Exploring Student and Faculty Beliefs about Inclusive Teaching in Engineering

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Abstract

Inclusive teaching is becoming a focal point in engineering education, with numerous calls for practices, measures, etc. to improve teaching and learning for all students. Cultivating inclusive practices within engineering classrooms can encourage persistence and retention in engineering and equip students with the skills necessary for success beyond academia. While inclusive teaching is widely recognized as a crucial component of education, there has been limited research within engineering education. The purpose of this paper is to present preliminary findings from a subset of student and faculty data and chart directions for future work. This study used insights from students and faculty to explore beliefs regarding inclusive teaching in engineering education settings. We used semi-structured interviews to examine beliefs related to inclusive teaching in engineering contexts. Our approach involved using first- and second-cycle methods to describe beliefs and organize them according to dominant themes. Preliminary findings indicate a diverse range of beliefs concerning inclusive teaching and suggest a shared sentiment among students and faculty participants regarding the importance of fostering student-professor personal connections, using inclusive pedagogical methods, and ensuring that courses address issues of diversity, equity, and inclusion in engineering. Given the importance of inclusive teaching in engineering education and its potential to positively impact the profession, our findings can inform faculty practices in ways that engage students and create a stronger sense of belonging in their classrooms. By developing a better understanding of engineering student and faculty beliefs surrounding inclusive teaching, this research can offer guidance on critical pedagogical skills.

Introduction and Background

Inclusive teaching is critical in engineering education. Despite decades of efforts to increase diversity and representation in engineering, the field remains predominantly male and white. Some of these challenges for greater representation are related, at least in part, to the need for more inclusive teaching approaches in engineering education. While there are numerous efforts to encourage and promote inclusive teaching in engineering (some within ASEE), relatively little remains known about faculty and student beliefs and experiences surrounding inclusive teaching. The purpose of this paper is to examine faculty and student beliefs surrounding inclusive teaching and to draw out themes that emerge across these groups. To accomplish this goal, we present a preliminary analysis of a subset of engineering student and faculty interviews.

In the following sections, we will introduce some relevant literature on inclusive teaching in STEM and engineering education, including current efforts and challenges. We then provide an overview of our data collection and analysis and the resulting themes. Given that this is a preliminary analysis, our implications and conclusions are tentative and so we also discuss how our future work will finalize our project and make more concrete recommendations.

Research on inclusive teaching in STEM offers a useful foundation to inform our current work, and we will focus on two aspects relevant to the current work. First, it offers practices, recommendations, and principles of inclusive teaching both within and outside engineering education. Second, some of this literature also addresses faculty challenges related to implementing these pedagogies.

One major component of diversifying the engineering profession is through creating a more inclusive learning environment (Mills et al., 2003). Literature on inclusive teaching is diverse and addresses a wide range of dimensions of teaching and learning. Here, inclusive teaching is generally meant to refer to engaging with students in ways that consider and value diverse perspectives and ways of knowing, and that make students feel as if they belong in the classroom. Inclusive teaching is becoming an increasingly important focus within engineering education, evidenced at least in part by the recent ASEE series, "Essentials of Inclusive Classrooms." Moreover, research has shown that minoritized students leave STEM and engineering not because of a lack of skill but instead a lack of belonging (Seymour & Hewitt, 1997).

There are several existing efforts to make engineering education more inclusive in different ways. For instance, Rooney (2020) developed a workshop that helped faculty work through topics such as implicit bias, growth mindset, interpersonal and teamwork skills, and other evidence-based practices that can promote inclusivity. Further, Dewsbury & Brame (2019) developed an interactive guide that would help instructors develop inclusive teaching practices. They emphasize the role of instructor empathy and self-awareness as well as the kinds of classroom climates they create. Relatedly, Hunter et al. (2010) lay out a professional development plan for lab instruction that emphasizes diversity, equity, and inclusion in STEM. They focus on diversity in terms of learning styles and preferences, learners' motivations and interests, and equitable collaboration, among other DEI-focused topics in STEM. These efforts and others highlight the diverse approaches taken to make STEM and engineering education more inclusive and point to the potentially wide range of beliefs faculty and students might have surrounding these efforts.

Second, implementing inclusive pedagogies overlaps with other novel or innovative pedagogies. For instance, problem-based learning encourages students to collaborate in authentic ways around meaningful, contextually rich problems (De Graaf & Kolmos (2003), Hmelo-Silver & Eberbach (2012), Johnson (1999), Kolmos & De Graaff (2014)), and instructor facilitation techniques share many similarities with other inclusive teaching principles (Hmelo-Silver & Barrows, 2006). However, instructors who use these kinds of active learning techniques often face various challenges. For example, Tharayil et al. (2018) note faculty challenges related to

skepticism around the effectiveness, time, and resources required to implement them, and student resistance. To enact inclusive teaching, instructors might have to learn new concepts, address topics in new ways, and engage with students in less familiar or comfortable ways. As a result, we argue that inclusive pedagogies might also incur some of the same challenges for instructors and resistance from students, and so prior work on these barriers helps inform our understanding of beliefs related to inclusive teaching.

In addition to challenges surrounding the kinds of practical student-teacher interactions with novel pedagogies, there is also the challenge of engineering culture and the barriers it might present to inclusive teaching. Some inclusive teaching approaches might be seen as politicizing topics in a discipline that often engages in the depoliticization of its concepts and methods (Cech, 2014). Cech notes how engineering education tends to depoliticize its topics and shows how students can disengage from the social or non-technical aspects of engineering problems over time. This belief that engineering is value-neutral or purely objective affects how engineering students see the problems they are asked to solve and the things they ought to think about when they solve them. Inclusive teaching in engineering can entail engaging with these non-technical aspects of problems, which can also lead to student confusion and resistance, posing a separate set of challenges for instructors.

Given the potential for inclusive teaching to improve engineering education and the potential challenges and barriers that might exist, it is critical that we better understand what students and faculty believe about their experiences with inclusive teaching in engineering. To address this gap, we pose the following research question:

> *What do students and faculty believe inclusivity teaching entails, and which beliefs are commonly shared and implemented in the classroom?*

Methods

The present work, conducted as part of a larger study, explores inclusive teaching through student and faculty perspectives. For this preliminary study, we analyzed data from 3 engineering faculty and 8 engineering students of various grade levels, genders, races/ethnicities, and majors from across the College of Engineering at a large public university on the West Coast. Faculty data was collected to learn about instructors' perspectives and the implementation of inclusive teaching methods within the classroom. The interviews focused on beliefs regarding the effectiveness of inclusive teaching practices, observations of inclusivity in action, and strategies for refining their existing teaching methods to foster inclusiveness. From our cross-sectional analysis, we compared data from both faculty and students, uncovering points of convergence and divergence in their viewpoints. This comprehensive examination not only evaluated the impact of inclusive teaching practices on shaping beliefs and perceptions within each group but also identified ways for faculty to add/improve upon their inclusive teaching efforts.

Recruitment and Data Collection

Faculty recruitment involved individuals who serve on various Justice, Equity, Diversity, and Inclusion (JEDI) committees within their departments and the College of Engineering, as they are the most likely to be thinking about these issues and implementing inclusive teaching practices in their classes. Students were selected from classes taught by the interviewed faculty members, ensuring a diverse sample for interviews and facilitating a standardized comparison with faculty responses. Gender and racial diversity were maximized in the student sample to ensure that the perspectives and voices of minoritized students were captured, as inclusive teaching is vital for all learners and can be especially impactful for students who are not from a dominant background.

Qualitative interviews were conducted to explore beliefs, practices, and perceptions surrounding inclusive teaching. The interviews were based on the following questions:

1. *What lessons, actions, or activities have you provided/been provided to foster inclusivity in the engineering environment?*
2. *What are some characteristics of an engineering teacher that fosters an inclusive environment?*
3. *Can you talk about a time when you experienced a lack of inclusivity?*
4. *How do you know or measure if you/a professor is being inclusive in the classroom?*
5. *What are some challenges you have experienced related to inclusive teaching in engineering?*

We completed a review for human subjects testing through the university's Institutional Review Board (IRB), and supporting documents of the study (survey, interview questions, informed consent forms, etc.) were submitted. We received approval before the continuation of the research project and were assigned project number 2023-173. Interviews were semi-structured to allow for both consistency across participants as well as flexibility for interviewers to pursue emergent or unanticipated findings as they arose.

Data Analysis

The audio data from the interviews were first transcribed automatically using Microsoft Word, cleaned, and then scrubbed of identifying information. Beginning with the analytic framework developed by Osman et al. (2021), we performed both emergent and a priori qualitative coding on interview transcripts. Our goal was to explore faculty and student perspectives on inclusive teaching, both within and beyond the classroom by focusing on their beliefs related to inclusive teaching in engineering. We performed qualitative coding in line with recommendations fromSaldaña (2013). We used first-cycle methods, such as descriptive coding, to identify and label relevant passages. This process allowed us to construct a thorough codebook outlining the diverse beliefs on inclusivity held by both students and faculty. We also implemented exploratory methods such as holistic coding and narrative coding to better understand any emergent themes that were not accounted for a priori. For example, the following passage was coded using descriptive coding, describing how faculty fostering personal connections with students helps cultivate an inclusive atmosphere.

> *Sometimes it's hard, like sometimes I feel shy to make that first step to engage or connect with the teacher. But if they reached out or connected with me first, then I would be a lot more willing. And then you can build a relationship with them and then learning becomes more enjoyable when you have a relationship with that teacher. [Student 1 Interview]*

We developed a list of 12 descriptive codes that helped us identify the different range of beliefs students and faculty held about inclusive teaching. Next, we used second-cycle coding methods, such as pattern coding, to identify themes and relationships both within and across student and faculty perspectives. This entailed reviewing our initial list of descriptive codes, organizing them,

and grouping them according to conceptual groups. For example, both students and faculty shared perspectives on beliefs related to evaluating or assessing inclusivity in the classroom. The following two quotes, from two different codes, were grouped to underscore the theme related to input or feedback from students in ways that can enhance inclusivity.

> *[Respondent] When I think of inclusive teaching, I think of making sure everyone in the classroom kind of feels heard and listened to and like they can have a place to share their voice. And, you shouldn't be scared to share an idea ask a question or speak up when you're confused about something. [Student 5 Interview]*

> *[Interviewer] Do you notice that [surveys] are helpful for you, that you feel like that you're giving good feedback to the professor?*
>
> *[Respondent] I feel like yes, because I feel like I feel heard and especially like with it being anonymous, I think it's good cause I think a lot of other people in the class might be like scared to say something or like when you're making a comment to teacher, you don't want them to give you a bad grade, or have them be annoyed that you didn't enjoy their class. [Student 5 Interview]*

While these two passages focus on different aspects of student experiences and contact points with faculty, they both center on the need to be heard and for students to be able to express how they feel regarding their learning. We performed this process of organizing our first-cycle codes into higher-order themes through second-cycle methods to develop the codebook laid out in Table 1.

To ensure credibility and trustworthiness, we followed recommendations from Stahl & King (2020) which offer concrete strategies for achieving validity and reliability in qualitative research, such as investigator triangulation, institutional checking on research (via IRB), and peer debriefing. Additionally, member checking, analytic memos, and audit trails were performed to ensure our findings are presented in ways that accurately represent student and faculty voices in engineering. The findings offer insights into the perspectives and experiences of engineering faculty and students regarding inclusive teaching. Furthermore, they present specific recommendations to enhance teaching and learning approaches in engineering, fostering depth and effectiveness.

Results

Preliminary findings suggest four distinct themes emerge related to student and faculty beliefs about inclusive teaching. These themes highlight a wide range of conceptualizations of inclusive teaching and highlight the diversity of ways that inclusive teaching can be implemented in engineering. We will address each theme in more detail along with participant quotes that help illustrate these different beliefs. Table 1 offers a brief overview of each theme, its operational definition, and its supporting descriptive codes from the first cycle analysis.

Table 1: Overview of emergent themes, definitions, and codes from the current data set

Theme	Definition	Codes
Attention to social dimensions of learning	Beliefs related to the importance of authentic personal connections and an awareness of relevant interpersonal dynamics	– Being aware of power dynamics and using words for a positive impact – Fostering student care, inclusion, and personal connections – Inclusivity promotes motivation and engagement
Implementing inclusive engineering pedagogy	Beliefs related to the ways different teaching methods can be inclusive or accessible	– Accessibility is inclusivity – Different learning styles and preferences – Inclusive teaching is effective teaching
Embracing diversity and representation	Beliefs related to the importance of understanding and accounting for diverse student experiences and differences	– Representation matters – Understanding student experiences and differences – Stereotypes can cause discomfort
Listening to student voices	Beliefs related to the role of student feedback or input in assessing or promoting inclusive teaching	– Surveys should be standardized and integral for teacher evaluations – Change needs to be implemented – Hearing students' voices is inclusivity

Attention to Social Dimensions of Learning

Our first theme, *Attention to Social Dimensions of Learning*, addresses beliefs related to interpersonal connections between students and faculty and the importance of students feeling cared for by their instructors. Both students and faculty believe that when there is some kind of meaningful personal connection, learning is more effective and the classroom is perceived as more inclusive. For instance, the following quote highlights a student's belief related to the importance of personal connections for their learning and engagement.

> *I think you could be more engaged in a class if you know the professor and you like the professor because you've created this connection and relationship with them, so that could impact your learning. So, you're more focused on what they're saying because you really like this professor. [Student 10 Interview]*

Relatedly, some faculty members shared beliefs about the importance of social aspects of learning through their attention to power dynamics common in educational settings.

> *Oh, one of the things some of us like to do is have office hours in the courtyard, and again like to me it's just… it's a nice day, we live in [a warm, sunny climate], why wouldn't we meet outside when we can? But I think there's also kind of a, you know, I'm not sitting in the throne in my office while you,*

the supplicant, come to me for assistance, you know, removes that kind of dynamic when we're all just sitting around the courtyard. I had office hours one night in the courtyard, it was getting dark, and for some reason, my student was going to an event afterward, and she had this like party light. So she turned on the party light. We had, like office hours with party light going on it was super fun. [Faculty 1 Interview]

Here, this faculty member talks about how by holding office hours in a neutral space and including student interests outside the class into office hours, they can make students feel more comfortable. Students and faculty both describe the importance of social connections and dynamics in creating an inclusive engineering learning environment.

Implementing Inclusive Engineering Pedagogy

Our next theme, *Implementing Inclusive Engineering Pedagogy*, focuses on beliefs related to the importance of effective teaching and accounting for the diversity of learners in a classroom. Many faculty participants held the belief that through accommodating and accepting all students, they could foster more effective connections and engagement with their students. This, in turn, created a learning environment where students felt more rooted in their learning and were more motivated to participate. The following quote illustrates this, showing a faculty member's belief in the importance of adjusting support to meet each student's needs.

[Interviewer] What comes to mind when you think of inclusive teaching in the classroom?

[Respondent] Meeting students where they need to be met, which differs from student to student. Giving students a safe environment where they can receive the support they need, whatever that looks like. And whether that is something like calling them by their preferred pronouns, or whether it is something like… I had a student who during tests would ask if she could go outside and talk through the question with me because she processed things verbally, you know, differently than when she was reading them. And so, we would just go out and I would read the question to her out loud and she would repeat it back to me that way she understood, which she wasn't able to do just reading it. So really simple accommodations like that and supporting that in how they treat each other and how students treat each other [Faculty 1 Interview]

Recognizing that standardized approaches may not effectively address the diverse needs of all students in the classroom, several faculty emphasized the importance of adapting their teaching methods to better accommodate individual student needs. Students also emphasized the importance of faculty recognizing student struggles and difficulties with instructional approaches in the classroom.

For inclusive teaching, I think it should include everyone's... not learning disabilities, but struggles with learning. One of the main ones that I have

struggled with is lecturing. I mean I think everyone knows that lecturing is not designed that well. Like a professor is supposed to speak within a certain amount of time, and a lot of times they don't post their notes or they don't record it. So, if you did not attend lecture that day for whatever reason, you're kind of left out of the loop. Also, when it comes to tests, tests are a big thing for me... that's been a main struggle for the past three years while I've been in college, just because of test anxiety. It's crazy how much your performance can be affected just by testing anxiety. It's not an accurate representation of you as a student. [Student 2 interview]

Students expressed the belief that inclusive teaching and faculty accommodation to diverse needs are essential for fostering their engagement and motivation to succeed in the classroom. Both students and faculty held beliefs centered around effective educational methodologies that stem from the importance of catering to the needs of all students.

Embracing Diversity and Representation

Our third theme, *Embracing Diversity and Representation*, revolves around the belief in the importance of recognizing that representation matters for students' feelings of belongingness in engineering. This theme highlights the significance of understanding diverse student experiences and differences and also addresses the need to include a variety of perspectives in classroom examples. The subsequent quote further illustrates this perspective, emphasizing the importance of representation and inclusion, particularly regarding racial diversity.

[Interviewer] What comes to mind when you think of inclusive teaching in the classroom?

[Respondent] Oh I think of how you're introduced to this school as predominantly white and how they're doing many things to try to make it more inclusive for us nonwhite individuals of the school... I think inclusive teaching includes making sure that examples you see in the classroom have our races introduced to these classes. So sort of making sure that we're heard as well, making sure the examples aren't only focused on white individuals. [Student 8 Interview]

In addition, students voiced beliefs about the importance of seeing themselves reflected in their peers and faculty. They expressed that this fosters a sense of community among individuals who share similar backgrounds and perspectives. For instance, one student highlighted the importance of female representation in STEM classes, noting the encouragement it provides and the need for equitable treatment from professors.

A lot of times in my STEM classes, I'm the only girl or one of two or three. So when other girls show up to office hours, it's really encouraging to see them also interacting with the professor and also standing up for their education, because it's really easy to get impostor syndrome and think, this is really

> *intimidating and I don't really belong here. But I'd like to see the professor interact the same way for other women in STEM just to make it seem like he or she cares about my education and another girl's education just as much as any other guy's. [Student 9 Interview]*

Students' beliefs regarding representation and faculty's acknowledgment of their role in fostering student belonging, are integral components of creating an inclusive learning environment. This mutual recognition highlights the importance of inclusivity and the impact it has on students' sense of belonging.

Listening to Student Voices

Underscored in the other themes, the last theme, *Listening to Student Voices*, explores beliefs surrounding the importance of making sure students feel comfortable speaking up and also incorporating feedback to foster an inclusive atmosphere. One student described the importance of feeling listened to as related to feeling included.

> *When I think of inclusive teaching, I think of making sure everyone in the classroom kind of feels heard and listened to and like they can have a place to share their voice. And you shouldn't be scared to share an idea or ask a question or speak up when you're confused about something. [Student 5 Interview]*

Another recurring belief among students centered around their desire to share their voices more effectively by evaluating or commenting on faculty teaching practices. Students expressed their views on the impact of providing feedback and its implications for faculty, and some students viewed the standardization and promotion of surveys as a positive approach to more accurately reflect their perspective, gather feedback from a broader range of students, and motivate faculty to implement changes based on their feedback.

> *I 100% think they should [incentivize surveys] because this basically creates less response bias. If you don't really have much of an incentive to fill them out besides this extra credit, then only people who feel very strongly about certain things are going to respond. So, then you don't really get these other opinions or the middle opinion. So, it kind of creates this skewed data. So, if you have this incentive of adding extra credit, I think more people are going to feel like they should fill it out. So, then you kind of really lower this response bias. [Student 10 Interview]*

Acknowledging the value of student voices and the importance of implementing changes based on feedback, there is a prevalent belief in standardizing surveys to effectively capture and address all student perspectives. For faculty, this approach ensures an understanding of student needs and facilitates targeted improvements in educational practices.

Summary of Findings

Preliminary findings highlight student and faculty beliefs about inclusive teaching that address a wide range of educational contexts and modes. Attending to the non-technical dimensions of engineering seems to be perceived as one way to engage in inclusive teaching, with both students and faculty noting the importance of social aspects of the classroom and interpersonal connections. Inclusive practices as a theme helps us elaborate on the different motivations for faculty and better understand how students interpret inclusive pedagogies. Embracing diversity and representation describes the ways we engage with issues of underrepresentation for women and minority groups in engineering and illuminates the different ways this idea is conceptualized for students and faculty. Finally, there is a strong belief surrounding the importance of student voices in creating an inclusive learning environment, and this theme describes the different ways these student voices are interpreted and included in the educational process. Overall, these findings offer a useful descriptive framework to better map out and characterize faculty and student beliefs surrounding inclusive teaching.

Key Findings and Discussion

Although these findings are preliminary and based on a subset of data, they nonetheless offer interesting insights into student and faculty beliefs regarding inclusive teaching. For example, the theme related to the social dimensions of learning emphasizes the importance of teacher-student relationships and the role of caring in beliefs about inclusivity. Indeed, Jones (2009) identifies "caring" as one of the five main components of academic motivation, noting the importance of students feeling that their instructor cares about their academic success. Our findings suggest that care may also play a role in student perceptions of inclusivity in the classroom, and so prior literature (e.g., Ross et al. (2017)), can offer insight into inclusive (i.e., caring) behaviors and practices.

Further, the relationship between beliefs and practices in engineering teaching is vital for creating inclusive learning environments. As evidenced by the interviews, inclusive engineering classrooms embody a commitment to diversity, equity, and inclusion (DEI), accommodations for diverse learning needs, various teaching approaches, and the cultivation of inclusive mindsets among faculty and students alike. Recommendations drawn from prior research, as discussed in Thomas (2016), align with our findings, emphasizing the importance of inclusive practices for student engagement and learning outcomes. However, Cech (2014) suggests that some may perceive certain inclusive practices as politicizing engineering education. Educating faculty about the underlying principles of inclusive teaching can help them understand that inclusivity is not necessarily political or aligned with specific "DEI agendas." This change in perspective can prompt faculty to embrace inclusive teaching practices as vital elements of effective pedagogy, rather than categorizing them within a purely social or technical framework. The synthesis of prior research and our findings emphasize the importance of integrating inclusive practices into engineering education for better teaching effectiveness and improved educational outcomes.

Future Work

The findings from this study were based on a subset of a larger dataset and are therefore preliminary. We will conduct coding and thematic analysis on an additional 12 student and 7 faculty interviews. Building upon the preliminary study, our goal is not only to deepen our understanding of the initial findings on inclusive beliefs but also to assess these insights through the lens of inclusive practices and challenges. During interviews, we also posed questions probing for practices and challenges related to inclusive teaching methods. Future work will entail a comprehensive data analysis, examining each of these in more depth from both faculty and student perspectives. To achieve this, new codes and themes will be established for each category, and a comprehensive codebook will be created for faculty implementation. In addition, we will perform a comparative analysis regarding the emergent themes. This will enable us to identify interactions or misalignments in viewpoints, explore strategies for removing barriers, and offer recommendations related to inclusive teaching methods. These findings can help us make more concrete recommendations to align faculty practices with student expectations in ways that promote inclusive teaching in engineering.

We are currently exploring these challenges in more depth, but we have initial evidence that some of the beliefs students and faculty hold also correlate to potential challenges. For example, while students and faculty believe that inclusivity involves embracing diversity and representation, this might be the result of experiences where students felt a lack of inclusion or representation in the classroom. Some beliefs about inclusive teaching may have been shaped by the negative feelings associated with challenging experiences. And although faculty in our sample expressed a belief in the importance of representation and belongingness, our participants were actively engaged in some kind of DEI work at the university. Students noted experiences where they felt the classroom environment did not embrace diversity and representation, suggesting a potential misalignment between student experiences and faculty perceptions. These findings will be used to make recommendations for faculty at our local university in the College of Engineering. Specifically, we will provide guidance on inclusive teaching practices specific to engineering and offer models to collect student feedback in ways that promote inclusivity (i.e., listen to and include student voices). We will provide recommendations on both practices they can implement and data they can collect related to inclusive teaching. The broader impacts of this study can foster a more inclusive and welcoming environment for students, while simultaneously refining faculty teaching practices and enhancing effectiveness in the classroom.

Conclusion

Inclusive teaching is a critical aspect of effective engineering education, and the purpose of this research is to explore faculty and student beliefs related to inclusive teaching. We used semi-structured interviews with engineering students and faculty to examine beliefs about inclusive teaching, specifically within engineering. Our preliminary analysis revealed four emergent themes that address a wide range of beliefs about inclusivity in engineering. Building interpersonal connections, adopting inclusive pedagogy, addressing issues of representation, and paying

attention to student voices were all different ways students and faculty thought about inclusivity in engineering. While there are some discrepancies in how these themes were expressed (i.e., some students expressed negative sentiments about the same ideas faculty were positive on), the findings offer insight into different ways that engineering faculty can create a more inclusive classroom and make students' voices feel heard. To effectively implement inclusive teaching practices, faculty may need to reevaluate or adjust certain beliefs about inclusivity. However, this underscores the significance of implementing inclusive teaching practices, which not only enhance classroom effectiveness but also promote student success.

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