: 22 Whites (11 female, 11 male); 15 African Americans (7 female, 8 male); 10 Hispanics (5 female, 5 male); 10 Native Americans (8 female, 2 male); and 9 Asian Americans (4 female, 5 male). This sample size was considered adequate to detect medium effects on gender. Each student was asked the same 61 questions and 15 of those questions provided the specific data on the concepts of teacher immediacy, student immediacy, gender homophily, and classroom climate (Table I).

> **The perception that gender differences exist in the classroom predicts that meaningful communication will not occur and that a positive interpersonal relationship will not exist between male and female students in the classroom.**

culture [12]. Both teacher immediacy and student immediacy are necessary to create a supportive communication climate in the classroom.

Homophily has been shown to be closely related to the frequency of communication and interpersonal attraction between two or more individuals [22]. If students could be encouraged to find similarities among themselves rather than focusing on apparent differences related to gender, they might feel more comfortable with one another in the classroom, which would lead to greater immediacy and a more positive learning environment.

Studies on classroom climate have shown that students associate their opinions of a class with the degree of support and sense of personal value that they receive from the instructor. To a limited degree, the importance of peer relationships in establishing a supportive communication climate in a classroom set-

Data Samples and Reliability

This paper examines classroom climate as it correlates to student satisfaction in the CS classroom, and considers the influence of gender homophily, teacher immediacy, and peer immediacy on satisfaction. It examines the following hypothesis:

H1: Teacher immediacy and CS program satisfaction will be correlated positively.
H2: Peer immediacy and CS program satisfaction will be correlated positively.
H3: Gender homophily and CS program satisfaction will be correlated positively.

The data for this study were gathered in 2002 and 2003 through in-depth interviews as part of a larger project on women in information technology. Interviews were conducted with 66 undergraduate students majoring in CS at four institu-

A content analysis coding scheme was developed based on four variables: teacher immediacy, peer immediacy, gender homophily, and satisfaction in CS. The following terms were operationalized:

1) *Teacher immediacy* was any comment about a negative or positive interpersonal communication relationship with an instructor or a teaching assistant. Example: "Doesn't have time to give personal attention to students," = negative teacher immediacy. "When I ask questions they help," = positive teacher immediacy.
2) *Student immediacy* was any comment about a negative or positive interpersonal communication relationship with

another student studying CS. Example: "Thinking that you can't do anything on your own without their [male students'] assistance," = negative student immediacy. "They [the other students] always treated me like one of the group," = positive student immediacy.

3) *Gender Homophily* was a single category utilizing any comment designating that there was (yes) or was not (no) a difference in CS students based on gender. Example: "I don't see any difference in me being a woman," = difference no. "The women don't speak up," = difference yes.

4) *Satisfaction* was any comment denoting an unreserved intention to stay in the CS department to complete a degree, any statement denoting that the person has never thought about changing their major from CS, or any statement that they are completely satisfied with their major. Examples: "No, never thought of changing my major," "I always knew I would be in computer science," and "There is nothing I don't like."

Two categories, negative and positive, were designated for teacher immediacy. Two categories, negative and positive, were designated for peer immediacy. Two categories, yes and no, were designated to measure any perceived difference between students in CS based on gender. One category "yes" was designated for satisfaction. This created seven categories. Statements were coded only once in a single category, creating an exclusive coding system. Each interviewee was designated by a numeric label (1-66) and each interview question was designated alphabetically. Therefore, each coded statement was designated by an alphanumeric label.

Two trained coders coded the interviews to ensure that data coding

was consistent. Each coder was first given the same data comprising 20 percent of the interview responses. After reconciling differences, the remaining data was then coded. Intercoder reliability [11] for each category was assessed using Scott's P, and reliability was established between coder one and coder two. Reliability for peer immediacy was 0.84, for teacher immediacy 0.77, for gender homophily 0.87, and for satisfaction 0.79. Overall, reliability was 0.81. All of these values are within the acceptable range for reliability. A total of 330 items were coded.

The data were analyzed in three stages. First, frequencies for all variables, including demographic variables, were investigated. Second, a number of bivariate relationships were computed using a chi-square analysis (Table II). Gender, immediacy, homophily, and satisfaction were measured against demographic variables such as ethnicity (White/non-White) and year in the CS program. Third, stepwise logistic regression was used to explore the relationships between the variables that were included in the hypotheses of the present study. A logistic regression model was tested with satisfaction as the dependent variable, and teacher immediacy, peer immediacy, and gender homophily as the independent variables.

Gender Homophily a Significant Retention Predictor

The first hypothesis predicted that teacher immediacy and CS program satisfaction would be correlated positively. No significant bivariate relationship (Table II) was found between teacher immediacy behaviors and CS program satisfaction and it was therefore not included as a significant predictor in the logistic regression model. Hypothesis One was not supported.

The second hypothesis predicted that peer immediacy and CS program satisfaction would be correlated positively. No significant bivariate relationship (Table II) was found

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Table I
Interview Questions

1. So far what are your impressions of your computer science program with respect to classes?
2. So far what are your impressions of your computer science program with respect to teachers?
3. So far what are your impressions of your computer science program with respect to fellow classmates?
4. Can you tell me something encouraging/discouraging that has happened to you or someone you know in your program studying computer science?
5. Have you considered changing your major from computer science to something else? If yes, why?
6. In your opinion, what is it like to be a woman in your computer science program?
7. Do any incidents come to mind that are related to being a woman in the computer science program?
8. Do you consider yourself as strong or stronger in computer science as the other men/women in your program?
9. Why do you think there are so few women that study computer science in your program?
10. Do women encounter obstacles that men do not in studying computer science in your program?
11. In your experience, how do the men you know in computer science view the women in computer science?
12. In your opinion, are careers with a computer science degree attractive to women?
13. If you could change something about your current computer science program to make it more attractive to women, what would they be and why?
14. Describe what you like/dislike about computer science?
15. Describe the typical computer science student in your program?

between peer immediacy behaviors and CS program satisfaction. Therefore, this variable was not included as a significant predictor in the logistic regression model. Hypothesis Two was not supported.

The third hypothesis predicted that gender homophily and CS program satisfaction would be correlated positively. Bivariate measures and stepwise logistic regression were conducted to determine which independent variables (teacher immediacy, peer immediacy, and gender homophily) would predict satisfaction in CS education. Results indicated a significant relationship. The perception that gender homophily exists was positively correlated with satisfaction ($x^2 = 19.9$, $p < .05$). Additionally, the logistic regression results indicated the overall model fit of one predictor of satisfaction, perception of gender homophily ($x^2 (1) = 10.30$, $p < .05$; Nagelkirke $R^2 = .22$; OR=.11[95%CI .023 to .547]). The odds ratio for this variable indicated a significant change in being able to predict satisfaction. Hypothesis Three was supported.

The purpose of the study was to investigate the communication climate in the CS classroom as it relates to the satisfaction of female CS students. In this sample, perceptions of a gendered homophilous culture detectable in the classroom climate signalled whether or not students would remain in their CS programs.

Specifically, the perception that gender differences exist in the classroom predicts that meaningful communication will not occur and that a positive interpersonal relationship will not exist between male and female students in the classroom. Moreover, those students who perceived a division based on gender were more likely to be dissatisfied in CS. Conversely, students who perceived that there was no difference between men and women in skill and ability, and in the way they were treated in the classroom, were more likely to be satisfied in CS. The perception of belonging to a particular culture has an impact on the way students and teachers interact, and on learning outcomes [5], [9], [31], [32]. The present finding provides a new theoretical context for the study of how a strong, male-dominated culture in the CS classroom affects the communication climate.

It is important to note that no significant relationships were found regarding teacher immediacy. There is extensive literature on measures and significance of teacher immediacy in relation to student success and retention in the classroom [16], [20], [30]. In this study, the connection between gender, climate, and satisfaction was supported, while teacher-student and student-student communication relationships were not. In the data set utilized for the present study, students commonly gave general answers about liking their peers and feeling supported. This is an indication that a more specific study addressing how individual peers who like and support one another build good peer relationships would be beneficial.

Immediacy needs further investigation that utilizes methodology asking for specific responses related to both teacher and peer immediacy.

Exploring the Influence of All Classroom Relationships

Research on teacher immediacy, peer immediacy, and gender homophily as an overall construct of communication climate in the classroom has a number of theoretical and practical implications. Theoretical implications include broadening the scope of current instructional communication studies. Studies need to go beyond the current concentration on teacher immediacy as the major factor affecting student learning outcomes to explore the influence of all classroom relationships. Practical implications of this research include refocusing interventions that are intended to increase the number of women who enter and remain in the study of CS.

The current study supports the self-reporting of women indicating that there is still a strong gender-centered culture in the post-secondary CS classroom [12], [24]. Several solutions have been suggested to overcome this dynamic. Some posit that more female role models and female-centered support systems would be helpful in retaining women in CS programs [7], [26]. Others have done research on providing all-female computer classrooms in schools [6], [29] to counter the effect of the masculine CS culture. Additionally, there has been a focus on designing a CS curriculum for girls [4]

Table II
Bivariate Relationship for Gender, Teacher Immediacy, Student Immediacy, Homophily, and Satisfaction in Computer Science

	Gender x^2	Satisfaction x^2	Teacher+ x^2	Teacher- x^2	Peer+ x^2	Peer- x^2	Homophily x^2
Gender		0.088	0.409	0.002	0.851	3.04	0.041
Satisfaction			0.001	0.148	0.015	0.015	19.90
Teacher+				0.203	0.680	0.129	0.541
Teacher-					0.001	2.37	1.07
Peer+						1.98	0.098
Peer-							0.120
p<.05							
n=66							

and promoting teacher sensitivity to gender issues in programming [3]. The aim of such remedies is to encourage girls to freely ask questions and make "mistakes" without feeling judged [1].

The present research, however, indicates that these solutions have limited efficacy, and that more work needs to be done on current classroom climates to change the gender-centered dynamic. Possible areas for improvement include observing the way that instructors communicate with males in contrast to females, structuring classes in such a way that females feel comfortable communicating with all of their peers, and creating a new, more individual culture that would facilitate a more supportive classroom climate.

While this study suggests that measures of both peer immediacy and teacher-student immediacy require further exploration, it is possible that a combination of prior knowledge and experience may also affect the ability of students to have positive interpersonal communication with their CS classmates. Past efforts at retaining women in CS have concentrated on providing early hands-on computer experiences and recruitment into programs. The premise of these efforts is that a critical mass of women will provide a community of scholars that will support each other. Some of these endeavours have been successful, but they do not tackle the underlying factors treated here. Researchers and schools should take a serious look at these factors when modifying programs to improve the retention of women.

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