The Voices of Our Students: Developing a Student Opinion Survey and Process to Support a Healthy STEM Educational Ecosystem

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Abstract

This Research paper describes the development of the Eco-STEM Student Opinion Survey as a tool designed to aid in the development of a healthy STEM educational ecosystem for students, faculty, and staff at a majority-minority Hispanic-Serving Institution. An important aspect of this endeavor is to obtain meaningful feedback from students about their experiences in STEM classrooms. However, current institutional student opinion surveys lack important context instructors require to make decisions as they intentionally construct inclusive classroom spaces. The Eco-STEM project is developing a student opinion survey and process designed to provide meaningful feedback to instructors. Climate, structure, and vibrancy, three aspects that are critical to evaluating the health of any healthy educational ecosystem, were used to develop the survey. This work is situated in the engineering education community's effort to create more inclusive classroom environments.

The Eco-STEM Student Opinion Survey contains three component parts: a Demographic Survey, a Values Survey, and an Experiences Survey. The Demographic Survey includes items previously shown by the Eco-STEM project to have significant impacts on perceptions of ecosystem health for our students, such as race/ethnicity, gender, living situation, and household income level. The Demographic Survey will be administered to students in their first semester, and participants will be provided with their previous responses each semester and given the opportunity to update them. The Values Survey has been developed based on the Eco-STEM project conceptualization of a healthy educational ecosystem, one that focuses on classroom climate, structure, and vibrancy. The Values Survey measures students' views on the importance of each aspect. Like the Demographic Survey, it will be administered to students in their first semester and then updated each semester as desired. Instructors will receive reports on their students' responses to the Demographics and Values Survey at the beginning of each semester, which will provide them with a basis for intentional decision-making and the establishment of an inclusive classroom space. Finally, at the end of each semester, students will be asked to respond to the Experience Survey for each course in which they were enrolled. This survey is also structured around the proposed constructs of climate, structure, and vibrancy. Reports provided to instructors on each of their classes at the end of the semester will provide useful feedback on which to reflect and design intentional changes for future courses.

In this paper, we describe the development of the three component parts of the Eco-STEM Student Opinion Survey as well as the proposed process of implementation. We also present the results of confirmatory factor analyses on a pilot study of the Values and Experiences Surveys, which measures the construct reliability for the proposed constructs of climate, structure, and vibrancy. Evidence of validity will enable the institutionalization of a new process that is

centered around the voices of our students and supports the evolution of an educational ecosystem in which all can thrive.

Introduction

In any educational setting, it is crucial that instructors receive feedback from students on how effective their instruction is. Both students and instructors benefit from improvements to teaching, pedagogy, and the classroom environment [1]. Tools that provide students an avenue to express what works and what does not will provide instructors with critical feedback to make intentional improvements in their classes [2]. This process is even more important at institutions that serve marginalized student populations, in which the normative culture and structure of higher education was not intended to support the success of these students.

Most higher education institutions provide student opinion surveys, sometimes called evaluations, at the end of the semester, as a way for students to provide feedback to faculty [3]. These surveys can be helpful if they ask questions that are adequately able to gauge the variety of factors impacting students' ability to learn and thrive in the classroom: teaching style, students' relationship with instructors, the classroom community, and factors outside of the classroom such as socioeconomic conditions, legal status, whether students work jobs outside of school, and more. However, surveys often do not capture a holistic view of the learning environment but rather ask only brief questions about student experience. There is also a plethora of existing research demonstrating the bias of traditional student evaluation processes against instructors who are members of marginalized social groups [4], [5].

This study reports on the results of developing, piloting, and evaluating a student feedback mechanism that attempts to capture a more holistic view of students' learning experience. This survey exists as part of a larger project, Eco-STEM, which was initiated in 2020 as an NSF-funded project to drive systemic changes in STEM education at California State University, Los Angeles, which is a Hispanic Serving Institution (HSI), where 72% of undergraduates are Hispanic/Latine, 83% are first-generation college students (meaning that neither of their parents has at least a 4-year college degree [6]), and 95% are commuters [7]. The student body has a variety of backgrounds and needs that are often overlooked; scant literature exists specifically on student evaluations of teaching at HSIs. The existing student feedback survey only features 11 items answered on a Likert scale from 1-5 and does not capture any context about the students' lives or expectations, which is necessary to holistically evaluate their experiences. We propose that a more robust feedback mechanism that more thoroughly captures students' lives, objectives, and experiences would better enable instructors to create learning environments that lead to student success.

As an earlier part of the Eco-STEM, a new faculty Peer Observation Tool and Process (POTP) was developed and deployed to align instructor evaluations with the goal of creating healthy learning environments in the classroom [8]. It was developed by adapting existing material from the University of Arizona, "Peer Review Teaching Protocols" [9] -- taking additional guidance from the University of Oregon, "Revising Teaching Evaluation" [10] and the multi-campus

"Teaching Quality Framework" [11] -- and centered around three major components of healthy classroom environments derived from the literature on ecosystem models of education: *climate, structure,* and *vibrancy* [12-14]. The result was three sets of instructor behaviors in the classroom that could be identified and evaluated by a teacher's peer in a two-way dialogue process (for examples, see Fig. 1; for more information, see [8]).

This survey series utilizes the same aspects of climate, structure, and vibrancy as in the POTP [8], but adapts them for student questionnaires. The survey features three main parts: the Demographics Survey (administered at the start of the semester), the Values Survey (administered at the start of the semester), and the Experiences Survey (administered at the end of the semester).

We have piloted the Eco-STEM Student Opinion Survey in several undergraduate engineering courses and investigated the validity of the new questionnaires through both qualitative evaluation and quantitative confirmatory factor analysis. Preliminary results show evidence of survey validity along the constructs of climate, structure, and vibrancy, and gives clear direction for future improvement. In conjunction with our Peer Observation Tool and Process [8], which allows faculty to work to improve the same classroom factors measured by our surveys, these questionnaires support continuous improvement of learning environments and student outcomes. As one of the first student opinion survey development and evaluation endeavors at an HSI, we believe that this work provides critical first steps for other Minority Serving Institutions (MSIs) that want to improve their instructor feedback processes, as well as reveals important directions for the field as it strives to embody inclusive education for an increasingly diverse student population.

Ecosystem Student Opinion Survey

Survey Development

This student opinion survey is developed based on previous work on a novel POTP aimed at instructor evaluation within an educational ecosystem paradigm [8] centered around climate, structure, and vibrancy. A subset of behaviors used in the POTP along these three facets of teaching and learning are illustrated in Fig. 1.

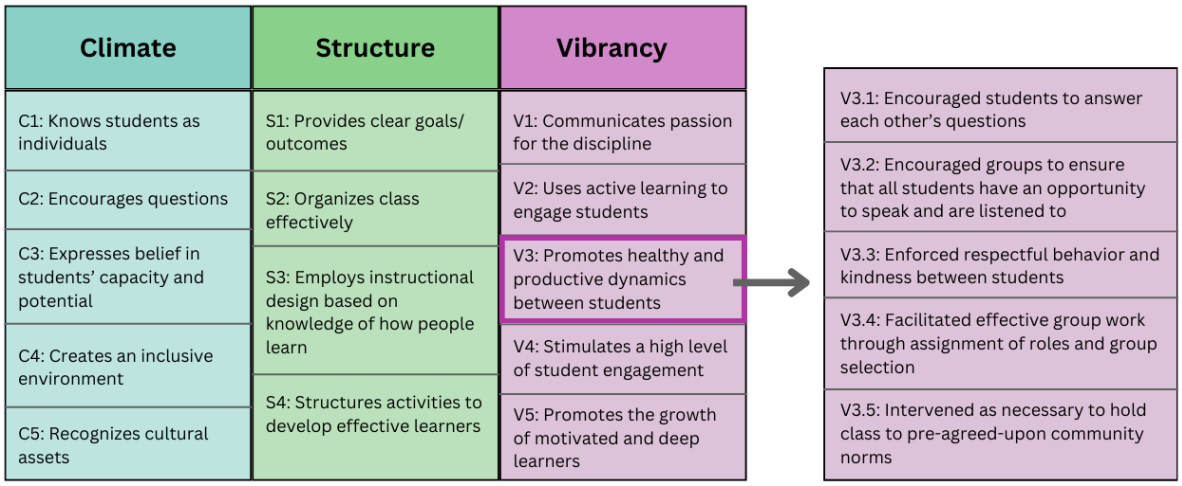


Figure 1: An illustration of measures and behaviors developed to gauge classroom ecosystem health for the Peer Observation Tool and Process [8].

Classroom climate describes the degree to which a classroom is supportive, inclusive, and recognizes cultural assets of students. Structure captures the mechanistic framework of the class, specifically the degree to which the activities and procedures are clear, helpful, and flexible, meeting students "where they are". Vibrancy indicates the degree to which the course and instructor solicits enthusiastic activity and high levels of engagement.

Behaviors used for evaluation within the POTP were adapted for a questionnaire format that could be used to gauge student attitudes about teaching and instruction in their courses. Importantly, the survey is split into two questionnaires: a *Values Survey* and an *Experiences Survey*. The Values Survey is administered to each student once, and students can update their responses each semester. The survey aims to allow students to express what is important to them for their learning experience, providing important perspective to faculty members at the beginning of each semester as they set up the class. The Experiences Survey is administered to students at the end of the semester and measures their instruction and learning experience along the same aspects of climate, structure, and vibrancy. These results are provided to instructors at the end of the semester, providing what we propose will be useful feedback to instructors.

The survey items, for both the Values and Experiences Surveys, are listed in Table 1.

Proposed Construct	Survey Code	Values Survey Item	Survey Code	Experiences Survey Item
		In your classes, how important is it that your professor... [Measured on 5-point Likert from "Extremely important" to "Not important at all"]		Indicate your agreement with each of the following statements about the class environment. [Measured on 5-point Likert from "Strongly agree" to "Strongly disagree"]
Climate	VC1	...knows who you are?	EC1	My professor knows who I am.

	VC2	...helps you feel comfortable asking questions and making comments in class?	EC2	I felt comfortable asking questions and making comments in class.
	VC3	...believes in your ability to learn and succeed?	EC3	My professor believes in my ability to learn and succeed.
	VC4	...makes you feel like part of the classroom community?	EC4	I felt like I was a part of the classroom community.
	VC5	...values you for what you bring to class through your own personal experiences, inside and outside of class?	EC5	My professor valued what I brought to class through my own personal experiences, inside and outside of class.
			EC6	In this class overall, I feel that my professor has created a learning atmosphere that makes me feel supported.
Structure	VS1	...clearly explains what you are expected to learn in the class?	ES1	I understand what I was expected to learn in the class.
	VS2	...clearly explains the work to be done on all assignments/activities?	ES2	Work to be done on all assignments/activities was clearly explained.
	VS3	...provides assignments/activities that are useful in helping you learn the course material?	ES3	The professor taught in the kind of way that works for my learning style.
			ES4	The assignments and activities helped me to learn the material.
			ES5	The professor used examples that were relevant to my own life and experiences.
	VS4	...provides feedback that is helpful for your learning?	ES6	The professor provides feedback on my work that helped my learning.
	VS5	...clearly communicates and implements grading criteria?	ES7	I understand how the professor determined the grades.
			ES8	I understand why I got the grades I got.
			ES9	The class was challenging in a way that was just right.
			ES10	The professor has organized and structured the class in a way that supports my learning experience.
Vibrancy	VV1	...is excited about the subject and shares this excitement with the class?	EV1	I can tell my professor was excited about teaching the class.
	VV2	...uses in-class problem solving, and other interactive approaches?	EV2	In class, we used interactive approaches beyond just traditional lecture to learn the material.
	VV3	...creates an environment where you interact with and learn from other students?	EV3	In class, I worked with other students in groups or pairs.
			EV4	My classmates and I learned from each other.
			EV5	I had a lot of interaction with other students in my class.
	VV4	...makes students feel interested and engaged?	EV6	My professor made me feel interested and engaged in this course.
			EV7	I applied what I learned in this class in the class assignments.
	VV5	...encourages students to think critically and question assumptions?	EV8	I feel encouraged to think critically and question assumptions.

	VV6	...relates the course material to real-world applications?	EV9	My professor connected what we do in class to current social and/or cultural events and issues.
	VV7	...encourages students to take time to reflect on their own learning?	EV10	My professor encouraged me to take time to reflect on what and how I was learning.
			EV11	Overall, the professor made the class engaging.

Table 1: Survey items for both the Values and Experiences Surveys, categorized by their proposed ecosystem constructs of climate, structure, and vibrancy.

Importantly, along with the Values and Experiences Surveys, the improved student opinion survey also includes a *Demographic Survey*. This survey is administered at the beginning of a student's first semester, and each semester they have the opportunity to update their responses.

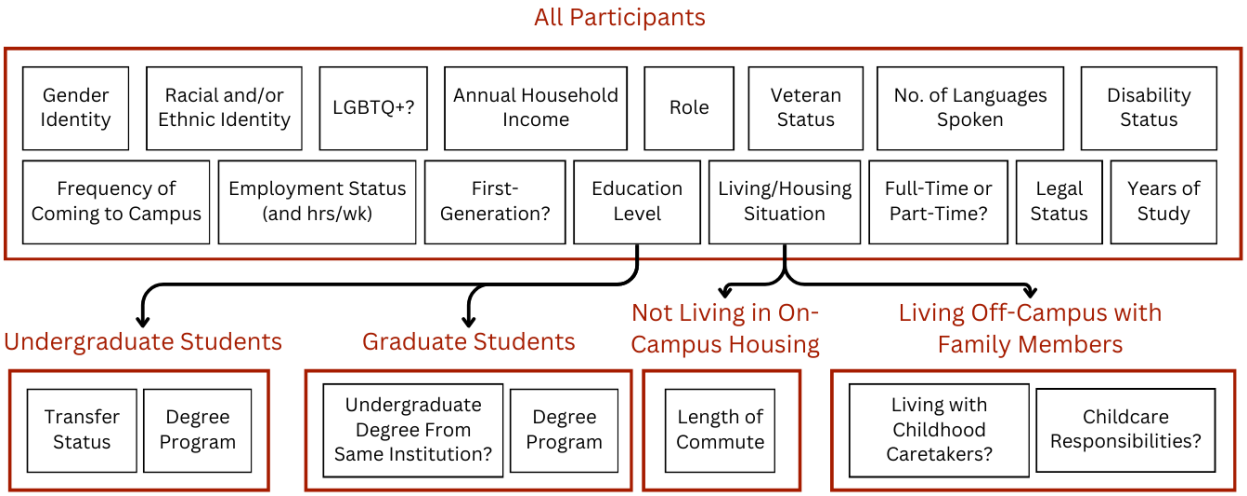


Figure 2: Questions asked to students in the Demographics Survey as well as survey logic flow.

The Demographic Survey includes both standard demographic items as well as those the Eco-STEM project has shown to have significant impacts on the education ecosystem at this institution, including race/ethnicity, gender, household income level, living/housing situation, and others [15]. The items in the Demographic Survey and the survey flow logic are shown in Fig. 2. Accounting for these demographics allows student responses to be contextualized within factors outside of the classroom - a level of analysis necessary to consider the effects of adverse social and economic forces on student outcomes. Instructors will be provided the demographic results of each of their courses in the aggregate at the beginning of the semester to help develop their understanding of their students' identities and lived realities, useful in every institutional context but imperative in ours, where there is a significant discrepancy between the backgrounds of the faculty and those of the students. During survey implementation, students' demographic data will also serve as independent variables of analysis in the research.

Survey Validation

Qualitative

Before running our pilot study, we recruited student participants to qualitatively evaluate the survey questions, compensating them with Amazon gift cards upon completion. In total, four students participated and provided feedback. Procedurally, each participant performed a "think-aloud" with a member of the research team; they talked through the survey items and explained how they would respond [16], [17]. During this process, participants reported items that they found confusing, and why, in addition to highlighting certain items as redundant. There were also a few instances of participants flagging questions as particularly interesting or asking for the opportunity to elaborate further on questions rather than answer them on a Likert scale.

This type of qualitative validation is important, as it allows us to match our desires to students' language and ways of thinking, making for more accurate results [17]. Based on these participant responses, we reformatted several questions before sending the Values and Experiences Surveys to our pilot group.

Quantitative

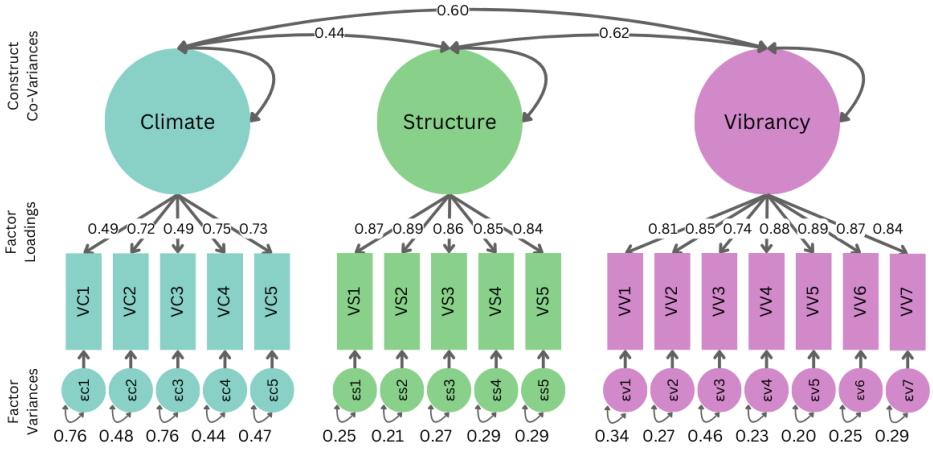
The second method by which we validated the Eco-STEM Student Opinion Survey was through Confirmatory Factor Analysis (CFA). CFA is a statistical method that can be used to assess the validity of a proposed theoretical model. Running a CFA results in an array of factor *loadings* and *variances* that describe how strongly certain factors (in our case, survey questions) contributed to the desired construct. A more detailed description of how to interpret CFA results can be found in the Discussion section.

The model that we constructed is that climate is measured by VC1-VC5 and EC1-EC6, structure by VS1-VS5 and ES1-ES10, and vibrancy through VV1-VV7 and EV1-EV11. Additionally, we constructed our models to allow for each construct (climate, structure, and vibrancy) to covary with each other.

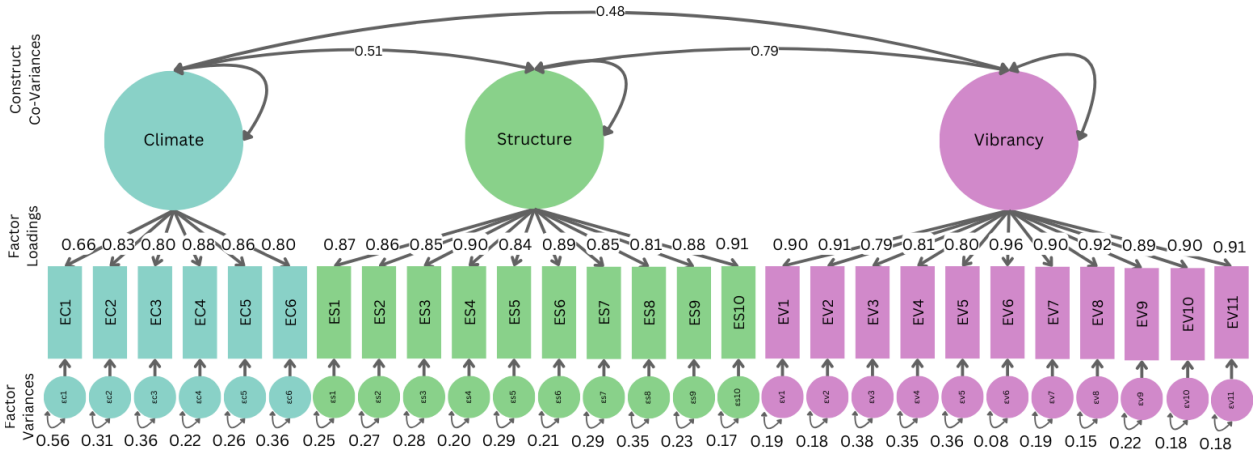
For our study, we statistically tested to what degree our model – climate, structure, and vibrancy being measured by the Values and Experiences questions listed in Table 1 – is statistically valid given student response data from a pilot survey. In short, this would allow us to assess how well our surveys are measuring our desired educational ecosystem measures. We separately tested models for the Values Survey results and the Experiences Survey results. In our case, factor loadings and variances describe the degree to which our survey questions captured the concepts of climate, structure, and vibrancy.

We collected student data by distributing the opinion survey electronically to STEM students who provided consent and received 116 responses for the Values Survey ($n_V = 116$) and 102 responses for the Experiences Survey ($n_E = 116$). Using the Lavaan package in R [18], we built both models and ran CFA using the Maximum Likelihood (ML) method, accounting for missing data with the Full Information Maximum Likelihood (FIML) method. The code used to build and run the model, as well as full raw results, can be found at https://github.com/ricknabb/eco-stem-

sos-asee-2025. Our Values and Experiences models and resulting factor loadings, variances, and errors are displayed in Fig. 3.



(a) Values model with loadings and variances



(b) Experiences model with loadings and variances

Figure 3: Values and Experiences models with fits from running CFA. Loadings are listed on single-sided arrows, and variances on double-sided arrows.

We measured the model fits using several goodness of fit measures, listed in Table 3a for the Values model and in Table 3b for the Experiences model. To measure our fit, we use common measures to gauge Structural Equation Model validity: Root Mean Square Error of Approximation (RMSEA), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI). These indices measure the degree to which the model we propose aligns with the statistical relationships between the data in our sample. For our purposes, this means that our model is valid, given our data, if student responses for each construct's (climate, structure, and vibrancy) items covary with each other.

Measure Name	Value	Measure Statistics
CFI	0.906	N/A
TLI	0.890	N/A
RMSEA	0.102	$p < 0.001$, 90% CI [0.086, 0.119]

(a) Values Survey model.

Measure Name	Value	Measure Statistics
CFI	0.867	N/A
TLI	0.855	N/A
RMSEA	0.118	$p < 0.001$, 90% CI [0.107, 0.128]

(b) Experiences Survey model.

Table 3: Model fit measures for the Values and Experiences Survey, modeled as in Fig. 2 and measured using a CFA model.

Discussion

Survey Validity and Future Improvement

Our qualitative and quantitative validation results both lend evidence toward the validity of our survey constructs. We find that our theorized model – that classroom ecosystem health can be assessed by measuring climate, structure, and vibrancy, in turn measured by the specific behaviors we query in the survey – does capture valid aspects of the classroom environment. Validating these Surveys is an important step towards institutionalizing student feedback mechanisms that align with ecosystem thinking; using a validated questionnaire gives us confidence that our surveys are measuring what we intended and can be used to obtain reliable results that will be useful to faculty.

Additionally, our results indicate that there are ways in which the Values and Experiences Surveys can be improved. Participants indicated in the qualitative portion of survey validation that several questions had confusing wording or were repetitive. As the sample was very small for this validation ($n = 4$), it should serve as a guideline for how to perform a larger qualitative validation in future work.

From our quantitative results, we see that our model fit is good but not strong. Kline suggests that a close fit yields RMSEA ≤ 0.05, a result between 0.05 and 0.08 is a reasonable fit, and a result ≥ 0.10 is a poor fit [19]. While both the Values and Experiences models would be classified as poor fits, we should also consider their CFI and TLI indices, which range from 0 to 1, where 1.0 is an optimum fit. Our scores (Values: CFI=0.906, TLI=0.890; Experiences: CFI=0.867, TLI=0.855) are on the higher side, which can be interpreted as acceptable fits.

One possible shortcoming of our data that may be contributing to a poor RMSEA is our sample size to questionnaire item ratio. Kline notes that for every q parameters in a model, there should

be at least *20q* data points [19]. For our Values model ($q_v = 17$), this would suggest at least 340 data points, and for our Experiences model ($q_E = 23$), 460 data points. Our *N* values, 116 and 102, respectively, fall significantly short of these criteria. As such, a poor fit can be more reasonably expected, and stronger weight should be placed on the CFA and TLI indices when considering the fit of the models.

Outside of measures of fit, we observe that our factor loadings are quite high for almost all factors. A high factor loading and low variance for a given questionnaire item indicates that it contributed significantly to the desired construct (i.e., climate, structure, or vibrancy). The only exceptions are for the Values model, VC1=0.491 and VC3=0.494, and for the Experiences model, EC1=0.660. The rest of the standardized factor loadings for both models are above 0.7, with most actually above 0.85, indicating very strong loading [20]. This indicates that most questionnaire items were strongly contributing to the desired constructs we wanted to measure with our surveys. Eliminating the three survey items with lower factor loading is one way we could both develop toward individually assessable constructs of climate, structure, and vibrancy, as well as shorten the overall length of the survey.

First Steps for Improving Instruction at MSIs

These are crucial preliminary results for the construction of measures to gauge student outcomes along the lines of educational ecosystem principles. Moreover, these are some of the few survey and validation results for data collected at an MSI. There is extensive research on how traditional higher educational paradigms are not structured to support minoritized students [21], [22], as well as advocacy for changing the educational paradigm to meet those students' needs [23], [24].

By validating these survey constructs, we ensured that the ecosystem measures we developed are adequately measuring student outcomes. Faculty who utilize these survey constructs can receive reliable results from student feedback that can subsequently be used to improve classrooms. This is additionally important for our context of measuring outcomes at an MSI, because other validated surveys are often developed in different contexts with student demographics that reflect far more privileged populations.

These surveys are part of a larger project, Eco-STEM, where we have also developed methods to improve the same classroom factors – climate, structure, and vibrancy – that are measured by the Student Opinion Survey. Specifically, our Peer Observation Tool and Process (POTP) [8] is a tool that faculty can use to improve the same set of behaviors as part of a peer review process. In short, the POTP allows instructors to mutually assess their behaviors in the classroom corresponding to these same ecosystem factors, reflect on their teaching, and identify ways to grow as educators. Generating the ability to better reflect on the climate, structure, and vibrancy of their classrooms will assist faculty to better address the same behaviors that drive student outcomes. In other words, faculty can reliably gauge their classroom ecosystem health and improve it based on student feedback.

Conclusion

Measuring student experience in the classroom is essential for developing and refining teaching practice – especially if the goal is to build socially just educational systems that effectively serve marginalized student populations. This study developed and validated a novel student feedback survey – including Demographics, Values, and Experiences components – with a pilot group of engineering undergraduate student participants. The aim of these surveys was to capture crucial aspects of students' experiences aligned with ecosystem-framed measures: climate, structure, and vibrancy. Our qualitative and quantitative validation results showed that our surveys captured important criteria for students, and moderately fit the desired constructs of climate, structure, and vibrancy. Importantly, these Surveys are some of the first developed and validated within the educational context of a Minority-Serving Institution (MSI). In conjunction with other tools we have developed for instructors to improve their teaching based on the same behaviors we measure in our Surveys, this set of questionnaires allows faculty to both measure and improve their classroom environments towards the goal of enhancing student outcomes.

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