How do Teaching Practices and Use of Software Features Relate to Computer Science Student Belonging in Synchronous Remote Learning Environments?

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ABSTRACT

When faculty behaviors foster students' sense of belonging in class, students report better learning experiences and are more likely to remain in the major. Sense of belonging is the feeling of being a valued and legitimate member of a community. Understanding teacher immediacy behaviors that cultivate belonging in postsecondary synchronous remote classrooms is important for retaining students in computing, where remote coursework is increasingly used to address increases in enrollment. This paper reports on an exploratory, survey-based study on the relationship between instructor immediacy behaviors and use of conferencing software features (e.g., chat, breakout rooms) with student sense of belonging in synchronous remote learning environments. Responses from 125 computing students from approximately 53 courses across the US show that students feel a moderate sense of belonging in their courses, with no differences found across demographic groups. Belonging was found to have a strong relationship with students' overall opinions of their courses and their likelihood of completing the major. Students' camera preferences and instructor camera requirements had no effect on belonging. A regression analysis showed that no tool use variables predicted student sense of belonging. However, two teacher immediacy behaviors, setting aside class time to talk about upcoming course content and use of humor, were significantly associated with an increase in sense of belonging.

CCS CONCEPTS

• Social and professional topics • Computer science education

KEYWORDS:

Belonging; Synchronous Remote Learning; Undergraduate Computing Education

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1 INTRODUCTION

Student sense of belonging has been shown in many empirical studies to result in positive student outcomes, including persistence [17, 33]. Sense of belonging is usually accomplished through interaction with relevant others in social spaces, both physical and virtual. Studies of synchronous remote learning since the COVID-19 pandemic shutdowns suggest that students are less engaged and experience a lower sense of belonging in their programs of study [23, 32, 35]. Prior to the COVID-19 pandemic, students who took online courses were most likely to be non-traditional students. Today, however, almost all undergraduates have experience with online courses, the use of which is likely to increase as computing departments seek to manage costs and enrollments. Understanding teaching behaviors and conferencing software tool use that enhance or distract from belonging is important for retaining these students. We describe below a survey-based study of computing students' sense of belonging in synchronous remote learning environments and explore the relationship between belonging with teacher immediacy behaviors and conferencing tool use.

2 MOTIVATION FOR THE STUDY

2.1 Belonging: Importance and Elements

Belonging is a basic human need that can shape many choices [20, 31]. Sense of belonging refers to one's subjective evaluation of how well they are interpersonally and intellectually integrated in a context, such as family, a workplace, or college. When students feel they belong, they perceive that they fit in, are valued by others in the context, connected to others, and supported socially and academically [31]. A large body of empirical studies shows that increases in belonging contribute to learning, engagement, persistence in STEM majors, motivation, enthusiasm, confidence, feelings of self-worth and

acceptance, and lower stress [17, 33]. Sense of belonging in STEM varies by demographic group, with students who are historically marginalized experiencing lower belonging [31].

In computer science, a few studies have demonstrated differences in sense of belonging based on demographic groups. Stereotypes about who belongs in computing can negatively affect minoritized students' sense of belonging in the profession. For example, women enter CS with lower sense of belonging, which also declines over time more than does that of men [16, 21, 28]. Sax, et al. found that women members of minoritized racial and ethnic groups may enter computing with sense of belonging on par with majority men, lower than minority men, and higher than majority women [28].

Students need to experience belonging in their institution, their departments, and in classroom learning spaces [17]. In these social spaces, belonging can be communicated explicitly and implicitly, and intentionally and unintentionally. For example, several experimental studies have shown that when messaging about what it takes to be successful in a field explicitly includes words denoting exceptional ability (e.g., "brilliance"), women are less likely to feel they belong, while men are not influenced [6]. Similarly, Cheryan and colleagues have studied "ambient" belonging to show how implicit messages in in-person and virtual computing classroom decor influences women's intention to enter and remain in computing [8, 9]. The study presented here focuses on implicit behaviors that can affect sense of belonging.

2.2 Teacher Immediacy Behaviors

Immediacy is defined as behavior that reduces physical and psychological distance between people. Immediacy behaviors enhance closeness, friendliness, and feelings of warmth and result in lower anxiety [34]. Immediacy behaviors can be both implicit and explicit and can take the form of nonverbal or verbal communication. Examples of positive nonverbal teacher immediacy behaviors are eye contact, smiling, moving close to students, nodding one's head, and relaxed body position. Examples of verbal teacher immediacy behaviors are use of humor, using students' names, connecting course topics to the outside world, having informal conversations with students, self-disclosure, and other "caring" behaviors [10]. Caring can also be shown tacitly by being clear in one's teaching, such as by regularly communicating the organization and flow of a course [22, 34]. Effects of positive teacher immediacy for students include better learning environments and higher perceptions of teacher credibility [19]. Many teacher immediacy behaviors are more difficult to accomplish in remote classrooms. For example, eye contact can only be simulated, it is impossible to move physically closer to students, and informal conversations are much more difficult to accomplish.

2.3 Conferencing Software Features

Conferencing software used for teaching remote classes, such as Zoom or Microsoft Teams, offer various features for engaging users in online classes. For example, breakout rooms have been recommended as ways to connect students, and chat, polling, and clicker questions are recommended as ways to encourage student interaction and show that their opinions matter.

2.4 Research Questions

The study presented here presents students' sense of belonging in a synchronous remote class they took in spring 2021 to find out how well they felt they belonged and whether certain teaching behaviors and use of tools influenced belonging. We asked the following research questions:

1. What is computing students' sense of belonging in their synchronous remote computing classes? How does sense of belonging relate to students' overall positive or negative experiences of synchronous remote computing courses?
2. How often did instructors use teacher immediacy behaviors and software tools thought to foster student sense of belonging? How effective do students find these teacher behaviors and tools for promoting positive engagement?
3. How is sense of belonging related to teacher immediacy behaviors and software tool use?

3 METHODS

We administered a survey of undergraduate computing students in April and May 2021. While 125 participants responded to the survey, 80% of responses were complete and 20% were partial. Also, students were branched only to applicable questions. As a result, the number of responses presented in the results will vary. The results reported are one component of a two-part survey. One set of questions asked students to name a particular class they had just taken and answer questions about it (this paper). The other set of questions, under preparation, asked students to compare online and in-person classes more generally.

Survey Items. The survey items came from a validated and highly reliable belonging composite scale and the operationalized themes emerging from an interview-based study of 32 undergraduate computing students during the 2020-21 academic year [13]. All survey items included either a Likert scale or nominal choices, with a "don't know" option that was placed outside of the scale to minimize the ambiguity of midpoints [26]. Survey items included:

- Belonging. Several psychometric scales have been used to measure belonging, including among computing students [25, 28]. The scale used in this study depends on the cognitive and affective constructs described and actively researched by theorists [1, 18, 31]; these are related to feelings of membership and commitment (i.e., fit, interest, liking) and security (i.e., support, acceptance, comfort). Because we study belonging at the classroom level, the nine-item scale incorporates experience with instructors and other students, and beliefs about the class subject matter. The scale does not include negative items that could trigger feelings of alienation and depression for ethical reasons. The scale was validated with more than 500 computing students; and has high reliability, with Cronbach's alpha = .907,

suggesting that taken together, the survey items measure a single theoretical construct.

- Interviews. In semi-structured interviews, students were asked about experiences in synchronous remote learning classes, including teacher practices and tool use interviewees believed affected their engagement or disengagement and overall learning. Emergent themes included frequency and effectiveness of specific teaching behaviors and use of conferencing software features. Also discussed was camera use in terms of instructor policy and student preferences. Survey items developed from these themes include seven teacher immediacy behaviors and six software features. These survey items were piloted with three computing students to ensure construct validity.

Survey Administration. To ensure that students were describing experience relevant to this study, the survey began by defining synchronous remote learning, then asked students to name a particular synchronous remote course they had just taken about which they answered questions. Whatever course title or code students had named was piped into each subsequent question to increase the chance that they were only thinking about their experience in that course. The survey began by asking students for an overall evaluation of the course to avoid order effects of the more detailed questions. The detailed questions were ordered as follows: frequency of immediacy behaviors, effectiveness of immediacy behaviors (only if frequency was not "did not use at all"), frequency of software tool use, effectiveness of tool use, belonging scale questions, and demographic questions. The completely anonymous survey was fielded during April and May of 2021 using Qualtrics software. No incentive was offered to complete the survey.

Sample Development and Profile. We used an email list of 2,270 computing professors in the U.S. The email addresses were stratified by type of institution (2-year, Historically Black Colleges and Universities, Hispanic-serving, liberal arts, research, and tribal colleges). We then sent invitations to faculty asking them to send a scripted email containing a survey link to their students. As the decision to forward or not forward the survey to students was made by these faculty members, there is no way to determine a response rate. The sample may also be biased in favor of students who felt a bond with that instructor. Most respondents (n = 102, 82%), were computer science majors and minors. Other disciplines included computer engineering, computer information systems, electrical and computer engineering, networking, and information science. Due to the small number of non-computer science students in each group, we were unable make comparisons across majors. Although no identifying information was collected, we conservatively estimate that students hailed from at least 53 distinct courses and at least 21 different universities. We collected demographic data so that we could explore differences across groups, but we did not find any ($p < .05$). Among students who chose to supply demographic information (N=99, 80%), categories include:

- Level and age. First year 19%, second year 23%, third year 19%, 4th and above 28%, graduate students 10%. Participants' ages ranged from 18 to 54. Age data was divided into a binary variable of "younger" students (aged < 24, n=73 , 74%) and "older" students (aged > 23, n =26, 26%).
- Gender. Men 54%, women 35%, showing significantly higher participation of women than is reflected in national graduation of computing majors. Non-binary or gender queer 7%, and prefer not to answer 4%.
- Race/ethnicity. Non-Hispanic White 49%, East Asian 17%, South Asian or Asian Indian 11%, Hispanic or Latino 9%, two or more races 6%, other 4%, and Black 3%. Students who identify as members of historically marginalized groups are underrepresented in the survey and were combined for inferential analysis.
- Citizenship. Domestic students 84%, international 16%.
- First-generation status. Neither of their parents had gone to college, 25%.

4 RESULTS

Results presented below have varying response rates, due to question branching and different levels of survey completion. The tables include means and standard deviations (SD) for scale items, and number of responses (N). To show distribution, we include sparklines (miniature column charts). "[Course]" in each survey item would be read by students as the actual course title or code they had written in.

Table 1: Feelings Toward the Course and Belonging

Overall Feelings	**N**	**Mean**	**SD**
To what extent do you feel positively or negatively towards [course]?	124	2.81	1.02
4-point scale from 1-Very Negative to 4-Very Positive			
Belonging Scale Items	**N**	**Mean**	**SD**
I like coming to [course].	115	2.94	1.07
I feel like my participation in [course] is valued.	109	2.94	1.08
I feel comfortable talking to other students in [course].	112	2.94	1.00
I fit in with the students in [course].	105	2.89	1.00
I feel comfortable asking questions in [course]	113	3.11	1.00
The instructor of [course] encourages me to succeed.	114	3.47	.81
I feel comfortable talking to the instructor who teaches [course].	114	3.38	.94
The professor respects students in [course].	115	3.57	.71
My experience in [course] has increased my interest in the course material.	115	3.05	1.08
Overall sense of belonging composite scale	101	3.20	.72

4.1 Belonging & Experience: Strongly Related

We began the survey by asking a single question about overall experience in the synchronous remote class on a four-point Likert scale, shown at the top of Table 1. About 66% of students felt

positive and 34% of students felt negative about the approximately 53 courses represented in the data, with a mean of 2.8, above the midpoint of 2.5. This value does not offer much insight by itself due to the number of different classes being judged. However, it is useful for providing understanding of how belonging relates to overall positive or negative feelings.

Also shown in Table 1, we asked nine questions about student belonging using a 4-point scale from disagree strongly to agree strongly. As shown by standard deviation and distribution (right-leaning showing more agreement), students had positive experiences with the instructors in these classes. A large majority of students felt that their instructors encouraged and respected them and felt comfortable talking to the instructor. Students' comfort asking questions in class was also relatively high, at a mean of 3.11 out of 4. While still relatively high, feelings of belonging related to interaction with other students, enjoyment going to the class, and feeling valued were lower and showed more variation.

We then compared belonging overall to overall perception of the course. We conducted factor analysis on the responses to the belonging survey items, exploring whether the nine items represented multiple factors. With two factors, student-related and instructor- and course-related items, there was significant cross-loading for feeling that one's participation is valued. Because feeling valued is a theoretically important element of belonging, and because the number of responses should be larger to meet the assumptions of principal component reduction, we chose not to remove this item. Instead, we use a single composite index for belonging, with theoretical justification. A class is a complex social environment which includes all these features; it is neither easy nor sensible to separate them. As a single scale, all nine belonging factors combined had excellent reliability (α = .907), meaning that respondents tended to respond to them in a similar way and that taken together, the nine survey items represent a single construct. Overall, students' sense of belonging was "moderate," with a mean of 3.2 and standard deviation of .72 (N=101). The distribution is left skewed, with several high belonging scores pulling up the mean (further analysis shows they are associated with many different course titles). We found no significant differences across demographic groups.

To assess the relationship between students' sense of belonging and their overall positive or negative experiences of synchronous remote computing courses, we used a Spearman's rank-order correlation. We found a statistically significant, strong, positive correlation between sense of belonging and overall perception of course, with a clear monotonic relationship ($r_s(122) = .784$, $p < .001$).

4.2 Teacher Immediacy Behaviors

Research question 2 asks, "How often did instructors use teacher immediacy behaviors and software tools thought to foster student sense of belonging? How effective do students find these teacher behaviors and tools for promoting positive engagement?" In this survey, we asked participants to indicate frequency of use as well as rate the effectiveness of the behaviors and tools identified in thematic analysis, which include:

- Humor. If done appropriately, humor brings people together through shared enjoyment and is shown to have positive effects for students (e.g., for softening criticism) [2]; humor also shows an instructor's authentic self [34];
- Instructor self-disclosure. Any information shared by instructors with students, and which cannot know by simply looking at instructors is self-disclosure; this is not necessarily intimate or invasive of privacy (e.g., "I rode my bike today" is not private). When relevant to the course, self-disclosure shows an instructor's authentic self, improves the meaningful connection of course content for students, and can build interpersonal relationships [7, 30];
- Connecting course content to the outside world. Meaningfully relating to students' interests is an important predictor of retention in computing [4, 19, 24];
- Showing caring with respect to students' organizational needs and learning. Instructor clarity creates positive connections with the instructor and the material, and reduces anxiety and time spent trying to make sense of organization [10, 19]; and
- "Cold calling." Asking students to answer questions involuntarily, when done without making students uncomfortable, creates the expectation that all students should participate and increases voluntary participation for both women and men [14, 15, 29].

The questions we asked to operationalize these behaviors were based in interview data and are shown in Tables 2 (frequency) and 3 (effectiveness). Students were asked to indicate the frequency of use on a four-point scale from "never" to "every class," and the perceived effectiveness of use on a five-point scale from "not effective" to "extremely effective." Effectiveness questions were only asked if a respondent indicated instructor immediacy behaviors were used in their class. Thus, response counts vary.

Table 2 Frequency of Teacher Immediacy Behaviors

How frequently does the instructor use the following teaching methods in [course]?	N	Mean	SD
Share a written or verbal classroom agenda for the day at the start of class?	125	3.14	.99
Set aside time at the beginning or end of class to talk about upcoming course content?	124	3.32	.75
Ask questions to individual students when they aren't raising their hands?	119	1.94	1.06
Connect course content to topical issues in the world today?	120	2.67	.96
Make jokes in or related to discussions happening in the chat?	118	2.18	1.05
Talk about things going on in their personal life?	121	1.89	.76
Releasing asynchronous recordings of the class?	123	3.53	.95

4-point scale from 1-Never to 4-Every Class

The most frequent teacher immediacy behaviors were "Sharing a written / verbal classroom agenda for the data at the

start of class," "Setting aside time to talk about upcoming course content," and "Releasing asynchronous recordings of classes." The regular use of these caring behaviors shows students that instructors are responsive to students' learning needs. This interpretation is sustained in effectiveness data, with students reporting these three most used behaviors were also the most effective, with strong consensus about their utility at promoting positive engagement.

Table 3 Effectiveness of Teacher Immediacy Practices

How effective do you think these teaching methods are at promoting positive engagement in [course]?	N	Mean	SD
Share a written or verbal classroom agenda for the day at the start of class?	109	3.69	1.09
Set aside time at the beginning or end of class to talk about upcoming course content?	113	4.10	1.00
Ask questions to individual students when they aren't raising their hands?	61	2.98	1.23
Connect course content to topical issues in the world today?	97	3.56	1.15
Make jokes in or related to discussions happening in the Zoom chat?	74	3.45	1.24
Talk about things going on in their personal life?	75	2.71	1.21
Releasing asynchronous recordings of the class?	105	4.29	1.14

5-point scale from 1-Not Effective to 5-Extremely Effective

"Connecting course content to topical issues" and "Making jokes related to discussions in zoom chat" were used less frequently, but still somewhat often. Humor and topical connections are less likely to be applicable daily to computing class material, and their more restrained usage is potentially indicative of these immediacy behaviors being used only when appropriate. Both behaviors were well received by students, with mean values of between "moderately" and "very" effective at promoting positive engagement in class.

More rarely, instructors asked questions to students when they weren't raising their hands (cold calling) and self-disclosed about their personal lives. These behaviors had the most mixed responses, with mean values between "slight" and "moderate" effectiveness.

4.3 Conferencing Software Features

We also asked students about the frequency and effectiveness of the following software features used in their synchronous remote computing classes:

- Screen sharing. Instructors present their screen in real time to participants;
- Breakout rooms. Subsets of students are expected to work together in private virtual rooms, which the instructor can visit as necessary;
- Chatbox. Students have text-based conversations, to which instructors can contribute and respond;
- Clicker questions. Instructors ask for student response to multiple choice type questions on course material during class. Often students must respond for a grade; and
- Polling the class. Instructors ask the class for their opinions and use the feedback to improve lecture or conversations.

Means, standard deviations, and distributions for software feature frequency and effectiveness are displayed in Table 4. Screen sharing was the most used feature as reported by respondents, with most students reporting its use every class. It was also considered highly effective by nearly all students, with a mean value between "very" and "extremely" effective. Students reported breakout rooms and chat as used somewhat frequently in their classes. Used more rarely were "clicker questions" and "polling the class." The effectiveness responses of the latter four software features have mean values of between "moderately" and "very" effective, with varying standard deviations largely due to varying response sizes.

Table 4 Frequency & Effectiveness of Software Tool Use

Tool	Frequency of use	N	Mean	SD	Effectiveness for positive engagement	N	Mean	SD
Screen Sharing		117	3.88	.44		117	4.50	.87
Breakout Rooms		117	2.14	1.16		66	3.17	1.33
Chatbox		117	2.68	1.04		99	3.51	1.11
Clicker Questions		117	1.34	.72		101	3.63	.88
Polling the Class		117	1.57	.82		79	3.54	1.21

4-point scale 1-Never to 4-Every Class **5-point scale** 1-Not Effective to 5-Extremely Effective

4.4 Camera Policy

An instructor decision unique to synchronous remote classes is camera policy. The instructor can choose to require cameras (with or without exceptions), encourage or discourage them, or ban them entirely. Participants reported (Table 5) that most instructors (71%) choose the policy of encouraging but not requiring camera use. While we did not specifically ask about which camera policy best promotes positive engagement, we did ask for student preferences. On this matter respondents largely agreed with instructors' practice, preferring that cameras be recommended but not required.

Table 5 Instructor Camera Requirements and Students' Camera Preferences

Camera Use	N	Camera Use	N
Instructor Requirement	100	Student Preference	106

(Left) Never allowed, Required to be off with exceptions, Encouraged to be off, Encouraged to be on, Encouraged to be on with exceptions, Always required (Right)

4.5 Humor & Caring Influenced Belonging

Our final research question explored how student sense of belonging relates to frequency of teacher immediacy behaviors and software tool use. We performed a regression analysis of the frequency with which instructors used the seven immediacy behaviors discussed in section 4.2 with our sense of belonging

index. The regression method was enter and the model met all assumptions. We removed variables that lacked significance ($p > .05$) one at a time based on magnitude of their effect in the model. The final model included only two variables as significant predictors, which were making jokes in chat and setting aside time in class to talk about upcoming course content. The R^2 for the overall model was 38.7% with an adjusted R^2 of 31.3%, a small to medium effect size according to Cohen [11]. This effect was significant $F(2, 93) = 22.665$, $p < .001$. In contrast to the teacher immediacy behaviors, none of the software features or camera policy were found to have any significant relationship with the belonging composite variable. Because only students who had experienced the immediacy behaviors and software tools answered effectiveness questions, the number of responses was too small to perform regression analysis with effectiveness as predictors of belonging.

5 SUMMARY AND IMPLICATIONS FOR TEACHING

Classroom belonging and overall experience in a class had a strong, positive correlation, extending prior research on belonging in undergraduate computing [25, 28]. This study substantiates research in other fields suggesting that high instructor organization promotes positive engagement and belonging [10, 19, 34]. Releasing recordings of classes, sharing a classroom agenda, and talking about upcoming content can show students that instructors care, and can reduce students' cognitive load, allowing them to focus less on making sense of course organization and more on learning computing [13, 19].

Like other studies, this study suggests that use of humor can influence student belonging. A review of four decades of research on humor in education provides evidence-based advice in the use of humor [2]. Scholars caution that instructors only use humor if they feel comfortable with it (not everyone is funny) and only if it is an authentic reflection of the instructor's personality. Also, specific principles should be followed: humor should never belittle students or others for what they believe or for their difficulty learning; humor should be relevant to students (especially, avoid old cultural references, such as TV series students would be unlikely to have familiarity with); and appropriate for audiences (e.g., using a photo of a student sitting on the toilet while reading Playboy magazine to discuss "input/output"—an example observed by a CS educational researcher—may inappropriately objectify women and offend students in general).

Cold calling and instructor self-disclosure both have been demonstrated to increase student engagement and belonging [7, 14, 15, 29, 30] but received a more mixed response by our participants. We theorize that this is due to the large number of classes represented by this study, and the variety of teaching approaches represented in our data. These two teacher immediacy behaviors have potential for backlash when done poorly. A typical norm that develops very quickly in classrooms is that certain students answer most questions. As a result, the rest of the students do not think about the questions, but instead wait for others to respond [14]. Cold calling done well leads students to believe that their participation is expected and valued, and has been shown to increase women's voluntary participation in class [15]. However, cold calling can make students feel alienated and inadequate if done in a way that singles out individual students or shames incorrect responses [29]. Instructors should follow recommended best practices by making sure students expect cold calling and understand how it will play out in classes [5]. When asking a question, instructors should give all students a moment to think about the answer, possibly using think-pair-share, then select a respondent [27, 29]. Similarly, research on instructor self-disclosure suggests that quantity of personal instructor information is not what matters, but appropriateness. Research suggests that self-disclosure should be appropriate to course material and should not be overly negative to avoid decreasing student motivation and engagement [7, 34].

6 LIMITATIONS AND FUTURE WORK

A wide range of teacher immediacy behaviors are not included in this study. For example, an important teacher immediacy behavior is learning and using students' names [3, 12]. In online classrooms, however, students' names are always visible, so the impact of using them is likely reduced. Many teacher immediacy behaviors are nonverbal, but nonverbal behaviors are difficult to study individually, since they are perceived "as a whole" [36]. They are also difficult to perceive online. Still, the teacher immediacy variables could be expanded in other studies, particularly if informed by focused observation-based methods.

This is a correlational study, preventing causal conclusions. Also, the study relied on sample emails sent out by instructors; as such, the sample is not random, and the response rate is unknown. The possibility that students who felt more positively towards their instructors may have responded more frequently cannot be discounted. Additionally, the data is based on students' self-reported recollections of frequencies, effectiveness, and attitudes. The research team did not directly observe instructors or what went on in classrooms, a potentially fruitful avenue for future research. Because only students who had experienced immediacy behaviors and software tools answered the effectiveness questions, the number of responses was too small to perform regression analysis that incorporated effectiveness as independent variables. The sample size is also too low for certain cross-group comparisons. Nevertheless, this study provides significant evidence that positive teacher immediacy behaviors increase student belonging, an important predictor of retention for undergraduate students, and which is known to be lower among students who are historically marginalized in computing.

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