

Developing and Sustaining Inclusive Engineering Learning Communities and Classrooms

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Abstract

Historically underrepresented students experience situations in the classroom that can negatively impact and undermine performance and persistence. To aid students, and historically underrepresented students, to succeed both academically and socially, previous research has indicated that instructors should create classroom environments that foster inclusivity and belonging. However, there is a lack of specific guidance for how to create these environments, especially in *engineering classrooms* where much of the focus is on *technical content*. This study is addressing this gap through developing and providing pragmatic, proven, and trusted practices for engineering faculty who are seeking to make their classrooms more inclusive environments for all students.

This research is informed by and aligned with the Theory of Change Model developed by Henderson, Beach, and Finkelstein which notes 4 categories of change strategies for higher education: disseminating curriculum and pedagogy, developing reflective teachers, enacting policy, and developing a shared vision among teachers and stakeholders. We have developed and piloted a list of inclusive classroom practices along with specific details, including implementation times, examples, and difficulty levels, to help faculty prioritize the practices. To support these efforts, we have also convened inclusive classroom focused learning communities for faculty. We are in the process of evaluating the effectiveness of these practices by examining student and faculty perceptions of the classroom environment through feedback and assessments including surveys and interviews.

Following the completion of these tasks, the inclusive practices list will be refined and continue to be implemented in classrooms participating in the study. After further study, the practices will be shared across diversity, equity, and inclusion engineering networks to serve as a model for creating more inclusive classrooms.

Introduction and Background

Historically underrepresented students experience situations in the classroom that can negatively impact and undermine performance and persistence. Students' academic and social success can be positively impacted when instructors create inclusive classroom environments that facilitate a sense of belonging. The academic and personal development of students can also be deeply linked with their interactions in their learning environments, so it is essential to prioritize the inclusive nature of those environments [1]–[3]. Historically minoritized and underrepresented students are more likely to experience prejudice and discrimination within and outside of their classrooms and are least likely to challenge the intellectual authority of educators [4]. The recognition and transformation of pedagogical decisions and classroom interactions that cultivate inclusive excellence in classrooms have shown to yield a positive climate and promote more equitable education outcomes [5], [6].

The impact of creating more inclusive classrooms is well-studied; however, guidance on creating inclusive environments in disciplines where technical rigor and content are widely prioritized, such as engineering, seems to lack specificity for the needs of the curriculum to adequately train students for their profession. Various pedagogical tools such as embedding a social justice framework into engineering curriculum and developing a sense of community in the classroom have been reported to improve student belonging [7], [8]. But there has been a lack

of actionable guidance for faculty about inclusivity when teaching more technical courses. From an instructor perspective, the lack of practical guidance in the literature makes implementation challenging because of the overlap in practices, uncertainty of timing, and the lack of information on which strategies have the highest impact. This study aims to address this gap through developing and providing pragmatic, proven, and trusted strategies for engineering faculty who are seeking to make their classrooms more inclusive environments for all students, and it also hopes to facilitate the implementation through fostering Inclusive Learning Communities (ILC) for faculty and educators.

Development of Menu and ILCs

This research, and in particular the development of the inclusive classroom strategies menu, is informed by and aligned with the Theory of Change Model developed by Henderson, Beach, and Finkelstein [9]. The model notes four quadrants of change strategies for higher education: disseminating curriculum and pedagogy, developing reflective teachers, enacting policy, and developing a shared vision among teachers and stakeholders. The first quadrant of disseminating curriculum and pedagogy focuses on teaching educators about new strategies they can use in the classroom and advocating for their use. Developing reflective teachers centers on encouraging and supporting educators as they develop new teaching concepts, action research, and curriculum development in the second quadrant. The third quadrant focuses on enacting policy changes and strategic planning which usually occurs at an administrative level rather than at the educator level. The final quadrant is focused on developing a shared vision among and empowering stakeholders to create an environment that fosters new teaching concepts and practices [9]. The research tasks for this work can largely be grouped into these quadrants from developing the inclusive classroom strategies menu which aligns with the curriculum and pedagogy quadrant to the development and piloting of the ILCs for faculty and educators which aligns with the shared vision quadrant.

The first task was to develop and pilot a list of inclusive classroom strategies through an extensive review of practices from both peer-reviewed literature and university teaching and learning center websites. This task curated the descriptions and instructions, examples of implementation, and references and impact reported for the listed strategies. This task also sorted the strategies into different timeframes, such as “pre-semester” or “in-classroom engagement” to suggest when educators should employ them. Other inclusive teaching strategies resources rarely include all this information. As the inclusive classroom strategies menu is refined over time, the development of the decision matrix will also further aid in implementation, ease, and effectiveness.

To help support the efforts of educators implementing practices, as well as provide a forum for feedback on the menu, we have also convened ILCs in alignment with the goals of the study. In these ILCs, the members are faculty, staff, or teaching assistants who are interested in creating more inclusive classrooms and are committed to three semesters of membership. The ILC employs the core ideas of a learning community (LC) from the Center for the Integration of Research, Teaching, and Learning (CIRTL). One of the core ideas the ILCs practice is the focus on shared discovery and learning through collaboration with an emphasis on selecting and implementing inclusive practices. Another strength of the ILCs is to foster functional connections among learners to ensure meaningful and productive time together. Framing the classroom strategies within university-wide initiatives and modeling the establishment of ground rules for respect and inclusivity were also employed in the ILCs.

The ILCs at each partner university were developed with these shared goals, but separately through either an existing LC or an LC exclusively created for this study. The first partner institution was the University of Pittsburgh (Pitt) and the ILC was created as a part of the Civil and Environmental Engineering (CEE) department's committee focused on inclusion, diversity, equity, and access. The members of the ILC were faculty within the CEE department. Students and staff were also invited to attend a few of the ILC meetings during the semester to give their perspectives on classroom and department climate to aid in strategy implementation. The second partner institution was Arizona State University (ASU) and the ILC was developed through the Research in Inclusive Science and Engineering Education Center which is focused on inclusive teaching. The members of the ILC at ASU were engineering faculty who were affiliated with the center. The third and final partner institution was the Colorado School of Mines (Mines). The ILC was created through the Trefny Center and Diversity at Mines where there is a focus on promoting research-based teaching and learning practices and the ILC members were engineering faculty and instructors.

Assessment Methods

One goal of this project is to provide faculty the support they need to successfully implement inclusive strategies in their engineering classrooms. Faculty success in creating inclusive classrooms is directly linked to student perspectives and outcomes, and thus we are collecting data from students in participating classrooms. The student-centered assessment plan is a mixed-method approach that includes survey response data asking students about their recognition of inclusive strategies, examination of the department and university climate, and a sense of community within the classroom. There is also an option for students to participate in an interview or focus group to provide further details and in-depth perspectives on whether the inclusive practices were effective for their learning environment. These assessments not only provide guidance on refining the inclusive classroom strategies menu but also help faculty improve their implementation of the strategies in the classroom.

In addition to receiving feedback from the students on their experiences in classrooms where faculty are implementing inclusive strategies, it is also essential to collect feedback from the participating faculty as well. Faculty need to see evidence of these inclusive strategies benefitting student learning, improving their confidence in using these strategies, and overcoming barriers to their implementation and sustainability. The faculty-centered assessment plan is two-fold. First, we are collecting data regarding the experiences of the faculty implementing the strategies. Second, we are collecting data on the effectiveness of the support they received from their membership in the ILC. We will use the collected feedback to improve and refine the inclusive classroom strategies menu and decision matrix. This feedback will also inform whether the ILCs are an efficient tool for initiating and sustaining efforts in creating more inclusive classroom environments within engineering departments and schools.

Results to Date

Thus far, we have created and developed the inclusive classroom strategies menu through the assessment of peer-reviewed literature and university teaching and learning center websites, which can be seen in part in Figure 1. The literature spanned the last five to ten years of research on inclusive strategies that have worked in classroom settings, especially those in engineering classroom settings. It was essential to not only review literature on proven inclusive classroom strategies but also review those strategies that teaching and learning centers utilize in their

classrooms because they are considered the practicing experts on shaping and shifting classroom environments.

Pre-Semester
Identity

- ☐ Examine the assumptions you currently have and have made previously about your students – This is a mental check-in for yourself that can provide reflection on your own implicit bias. Actively commit oneself to the process of self-actualization to increase awareness of your own worldview.
- ☐ Learn different teaching techniques to vary teaching methods during the semester and ensure they are all accessible to all students
- ☐ Learn about implementing techniques that can decrease the potential intimidation that students feel towards instructors
- ☐ To the best of your ability, ensure that the classroom is physically accessible and usable by all students and plan for accommodations for students whose needs are not fully met by the instructional design

Relational

- ☐ Anticipate and prepare for potentially sensitive issues that may come up during discussions – Try to be versed in current events, especially those that could/would affect students (whether that is based on age or marginalized group). Devise personal strategies for managing yourself and the class to turn those potentially heated moments into powerful learning experiences.
- ☐ Build your schedule to ensure your availability for your students both inside and outside the classroom – Preparing this before the semester intentionally can make a difference to both you and students during the semester

Figure 1. A portion of the Inclusive Classrooms Strategies Menu.

The strategies were organized by timing of the semester and using the Aspire Alliance's inclusive professional framework's three core domains of identity, intercultural, and relational. Listing the strategies according to the best timeframe to utilize them during the semester was unique, in comparison with other strategy tools, as it helped guide faculty through the semester. The categories used for the strategies menu were Pre-Semester, Syllabus, In-classroom Engagement, and Discussion Tools. Identity focuses on mitigating bias in class design, content, grading and groupwork through developing an awareness of self and others' social and cultural identities. Intercultural focuses on supporting students' connections to content and encouraging them to be their authentic selves through developing an understanding of cultural differences and how those impact peer-to-peer interactions. The last domain, relational, focuses on building trusting relationships among peers and instructors, encouraging student belonging, and inclusive communication which all support interpersonal interactions [10], [11]. Through this inclusive classroom strategies menu, faculty were able to choose the strategies they wanted to focus on and implement in their classrooms during the Fall 2021 semester.

During the first semester, we also developed and piloted the faculty and student surveys to receive feedback on strategy implementation, the ILCs, and student experiences in classrooms where strategies were implemented. The student survey was developed by combining existing survey instruments that were used to assess feelings about the classroom and university environment as well as peer and instructor interactions. Instead of focusing only on classroom and university climate, the faculty survey asked instructors about what strategies they implemented, their ease and needs for implementing these strategies, and their assessment of their participation in their institution's ILC.

The preliminary results of the student and faculty surveys are listed below in Tables I and II, respectively. For the student survey demographics, there were 18 student respondents, and they were all from Pitt. The participating students were primarily white (88%) and self-reported a grade point average greater than a 3.0 (94%). More than half of the student survey respondents were in their fourth or fifth undergraduate year (53%), half identified as female (50%), and a

majority reported their sexual orientation as heterosexual (81%). Only one student identified as a student athlete sponsored by the University, and two students identified as having a mental health or development disability. The student survey respondents also included two international students and two first generation college students. For the faculty survey, we had 7 faculty respondents of which 57% of them taught at Pitt and the other 43% taught at Mines. It is important to note that the results in these tables are from one semester and there was a low response rate, which in part could be due to the increased burden on faculty and students due to the ongoing pandemic. However, as more semesters, faculty, and students are included in the study, the data and statistics should continue to strengthen and diversify with time.

Table I. Selected Student Survey Results from Fall 2021 Semester.

	<i>Strongly Agree</i>	<i>Agree</i>	<i>Neither</i>	<i>Disagree</i>	<i>Strongly Disagree</i>
<i>Questions</i>					
Feel reluctant to speak openly in class	0%	6%	17%	33%	44%
Feel spirit of community in classroom	22%	56%	17%	6%	0%
Feel encouraged to ask questions	72%	17%	11%	0%	0%
	<i>Very Often</i>	<i>Often</i>	<i>Sometimes</i>	<i>Never</i>	
Diverse perspectives included in class material	29%	35%	35%	0%	
Connected class material to societal problems or issues	72%	22%	6%	0%	
	<i>Peers</i>	<i>Professor</i>			
Rate Quality of Interaction on a Scale from 1-7 (1 being low to 7 being high)	5.82 (Mean)	6.41 (Mean)			

The results from the student survey showed that most students felt that the people who have the largest impact on their success as an engineering student were their peers and instructors as opposed to their departments and institution. Most students also strongly felt encouraged to ask questions in class, experienced a connection between classroom material and societal problems or issues, and that their instructor provided flexibility during the pandemic. Most students also felt they could speak openly in class and agreed that they felt a spirit of community in their courses. On average, students also indicated a high quality of interaction with their instructors and peers at 6.41 and 5.82 out of 7, respectively. However, less than half of the students felt that diverse perspectives were included in their course material more than half of the time (Table I).

These results show that the strategies implemented from this study's inclusive strategies menu could have made a positive impact on the classroom climate, however, more data will help to strengthen this observation. Another result of interest is that on average, students indicated their interactions with their instructors more highly than that with their peers. This could be an area of improvement to explore for the inclusive classroom strategies menu to provide faculty with strategies that help students with being more inclusive and understanding of their peers. It is also important to recognize that a large proportion of the students who took the survey were White and more than half of them were in their fourth or fifth year as undergraduate students. As found in the literature review for this study, historically minoritized and marginalized students tend to have a different experience in the classroom as opposed their other peers and this could

have impacted the survey results. Senior students are also more likely to feel comfortable asking questions and participating in the classroom due to longevity in the university classroom environment and this also could have skewed the student survey results.

Table II. Top 3 Most Utilized Inclusive Strategies Among Faculty During Fall 2021 Semester

	<i>Strategy</i>	<i>% Used</i>	<i>Strategy</i>	<i>% Used</i>	<i>Strategy</i>	<i>% Used</i>
<i>Timeframe</i>						
Pre-Semester	Building in availability for students ⁴	18%	Preparing for potentially sensitive issues in class ⁴	15%	Varying teaching methodology ¹	15%
Syllabus	Promoting empathy throughout ⁴	13%	Differentiating instruction ¹	13%	Explicit course goals and listing out resources ¹	11%
In- Classroom Engagement	Using preferred names and pronouns ²	8%	Using straightforward language and humor when appropriate ⁴	7%	Recognizing effort and setting goals ⁴	7%
Discussion Tools	Using preferred names and pronouns ⁴	13%	Modeling inclusive language and judgement-free classrooms ³	11%	Acknowledging different ways of knowing ¹	11%

Aspire Alliance Domains Table Legend: ¹Mostly Identity, ²Mostly Intercultural, ³Relational and Intercultural, ⁴Mostly Relational

The results from the faculty survey showed which strategies were most utilized by the participating faculty for each of the timeframes in the menu (Table II). There was no one strategy used by a majority of the faculty. Some of the faculty also responded with strategies that they implemented that were not on the inclusive strategies menu but were aimed at improving inclusivity in their classrooms. Adopting a learner's mindset of rewarding for learning rather than rewarding for achieving points, making time for group work during class, and providing online classroom recordings were some of these other strategies that were implemented. The survey also asked faculty for their feedback on the ILCs to help make them more impactful. Some of these suggestions included increasing the number of faculty participants to provide a larger pool of experiences as well as more time to convene and share lessons learned, particularly with successful implementation of strategies.

Conclusion and Future Direction

The first semester of this study saw the development and pilot of the inclusive engineering classrooms strategies menu and the student and faculty surveys for the assessment of that menu. As more semesters and participants are included in the study, the statistics on the impact of the implementation of these strategies will both strengthen and aid in refining the strategies menu. Collecting additional feedback, particularly from the faculty, will also help to develop the decision matrix for the strategies menu to further promote and support the implementation of inclusive strategies in engineering classrooms. Following additional refinement, the menu will be launched at other institutions as well as across diversity, equity, and inclusion networks to serve as a tool for creating more inclusive classrooms. We recognize that there is a need to fully develop a formal toolkit in which faculty can easily review and adopt practices into their teaching. This study represents the beginning of the journey to that fully realized toolkit to use across all engineering classrooms and curriculums.

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