Linking Faculty Attitudes to Pedagogical Choices: Student-Centered Teaching in Introductory Computing Classes

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ABSTRACT

Research suggests using student-centered practices in the classroom is a key component of attracting and retaining diverse students. To better understand the link between attitudes toward students and learning and the usage of specific teaching strategies, we analyze survey responses from 54 faculty who teach introductory computer science (CS) courses from 15 U.S. colleges and universities participating in BRAID. Using principal component analysis, we scale responses to 10 attitudinal questions into four dimensions: *rugged individualism* ("learning and success are the individual student's responsibility"), *challenging work* ("the pace and workload in CS is hard"); a *developmental orientation to learning* ("students need individual attention in a non-competitive environment"); and *capable students* ("all students can do well in my class"). We then test these scales on four types of teaching: three student-centered approaches—*collaborative learning approaches*, *discourse activities*, and *student-led learning*—and one traditional approach, *lecturing*. Results indicate that a developmental orientation predicts the use of discourse activities and student-led practices, but not collaborative learning approaches. Rugged individualism is associated with frequent lecturing. None of our scales predict the use of collaborative learning approaches, and neither attitudes for "challenging work" nor "capable students" predict any of the pedagogical approaches in our study. We examine differences by certain faculty characteristics and discuss the ramifications of these results for promoting more widespread adoption of student-centered teaching.

CCS CONCEPTS

• Social and professional topics ~ Computing education

KEYWORDS

student-centered teaching; instructor-centered teaching; lecturing; faculty attitudes; developmental orientation; collaborative learning

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1 INTRODUCTION AND LITERATURE REVIEW

Postsecondary computer science (CS) departments are an integral part of the pipeline for individuals to attain careers in computing. As such, CS departments have borne the brunt of burgeoning interest in computing careers and are facing record enrollments in computing majors and computing courses [11]. As enrollments increase, it might be tempting for some CS faculty to rely on instructor-centered teaching methods that focus on one-way content delivery (e.g. lecture, use of slides, etc.) that make managing an introductory course with hundreds of enrolled students seem easier. However, when students are passively learning, such as listening to a lecture and taking notes, their conceptual understanding of course content suffers [34]. Student-centered approaches, which prioritize students' experiences and development by increasing interactivity between and among students, instructors, and the course content [23], are more effective in achieving student learning and professional skill development. Research suggests these approaches have a myriad of benefits for students in STEM courses, including enhancing student engagement [33] and performance [17, 32]. Student-centered approaches are also a cornerstone of efforts to broaden participation in computing because they are particularly beneficial for women [25], who are vastly underrepresented in undergraduate computing majors [39]. Given these positive outcomes, the computer science education community has focused on promoting the adoption of student-centered teaching methods among CS instructors. For example, the National Center for Women and Information Technology (NCWIT) has developed the web-resource EngageCSEdu, which outlines a number of research-based, student-centered teaching strategies for CS instructors and serves as an outlet for instructors to share peer-reviewed lesson plans that utilize these practices [28].

Although there is great momentum around student-centered approaches to CS teaching, a recent study suggests traditional teaching methods such as lecturing are used by most CS faculty, and are used more frequently, than student-centered practices throughout CS higher education [21]. Reasons CS faculty provide for not trying student-centered practices include lack of time, being satisfied with current teaching methods, and logistical concerns such as lacking familiarity to implement the innovation [22, 36]. To address these challenges, this research has called for developing a better understanding of what instructors do in class, and why, to better inform strategies and messages for increasing broader adoption.

If a goal of CS education research is to get more CS instructors to adopt innovative teaching methods, it is important to first understand what attitudes they have and how those attitudes relate to classroom behaviors. Depending on these connections, it might be more effective to encourage faculty to first adopt student-centered *attitudes* than to focus on encouraging adoption of specific student-centered practices [9]. Indeed, having positive attitudes about students is a key component to the effectiveness of student-centered pedagogy; instructor attitudes shape students' engagement in course content, particularly in introductory STEM courses [18].

To better understand the nexus between attitudes held by faculty about students and their use of teaching practices in CS courses, the present study draws on survey data collected from 54 introductory computing instructors in the U.S. This research is driven by two research questions:

- What attitudes do CS instructors have about their students?
- To what extent are differences in attitudes related to using student- or instructor-centered teaching practices?

2 CONCEPTUAL FRAMEWORK.

To explain faculty adoption, we draw on Ajzen's Theory of Planned Behavior (TPB) [2, 5, 38] and its earlier iteration, the Theory of Reasoned Action (TRA) [3, 4]. As a general social psychological model, the theory stipulates that any behavior is predicted by three primary considerations: (1) favorable or unfavorable *attitudes toward the behavior* and its anticipated results; (2) *subjective norms*, or perceived external social pressure to (not) perform the behavior; and (3) *perceived behavioral control*, or the ease/difficulty of accomplishing the behavior given aptitudes, resources, etc. These three considerations are in turn shaped by beliefs and attitudes specific to the behavior, actors, and setting, and as such, theoretical assumptions about what may drive CS faculty to adopt teaching practices must be rooted in specific attitudes related to specific contexts and social interactions [30]. Therefore, faculty use of teaching practices should theoretically depend on attitudes about the teaching method, students, and learning in general ("attitudes toward the behavior"); their beliefs about the opinions of their peers and their department ("social norms," which we explore in [26]); and their perceived level of autonomy to make changes in their classrooms or to curriculum ("perceived behavioral control").

Many previous studies lend support to the explanations offered by TPB and TRA about behavior adoption in general [5, 12, 13, 19, 27] and behavior adoption in educational settings specifically [1, 10, 37]. Some studies have suggested the model be expanded by adding "antecedent" sub-components to perceived control [30] or attitudes [8], or adding other factors such as past behaviors/habits [6]. We opt for a simplified model for the sake of brevity, and because our purpose is not to validate the theory, but to employ it as a conceptual framework to better understand faculty teaching behavior.

3 METHODS

This section describes our data collection, measures, and data transformations. This research is couched in the larger BRAID Research project, which is a national study of efforts to broaden participation among women and students of color in undergraduate computing.

3.1 Data Source and Sample

3.1.1 Survey Design. The survey instrument used for this paper is modeled on the Higher Education Research Institution's faculty survey [20], a prominent nationwide survey of college faculty. Content modifications made to fit the context of CS higher education are informed by evidence-based practices found in the EngageCSEdu collection. The survey instrument was peer-reviewed by members of the project's advisory board and revised using their feedback.

The survey was designed to probe instructor behaviors and attitudes related to teaching introductory computing courses, including their use of certain programming languages, the frequency of lecturing and using various student-centered teaching practices, and attitudes and beliefs toward teaching, students, and their department. It also includes questions about instructors' background characteristics.

3.1.2 Sampling. The survey was fielded online using Qualtrics. Survey data were collected during the 2015-16 and 2016-17 academic years from introductory computing course instructors of various ranks, teaching at 15 research colleges and universities (13 public, 2 private) located across the U.S. that participate in the Building, Recruiting, and Inclusion for Diversity (BRAID) Initiative. Institution representatives identified introductory courses being taught and provided the research team with names and contact information for these courses' instructors.

In total, survey invitations were emailed to 257 instructors, which netted 94 respondents (response rate = 36%). Some instructors teach a single introductory course multiple terms and were surveyed multiple times. Because this study investigates the connection between attitudes and behavior, we felt it was inappropriate to treat multiple sets of responses from the same individual as separate "cases," even though people are not static in their attitudes or behaviors. To resolve duplication, we retained only the most recent set of responses per faculty member. We also removed cases that had missing data for over half of the survey. This resulted in a final sample size of 54 unique respondents.

3.1.3 Respondent Profile. In our sample, approximately 30% identified as being traditional tenure track (n=16), 28% tenure track teaching- or practice-focused (e.g., "clinical" or "teaching professor," n=15), and 43% non-tenure track teaching (n=23). Among traditional tenure track faculty, one (6%) was a dean, five (31%) were professors, six (38%) were associate professors, and four (25%) were assistant professors. Age ranged from approximately 23 to 67 years old (average=45); years of teaching experience ranged from less than one year to over 40, with an average of approximately 14 years. Twenty-nine percent of the sample were women, 71% men; no respondents selected a non-binary gender identity. The majority were White (n=41, 77%), East, Southeast, or South Asian (n=6, 11%), or Middle Eastern (n=3, 6%); three respondents (6%) were Black or Latin-X. One respondent did not provide responses to gender and race/ethnicity questions.

3.2 Measures

3.2.1 Attitudes Toward Students and Teaching. To answer our research questions, we asked instructors to "indicate the extent to which you disagree or agree with each of the following in relation to your <course name> course this term," and provided a list of attitudes about teaching and student learning. Items and response frequencies are shown in Table 1, ordered from highest to lowest total agreement. Over 90% of instructors encourage students to approach them for help and believe that there are no dumb questions. 84% agreed to some extent that all students can excel, suggesting that they may subscribe to the growth mindset [15]. However, 67% of respondents agreed that success is primarily up to students, which may suggest their belief in a growth mindset is somewhat blended. We discuss results of our first research question, "what attitudes do instructors have toward students," in more detail in the results section.

To identify underlying trends in attitudes toward students and learning that we could then test with teaching practices, we extracted dimensions using principal component analysis (PCA) with oblique rotation. This method is best suited to exploratory feature extraction when no underlying theory exists and extracted dimension may be correlated [14, 16]. PCA results are shown in Table 2. Four factors emerged: (1) *rugged individualism*, expressing a belief that "learning and success are the individual students' responsibility"; (2) *challenging work*, expressing that "the pace and workload in CS is difficult"; (3) a *developmental orientation to learning*, centering on a belief that "students need individual attention in a non-competitive environment"; and (4) *capable students*, expressing that "all students can do well in my class." All extracted scales met a minimum composite reliability score, and although alphas are small, they also meet a minimum threshold based on the number of items in each factor [24, 31].

3.2.2 Teaching Practices. To obtain dependent variables to answer our second research question, how attitudes influence the use of student- and instructor-centered practices, we asked faculty, "In teaching <course> this term, how frequently do you employ the following teaching practices?" Modeled on the HERI faculty survey, response options were ordinals: "Not at all," "Occasionally," and "Frequently." Practices and frequencies are listed in Table 3 on the next page, ordered from highest to lowest frequency of use.

Instructor-centered teaching practices are operationalized by the use of lecturing (shown with an asterisk in Table 3). While lecturing is often an irreducible component of student-centered practices, the frequency with which lecturing was used among respondents (85% selected "frequently") seems to indicate that

Table 1: Attitudes on Teaching and Learning, Frequencies

Attitudes on Teaching and Learning		Str Dis	Dis	Ntr	Agr	Str Agr
I encourage all students in this course to approach me for help.	N	1	0	1	6	46
	%	2%	0%	2%	11%	85%
In this class, there is no such thing as a question that is too elementary.	N	1	2	2	13	36
	%	2%	4%	4%	24%	67%
All students have the potential to excel in this course.	N	0	3	6	13	32
	%	0%	6%	11%	24%	59%
It is primarily up to individuals whether they succeed in this course.	N	1	8	9	22	14
	%	2%	15%	17%	41%	26%
I try to dispel perceptions of competition in this course.	N	0	3	17	15	18
	%	0%	6%	32%	28%	34%
There is not enough time available to give every student individualized attention.	N	5	14	10	9	16
	%	9%	26%	19%	17%	30%
Most students learn best when they do their assignments on their own.	N	2	13	16	11	12
	%	4%	24%	30%	20%	22%
The amount of material that is required for this course poses a substantial challenge to students.	N	3	12	17	15	7
	%	6%	22%	31%	28%	13%
Most students are well-prepared for the level of difficulty of this course.	N	4	19	13	15	3
	%	7%	35%	24%	28%	6%
Students are often overwhelmed by the pace of this course.	N	1	17	18	15	2
	%	2%	32%	34%	28%	4%

Notes: "Str Dis"="Strongly Disagree," "Dis"= "Disagree," "Ntr"="Neutral," "Agr"="Agree," and "Str Agr"="Strongly Agree." "N" = number of instructors who selected a particular response option.
The list of practices is ordered from highest to lowest total agreement.

Table 2: Underlying Dimensions of Attitudes toward Students and Teaching, Principal Component Analysis Results

Attitudes toward Teaching, Dimensions	(1)	(2)	(3)	(4)
It is primarily up to individuals whether they succeed in this course.	**.82**	.01	.13	-.05
Most students learn best when they do their assignments on their own.	**.77**	.06	-.31	-.09
Students are often overwhelmed by the pace of this course.	.19	**.72**	-.23	-.35
I encourage all students in this course to approach me for help.	-.08	**.65**	.02	.17
The amount of material ... poses a substantial challenge to students.	.41	**.63**	.33	-.22
There is not enough time available to give every student individualized attention.*	.05	-.18	**.78**	.15
I try to dispel perceptions of competition in this course.	-.38	.34	**.64**	.09
In this class, there is no such thing as a question that is too elementary.	-.30	.45	**.46**	.35
All students have the potential to excel in this course.	-.08	.16	-.02	**.84**
Most students are well-prepared for the level of difficulty of this course.	-.02	-.27	.28	**.65**
Composite Reliability	.77	.70	.67	.72
Cronbach's Alpha	.52	.56	.45	.41
N	54	53	53	54
% of Variance Explained	1.72	1.78	1.59	1.48
Cumulative % of Variance	1.72	3.50	5.08	6.57

Notes: Barlett's test of Sphericity Chi^2=75.908, df=45, p=.003; Kaiser-Meyer-Olkin Measure of Sampling Adequacy=.500, Extraction Method: Principal Component Analysis using oblique (Oblimin) rotation with Kaiser Normalization.
* Item reverse-coded to match positivity of scale.
Bolded item loadings represent "centrality" to the extracted factor and were used to calculate Cronbach Alphas.
Shaded areas are intended only to enhance legibility.
Extracted Component Labels:
(1) Rugged individualism
(2) Challenging work
(3) Developmental orientation
(4) Capable students

Table 3: Teaching Practices Usage in an Intro CS Course

Frequency of Usage		Never	Occass	Frqtly
Lecturing*	N	2	6	46
	%	4%	11%	85%
Class discussion	N	8	15	30
	%	15%	28%	57%
Group work	N	12	19	22
	%	23%	36%	42%
Interdisciplinary connections to CS	N	15	22	15
	%	29%	42%	29%
Student choice in activities and assignments	N	22	23	6
	%	42%	34%	25%
Peer instruction of course content	N	25	15	11
	%	50%	23%	27%
Pair programming	N	26	12	14
	%	50%	37%	13%
Student presentations	N	33	13	5
	%	65%	25%	10%

Notes: "Never" = "Not at all" in the survey; "Occass" = "Occasionally"; and "Frqtly" = "Frequently." "N" = number of instructors who selected a particular response option.
The list of practices is ordered from highest to lowest usage.
*Asterisk denotes an "instructor-centered teaching practice," and non-asterisked items are considered "student-centered teaching practices."

lecturing may often be used as its own independent teaching practice, divorced from student-centered activities.

Specific student-centered teaching practices used in this study are listed in Table 3 as non-asterisked items. This list was derived from a subset of evidence-based practices advocated for in the EngageCSEdu collection. To identify underlying trends that could generate deeper insights as to why faculty frequently use different *types* of student-centered practices, we employed factor analysis (aka principal axis factoring, or PAF). Factor analysis was selected because, based on prior work [26], we had a theoretical model explaining how items would load. PCA was also run to confirm the model; identical dimensions with very similar loadings emerged, so we retained the PAF scales. Results from the factor analysis, shown in Table 4, adhered to our expectations, with the exception that "peer instruction" had lower item loadings than predicted. Extracted factors, numbered in parentheses in the table, represent the following: (1) *collaborative learning*, (2) *discourse activities*, and (3) *student-led practices*. All factors had sufficient internal reliability and alpha coefficients, given the number of items in the scale.

An additional scale was created by summing the frequency responses to all student-centered items. This scale represents the relative frequency of using more student-centered practices in general. The scale had satisfactory cohesion (alpha=.69) and is normally distributed (mean=6.02, SD=3.02, skew=.22; KS-normality test coefficient=.11, p=.40).

We observed only one statistically significant difference in student-centered teaching scales among personal and professional variables. The collaborative learning scale was negatively, moderately correlated with being in a non-tenure track teaching role, compared to being in a tenured/tenure-track role (r=-.41, p=.004). Why we obtained this result is unclear.

Table 4: Underlying Dimensions of Student-Centered Practices, Factor Analysis Results

	FACTORS		
Student-Centered Practices	(1)	(2)	(3)
Pair programming	**.91**	.17	.22
Group work	**.59**	.44	.43
Class discussion	.15	**.87**	**.52**
Interdisciplinary connections to CS	.24	**.54**	.24
Student presentations	.21	.37	**.75**
Student choice in activities and assignments	.24	.34	**.60**
Peer instruction of course content	.30	.34	.30
Composite Reliability	.73	.68	.66
Cronbach Alpha	.72	.55	.62
N	51	51	49
% of Variance Explained	30.0	12.3	7.0
Cumulative % of Variance	30.0	42.2	49.2

Notes: Bolded item loadings represent "centrality" to the extracted factor and were used to calculate Cronbach Alphas.
Extracted Factor Labels:
(1) Collaborative Learning
(2) Discourse Activities
(3) Student-Led Practices

4 RESULTS

4.1 Instructor Attitudes toward Learning

To answer our first research question, we examined responses to questions related to beliefs about students, student learning, and student preparation (shown previously in Table 1). Most of the CS faculty surveyed reported encouraging students to approach them for help (96%) and to ask questions (91%). Likewise, many of the faculty reported a belief that students could succeed in their course (83%). Thinking of classroom environment, about two-thirds agreed that they try to dispel competition in their course (62%). Considering individual agency, about two-thirds agreed that it is up to the individual students themselves if they will succeed (67%), but only 44% agreed that students learn best on their own. There was less general agreement on the topic of giving students individual attention: only 47% agreed that they have time to do so—though this does not necessarily indicate what level of attention faculty think students need. Finally, instructor responses varied widely when asked about student preparation for the difficulty of course content. Specifically, less than half think students will be substantially challenged by the course material (41%) or that their students are well-prepared (42%), and about one third agree that students are overwhelmed by the course pace (32%).

As mentioned in section 3.2, these attitudes were scaled to identify underlying trends that might be more informative than single-item opinions. Results indicated that responses clustered into four themes representing different perspectives: (1) *rugged individualism*, (2) *challenging work*, (3) *developmental orientation*, and (4) *capable students*. No statistically significant differences were observed between genders, although one attitude scale came close: men had higher scores than women for "rugged individualism" (Mann-Whitney U=165.0, p=.051). Other personal and professional characteristics such as faculty type, years of teaching experience, age, and speaking English as a second language had no statistical relationship to our attitude scales.

Table 5: Predicting Student-Centered Practices with Faculty Attitudes, Ordinary Least Squares Regression Results

OLS Regression Results	Std B	SE	R^2
Collaborative Learning Practices			.02
(1) Rugged individualism	-.11	.15	
(2) Challenging work	.17	.14	
(3) Developmental orientation	.21	.14	
(4) Capable students	.06	.16	
Discourse Activities			.23
(1) Rugged individualism	-.22	.13	
(2) Challenging work	.10	.12	
(3) Developmental orientation	.39**	.12	
(4) Capable students	.15	.13	
Student-Led Practices			.27
(1) Rugged individualism	-.18	.12	
(2) Challenging work	-.07	.11	
(3) Developmental orientation	.40**	.11	
(4) Capable students	.16	.13	
Student-Centered Practices in General			.28
(1) Rugged individualism	-.23	.37	
(2) Challenging work	.09	.36	
(3) Developmental orientation	.43**	.37	
(4) Capable students	.19	.37	

Notes: significance levels: * p<.05; ** p<.01; *** p<.001
Dependent variables are listed in bold above each respective model.
Shaded areas are intended to enhance legibility.
"Std B"=standardized beta coefficients, "SE"=standard error, "R^2"=adjusted r-squared, which reflects the percent of variance explained by the model (i.e., effect size), adjusted for the number of predictor variables used.
Numbers in parenthesis in the independent variable list correspond to extracted dimensions from Table 2.

4.2 Predicting Student-Centered Practice Use

To answer our second research question, we used ordinary least squares (OLS) linear regression to test how attitudes toward students influence faculty use of certain types of student-centered practices. First, we ran four models using the attitudes scales from Table 2 as independent (predictor) variables, and each student-centered teaching practice scale from Table 4 as a dependent variable. The four (separate) regression models are shown together in Table 5, separated by lines.

We found that none of the faculty attitudes we used predicted the use of collaborative learning practices in our first model. However, we found that holding attitudes related to a developmental orientation predicted use of discourse activities (i.e. class discussion, introducing interdisciplinarity) in the second model, and predicted use of student-led practices (e.g. student choice, student presentations, discussion) in the third model. In the fourth model, we found that developmental orientation also predicted more use of student-centered practices in general. Overall, development orientation was a strong predictor for student-centered teaching.

While not statistically significant, the scale operationalizing rugged individualism was negatively related to each of the student-centered practices and to overall use of student-centered practices. The negative relationship with overall use nearly reached a level of statistical significance (p=.067), and it is conceivable that this relationship might be significant if tested using a larger sample. Overall, this trend suggests that faculty who feel strongly that success is up to the individual student *may* be less inclined to use student-centered methods, though this hypothesis needs to be confirmed using a larger sample, more nuanced questions probing this attitude, and an expanded list of student-centered practices.

In this study, attitude scales related to believing that students are capable and believing that students find CS content challenging were not statistically related to any of the student-centered teaching types. This finding may result from an interesting scenario in which some faculty who think students are capable may believe that the content will not challenge students *because* they are using effective pedagogy, while others may think that content *is* challenging but students can excel with effective pedagogy.

4.3 Predicting Lecturing

For our second research question, we also wanted to know how attitudes influence the use of instructor-centered teaching—i.e., lecturing. Because so few instructors reported using lecture "not at all" or "occasionally," we collapsed low-use responses to run a meaningful analysis. Results for the logistic regression that predict "lecturing frequently" are shown in Table 6. Coefficients are reported as exponentiated betas. The coefficients indicate the relative effect each attitude type has on the probability of lecturing more; values over 1 represent a positive impact, values less than 1 represent a negative impact.

Results show that stronger beliefs in rugged individualism, i.e., believing that success is the purview of students, significantly increase the chances of lecturing frequently. A "1 unit" increase corresponds to tripling the likelihood of using lecture frequently. It is perhaps not surprising to see that faculty who believe most strongly that students should complete assignments alone and that students themselves determine their success would rely more heavily upon lecturing as a form of teaching. This finding speaks to the importance of how an attitude, such as that of rugged individualism, may influence increased use of an instructor-centered practice.

Table 6: Predicting Lecturing with Faculty Attitudes, Logistic Regression Results

Odds Ratios of Lecturing "Frequently"	Exp(B)	SE	Wald
(1) Rugged individualism	3.39*	0.57	4.56
(2) Challenging work	1.00	0.50	0.00
(3) Developmental orientation	0.33	0.66	2.81
(4) Capable students	2.31	0.47	3.18
Constant	12.19***	0.69	12.98
N	52		
-2 Log Likelihood	34.23		
Cox & Snell R^2	0.182		
Nagelkerke R^2	0.315		

Notes: significance levels: * p<.05; ** p<.01; *** p<.001.
"Exp(B)"=exponentiated beta coefficients (odds ratios); "SE"=standard error.
Numbers in parenthesis in the independent variable list correspond to extracted dimensions from Table 2.

5 DISCUSSION AND IMPLICATIONS

A key challenge facing the CS education community is the paradox between extensive research supporting the use of the student-centered teaching, and recent findings that most CS instructors rely heavily on lecturing [21]. This exploratory study investigates the extent to which attitudes about students shape whether or not faculty use student-centered teaching. Results show that CS instructors generally hold attitudes that align with "student-centered" approaches, and that these attitudes are, in fact, related to adopting student-centered teaching. For example, the majority of CS instructors invite questions from their students and most work to dispel competition in their classrooms. In turn, those student-centered attitudes, particularly holding a developmental view of student learning, contribute to using evidence-based pedagogy. A developmental orientation is significant in predicting the use of student-centered teaching methods in the aggregate, as well as in predicting some specific types of teaching practices—notably the use of student-led and discourse activities. On the other hand, those who hold individualistic attitudes about student learning are more likely to lecture and may be less likely to use student-centered practices.

The findings from this study lend support to the Theory of Planned Behavior. When we introduced attitudes toward student learning into models predicting teaching behaviors, we found that attitudes explain 28% of the variance in use of student-centered approaches overall, 27% of the use of student-led approaches, 23% of the use of discourse activities, and between 18% and 32% of lecturing frequently. Though there is still a sizeable proportion of the variance unexplained by our models, we were surprised that nearly 30% of the variance *is* explained, given that our small sample size did not allow us to control for other variables such as instructor or institutional characteristics.

However, attitudes do not appear to predict the use of all forms of student-centered teaching, as the attitudinal dimensions measured in this study explained only 2% of the variance in using collaborative learning approaches. This finding warrants further investigation; we suspect that there are many factors not captured in our study that influence the use of collaborative learning (and other) approaches. The TPB suggests that social norms and control are also key determinants of behavior. It may be that departmental encouragement and colleague influence are driving faculty adoption of certain teaching methods like collaborative learning approaches. We explore this hypothesis using the same dataset we used here in [26].

The CS education community should leverage this study's findings to increase the adoption of student-centered teaching practices among faculty. First, faculty and administrators might seek to foster developmental attitudes among CS instructors. This could include training for instructors and graduate students to approach teaching from a development perspective. Additionally, faculty attitudes about students might be considered in the hiring process. While search committees likely ask prospective faculty about their teaching approaches, they should also consider asking about their attitudes toward student learning, as those who hold developmental views may be more likely to use student-centered approaches.

In addition to seeking to promote developmental views about student learning, these findings suggest a cautious approach to individualistic orientations. Faculty who held strong beliefs about students' individual agency and ability to succeed (rugged individualism) were more likely to lecture frequently. Lecturing is not inherently bad [21]; providing sufficient foundational information to students is essential to learning [35], and as such, many student-centered practices have a lecture component. But, lecturing is limited in its scope in that it provides content, but does not provide students an opportunity to engage critically with that information. This study's findings suggest that faculty who primarily rely on lecturing may feel that they are providing all the tools a student needs to succeed and are merely allowing students to self-select their level of involvement in their learning. However, extant research supports the use of multiple, active learning-based pedagogies, in addition to lecture, for the best outcomes by the most students [7, 29]. Our study demonstrates that most faculty hold at least some individualistic orientations to student learning, and there may be positive outcomes associated with holding at least some individualistic views of student learning. However, at the far end of the spectrum, some faculty may believe that students are wholly responsible for their learning and thus rely upon lecturing as a primary pedagogy.

Many unanswered questions remain. How do faculty form implicit theories of learning, and what experiences contribute to their attitudes toward students? Interactions with students almost certainly influence, and are influenced by, faculty attitudes and expectations. The degree to which faculty attitudes change over time based on specific types of experiences would be an interesting study, though other (and perhaps more feasible) lines of inquiry might also shed light on these complex relationships. Future research might consider how teaching behaviors are reciprocally influenced by individualistic views, belief in a growth mindset and students' capacities, and the degree to which teaching approaches can render difficult concepts more approachable for students.

LIMITATIONS

In addition to common limitations with cross-sectional survey research and attitudinal questions (response style biases, satisficing, interpretations of prompts that differ from our intended meaning, etc.), this study has several other limitations. First, beliefs about teaching are nuanced and diverse; it is nearly impossible that we included all salient attitudes and opinions relevant to our research questions. We strongly recommend that other studies dig deeper and broader into relationships between specific attitudes and teaching decisions, including how faculty conceptualize lecturing and student-centered practices, and how faculty develop these attitudes. Second, our sample size is small. While we constrained our models to avoid overspecification, some relationships that did not achieve statistical power may or may not have done so in a larger sample, and we did not compare these predictors with other determinants known to influence faculty adoption of teaching practices (see [22, 36]). Similarly, while our scales have sufficient composite validity, Cronbach Alphas were low, due to the limited number of items used in each scale's construction. Future research should develop items that contribute to, expand, and challenge the attitudinal framework we developed here. Finally, data comes from institutions participating in a program focused on implementing interventions to address diversity and inclusion efforts. Because of this, survey respondents are not a randomly drawn sample, and may have unique features compared to the general population of intro CS instructors. Nonetheless, we were able to identify links between attitudes and pedagogical choices that provide useful insights to the CS education research community.

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