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Creating an equitable and inclusive STEM classroom: a qualitative meta-synthesis of approaches and practices in higher education

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How can Science, Technology, Engineering, and Mathematics (STEM) faculty integrate a humanistic approach to create environments where students do not feel marginalized? Changes are necessary to address the historically exclusive climate and systemic oppressive classroom policies and classroom practices dominated by White, patriarchal, Eurocentric perspectives pervasive in many STEM higher education classrooms. By incorporating approaches and practices documented in the literature over time and across multiple STEM disciplines, faculty can create equitable and inclusive (EI) classrooms. However, the challenge for individual faculty members is consolidating the information to identify fundamental elements necessary for establishing EI spaces. This project addresses that challenge by conducting a comprehensive meta-synthesis of higher education literature to identify themes for what constitutes an EI classroom and recommendations for how faculty can facilitate one. The dataset includes 61 articles from 277 authors and 48 unique journals and reflects a timeframe of January 1995–June 2021. Our findings are organized into four key concepts, indicating that EI pedagogies related to the affective, cognitive, and metacognitive categories of learning are vital to an equitable and inclusive classroom. However, the essential finding of this analysis was the importance of the fourth key concept, faculty cultural competency and elements related to the climate and structure of the classroom, referred to as Faculty Agency and Action (FAA). The results of this meta-synthesis were compared to the most frequently cited seminal works within the field, demonstrating that although these individual works contain most, they do not include all of the themes indicated by this study and, in some cases, over- or underrepresent some of the topics discussed. As mirrored in the most frequently cited works and the findings of this meta-synthesis, it takes incorporating classroom-focused approaches and faculty's reflective resolve to understand and change how dominant and privileged identities are reflected for classrooms to be equitable and inclusive in STEM.

KEYWORDS

equity-mindedness, equity, inclusive classrooms, inclusion, STEM, higher education, meta-synthesis

Introduction

Science, Technology, Engineering, and Mathematics (STEM) higher education classrooms are not race-, gender- or class-neutral; therefore, change is necessary to address the resulting exclusive climates that historically and currently exists in many STEM classrooms. Interventions and initiatives supporting students (e.g., Beichner, 2007; Kuh, 2008) have resulted in an increased representation of those with marginalized identities studying STEM. However, many current student-focused approaches attempt to fix the symptoms rather than addressing the classroom cultures perpetuating inequities (Peña et al., 2006; Asai, 2016).

Rethinking classroom culture in support of equity is an imperative that requires equity-mindedness (Bensimon, 2018): a shift from a student-deficit perspective to a mindset that acknowledges that institutional and faculty changes are necessary to address educational disparities within higher education. Equity emphasizes the need to reinforce ideas and habits that achieve outcome parity and close educational disparities (Bensimon, 2018). Inclusion is the purposeful engagement with diversity (Bensimon, 2018) through "authentic and empowered participation and a true sense of belonging" (The Annie E. Casey Foundation, 2014). Encouraging faculty and administrators to follow an equity and inclusion mindset provides an opportunity to recognize and dismantle systemic, discriminatory structures and barriers students face in STEM environments (Center for Urban Education, 2018; Achieving the Dream, 2022).

An equity and inclusion mindset leverages varied and interactive approaches to teaching and learning. First, centering the student in teaching strategies is associated with constructivism, where students' prior knowledge is integrated into learning (e.g., Hernandez et al., 2013). Tangney (2014) argues, however, that learner-centered teaching is founded in theories beyond constructivism and includes the undervalued humanist approach. Humanism accounts for the personal and cultural experiences students bring as individuals to learning (Lee et al., 2021), emphasizes competencies more frequently associated with the humanities rather than with STEM (Bourdeau and Wood, 2019), and underscores relationships (notably the student-instructor relationship) as a critical element in quality teaching (Torrisi-Steele, 2018). While educators and researchers have long recognized that these approaches benefit all learners, these approaches are not always used in practice to create equitable environments. Faculty can only create classrooms where students feel they belong, are respected, and are cared for if they incorporate equitable and inclusive (EI) classroom strategies. To do so they need to understand (1) what strategies are necessary to dismantle STEM classroom policies that are systemically oppressive and marginalizing and (2) how to replace classroom practices that represent a system dominated by White, patriarchal, Eurocentric perspectives (Tanner and Allen, 2007; Miller et al., 2021). The STEM education community has explored strategies to assist faculty in creating EI higher education environments by, for example, using active learning strategies (Tang et al., 2017; Beier et al., 2019), incorporating students into classroom decisions (Couch et al., 2015), creating a curriculum that includes a broader representation of identities and viewpoints (May and Chubin, 2003; Riggs, 2018) and incorporating teaching strategies and experiences that increase student sense of belonging (e.g., Rodriguez and Blaney, 2021).

In a quickly growing field, approaches for creating EI classrooms have been published over time and across STEM disciplines and reflect multiple fields of study. The challenge for university faculty is consolidating the literature to understand the breadth of opportunities to create EI STEM classroom environments (Considine et al., 2017). This research study addresses this challenge and, as a result, aims to encourage more faculty to explore equitable and inclusive pedagogies. Using a qualitative meta-synthesis framework (Levitt, 2018), we have cataloged components of EI in STEM higher education classrooms from literature published through June 2021 and interpreted meaning from these studies (Walsh and Downe, 2005).

In this study, we argue the need for a comprehensive understanding of the literature to highlight the components of equitable and inclusive environments and amplify the voices of the STEM community. As opposed to compiling practices, this study synthesizes literature over time and across disciplines to provide higher education STEM faculty with a roadmap of EI concepts that influence the classroom and provide a comprehensive corpus of references to explore specific EI topics of interest. Notable work that is highly quoted and influential in the field has highlighted important EI strategies (e.g., Lage et al., 2000; Gay, 2013; Tanner, 2013; Zumbrunn et al., 2014; Dewsbury and Brame, 2019; Theobald et al., 2020), but their recommendations are not compiled directly from the literature as will be done in the present study. Further, we compared our findings with those of these seminal works to identify novel or overlooked areas and to highlight any trends reflected within our meta-synthesis findings. Our meta-synthesis surfaces significant ideas validated by published research, and calls attention to opportunities for creating EI classrooms that are not represented or underrepresented in these other compilations of EI practices.

Methods

Meta-synthesis approach and literature search

We used a meta-synthesis approach to systematically review, summarize, and understand elements in previously published literature (Walsh and Downe, 2005; Saldaña, 2016; Levitt, 2018). As opposed to a meta-analysis, which only evaluates quantitative data (Grant and Booth, 2009), a meta-synthesis integrates data from both qualitative studies (Walsh and Downe, 2005; Saldaña, 2016; Levitt, 2018) and quantitative studies (Urquhart, 2011). In addition, following a meta-synthesis research design was a deliberate choice, as this study aims to interpret a large set of data to present a conceptualized framework of concepts (Finfgeld-Connett, 2010) and follows an interpretive, rather than just aggregative, exploration of the data (Sutton et al., 2019). This differs from a literature review in that rather than compiling a summary of individual articles, it brings together a deeper understanding of the data, describing patterns, concepts, and emerging theories (Finfgeld, 2003; Leary and Walker, 2018). We used both quantitative and qualitative studies as part of our dataset but only gathered qualitative data from all parts of the articles as a data source. Reviewing previously published literature utilizing this approach allows researchers to create meaning from a large set of literature (Levitt, 2018), giving readers a broader depth of knowledge on the topic.

We initially identified relevant literature only from the ERIC (Education Resources Information Center) digital library, a database sponsored by the Institute of Education Sciences (IES) within the United States Department of Education, using a combination of terms and refinements and snowballing. The date range of our dataset represents the chronological boundaries of ERIC when we completed our search (through June 2021). The total number of findings across the ERIC database was 13,244. These methods and all subsequent methods are depicted in Figure 1.

Our search for relevant literature used the following key terms: "achievement gap," "culture," "culturally responsive," "diversity/diverse," "equitable/equity," "inclusive/inclusion/inclusive excellence," "learning AND relevant," "minority," "multicultural," and "social justice." The assumptions for our search were: "AND higher education," "AND classroom," "NOT pre-service," "NOT preservice," "NOT teacher educat*," "NOT online," "NOT distance learning," "NOT supervis*," and "NOT mentor*." Our search was refined by the terms: "STEM," "science," "biology," "chemistry," "physics," "technology," "engineering," and "math*."

Criteria for inclusion in the dataset required that the research be peer-reviewed, situated in higher education, specifically four-year institutions, and US-based. The choices for inclusion criteria were intentional, as the environment in K-12 is distinctive from higher education institutions and was not our focal environment. Further, students enrolled in two-year institutions and those located outside of US-based institutions have their own unique backgrounds and challenges. In addition, we excluded literature that concentrated on preservice or teacher education and medical education to emphasize general classroom approaches that could be applied to all STEM students. Reference snowballing from initial research findings was also used to discover relevant articles (Choong et al., 2014).

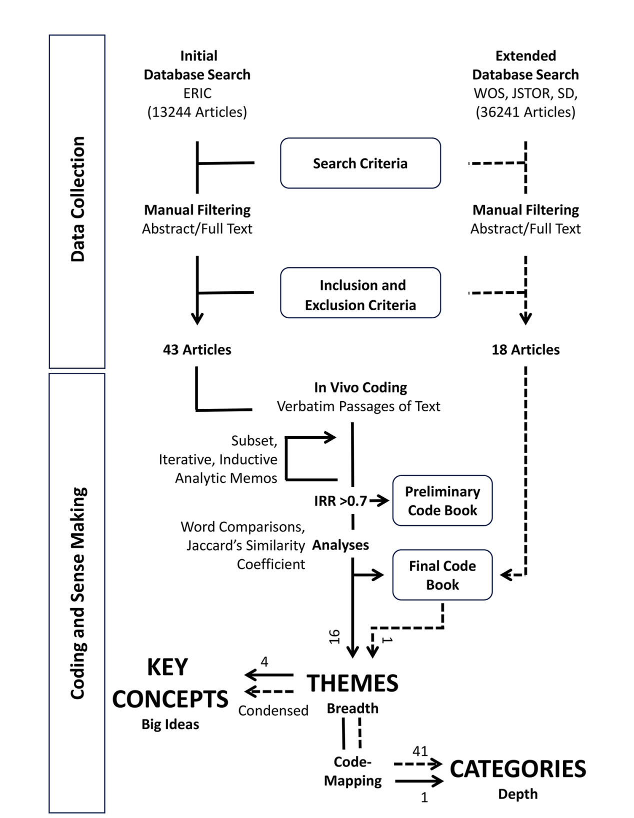

FIGURE 1
Methods Diagram of the Meta-synthesis and Coding Approach. Flowchart of the overall meta-synthesis process. The first cycle of data collection (database searching and manual filtering) used ERIC, represented on the left by solid lines. Coding and sense making followed using *in vivo* coding and analysis to determine emergent themes, key concepts, and categories (numbers on each corresponding solid arrow notes the abundance of each). A second round of data collection occurred using WOS, JSTOR, and ScienceDirect, represented on the right by dashed lines. Using the finalized codebook, coding and sense making continued with *in vivo* coding passages into the finalized themes, key concepts, and categories (with numbers of each labeled on corresponding dashed arrows).

By reading abstracts and articles, we manually filtered results to identify studies that described or used classroom applications or approaches, were generally classroom specific (not a lab environment), were not focused on student success beyond the classroom or learning styles, were not focused on work that specifically excluded STEM, and had an equity and inclusion focus. We did not include theoretical-based articles or those focused solely on institutional-level policies and practices. After filtering through the abstracts, we identified 43 articles from ERIC for coding. The process was repeated for Web of Science (WOS), JSTOR, and ScienceDirect, using the chronological boundaries of the databases through June 2021, resulting in 26,421 additional identified articles from these three additional databases. After removing duplicates and filtering abstracts (using the specific inclusion criteria described above), 98 articles were identified from the latter search, further reduced to 18 articles that contained specific classroom applications. The final dataset compiled from all databases included 61 articles from 277 authors and 48 unique journals between January 1995–June 2021.

Initial coding, code-mapping, and theme processing using the ERIC database

We (VLD and SMK) used NVivo qualitative coding software (QSR International Pty Ltd, 2018) to code a subset of articles from our larger dataset. The subset of articles was arbitrarily selected from the ERIC dataset. This coding process used *in vivo* coding to organize verbatim passages of text to highlight the voices of the researchers who authored the studies in our dataset (Saldaña, 2016) and references therein. We recognize that in some instances, our coding captured paraphrases where authors used their own words to distil the ideas of others within a STEM context. We purposely avoided coding direct quotes used in our articles to limit double-counting phrases that may have occurred elsewhere in our dataset and properly attribute wording to their sources. Verbatim passages of text were then grouped into themes based on their content (Saldaña, 2016). Coding a subset of articles allowed for an inductive and iterative coding approach to familiarize the coders with the descriptive coding process, develop a preliminary codebook, and establish acceptable reliability between coders (Saldaña, 2016). When appropriate, passages of text were coded into multiple themes. After four articles were coded, we determined that subset coding was complete because the coders reached a threshold of satisfactory intercoder reliability, a Cohen's Kappa value of 0.76, considered a "moderate" agreement (McHugh, 2012; O'Connor and Joffe, 2020).

Using the preliminary codebook established during the subset coding, the coders independently applied *in vivo* coding to code approximately half of the remaining ERIC dataset, with overlap to allow for continued analysis of intercoder reliability. Over time, intercoder reliability increased to an average of 0.92, considered an "almost perfect" agreement (McHugh, 2012; O'Connor and Joffe, 2020). Coders maintained analytic memos to allow for independent documentation of the coding process (Figure 1), including questions and possible revisions to the codebook (Saldaña, 2016). Coding was a fluid, collaborative process in which coders revised and consolidated the preliminary codebook and discussed concerns or discrepancies that occurred while coding and were documented in the analytic memos.

The coders purposefully explored the extent of overlap in the preliminary codebook using word comparison representations in NVivo (treemapping, dendrograms, word clouds). In addition, to qualitatively visualize the percentage of overlap, the coders employed a 50% overlap threshold of Jaccard's similarity coefficient analysis, indicating that verbatim passages within two themes shared an overlap of at least 50% (Glen, 2016). Following these analyzes, the codebook was minimally updated after combining themes with greater than a 50% overlap. The finalized codebook consisted of 16 themes that emerged from the ERIC dataset; a theme identifies "what a unit of data [verbatim passages] is about and/or what it means" (Miles et al., 2020). The remainder of the ERIC dataset was coded using the finalized codebook.

To synthesize and catalog components of inclusive and equitable STEM higher education classrooms, we used code-mapping, a second-cycle coding approach, to evaluate content within each theme (Saldaña, 2016; Figure 1). Code-mapping uses a hierarchical approach and iterative analysis to "bring meaning, structure, and order to data" (Anfara, 2008, as quoted in Saldaña, 2016, p. 218). First, within each theme, all verbatim passages of text were labeled with a one- or two-word tag, which summarized the content of the passage. Then, tags were compared and consolidated into categories by matching keywords and checking for overlapping synonyms. Through this process, we identified a collection of unique ideas (categories) that describe the breadth and depth of each theme, cataloging the components of inclusive and equitable classroom approaches; see Figure 2 for an example of code-mapping.

To interpret meaning from the dataset, we condensed our themes into a set of key concepts, representing the major ideas that resulted from the meta-synthesis. Although no standardized number of major themes or concepts exist for a meta-synthesis (Saldaña, 2016), experts recommend five to seven larger interpretive ideas (Creswell, 2013; Lichtman, 2013). Because many of our themes emphasized student learning, we organized our themes using three major domains of learning (Vermunt, 1996) as an organizational framework. We did not use Vermunt's domains of learning as initial underlying theory; rather, this emerged as we analyzed our dataset. We found many themes emphasized concepts of student learning; therefore, we scaffolded our results using a structure with which faculty are likely familiar. The framework includes Impact on Students' Affective Learning, Impact on Students' Cognitive Learning, and Impact on Students' Regulatory Learning. Affective learning activities include student feelings and emotions that affect learning (Vermunt, 1996), including student motivation and attitude toward learning (Krathwohl et al., 1964). The cognitive learning category includes activities that "process learning content" (Vermunt, 1996) and describes how students develop knowledge and skills (Bloom et al., 1956). Metacognitive activities incorporate the perceptions and personal knowledge about one's learning process (Flavell, 1976) to regulate affective and cognitive learning activities (Vermunt, 1996). Eleven of the 16 themes were encompassed by this framework. The final key concept, including the remaining five themes, was not specifically associated with student learning. Instead, it contained faculty- or classroom organization-based elements that faculty could use to dismantle oppressive and marginalizing structures and policies within the classroom. These themes were grouped into a final key theme: Faculty Agency and Action (FAA).

Inclusion and processing of additional databases

Using the finalized codebook, we repeated the process for the articles identified from WOS, JSTOR, and ScienceDirect. The verbatim passages of text identified from *in vivo* coding were coded into existing themes where appropriate (finalized codebook) and labeled with tags to determine categories. One new theme emerged (growth mindset) from this process, which was encompassed by an existing key concept (affective learning).

Reference articles for comparison

In recognition of previous work that aimed to summarize inclusive and equitable classroom practices, we compared our findings to recommendations from our dataset's most cited articles (six articles representing the top 10% most frequently cited articles of the dataset), which we refer to as "reference articles." Reference articles were determined by calculating a standardized citation count, dividing how many times the article has been cited on Google Scholar by the number of years since the article was published (which was determined in, 2022). For example, an article published in 2020 with 426 citations would have a standardized citation count of 213. The six reference articles represent around 14% of our data (108 coded passages).

To compare the themes emerging from the meta-synthesis with EI concepts in these reference articles, we calculated the coding frequency of each theme in our dataset to determine the percentage of coded passages in each theme. For example, the affective learning theme comprised 25.8% of our data. We then mapped ideas from the reference articles onto our coding structure, including frequency, to determine where the data aligned with recommendations found within the reference articles and to what degree these were not represented and underrepresented in those six articles.

Positionality statement

In this study, we focus on the voices of the authors within our dataset, but we would like to disclose and intend to be transparent and reflexive about our identities associated with the work we have completed for this project. This research involves decision-making in selection criteria, analysis, and interpretation that may reflect our biases. All authors identify as White, heterosexual, non-disabled women, and SMK and VLD identify as first-generation students.

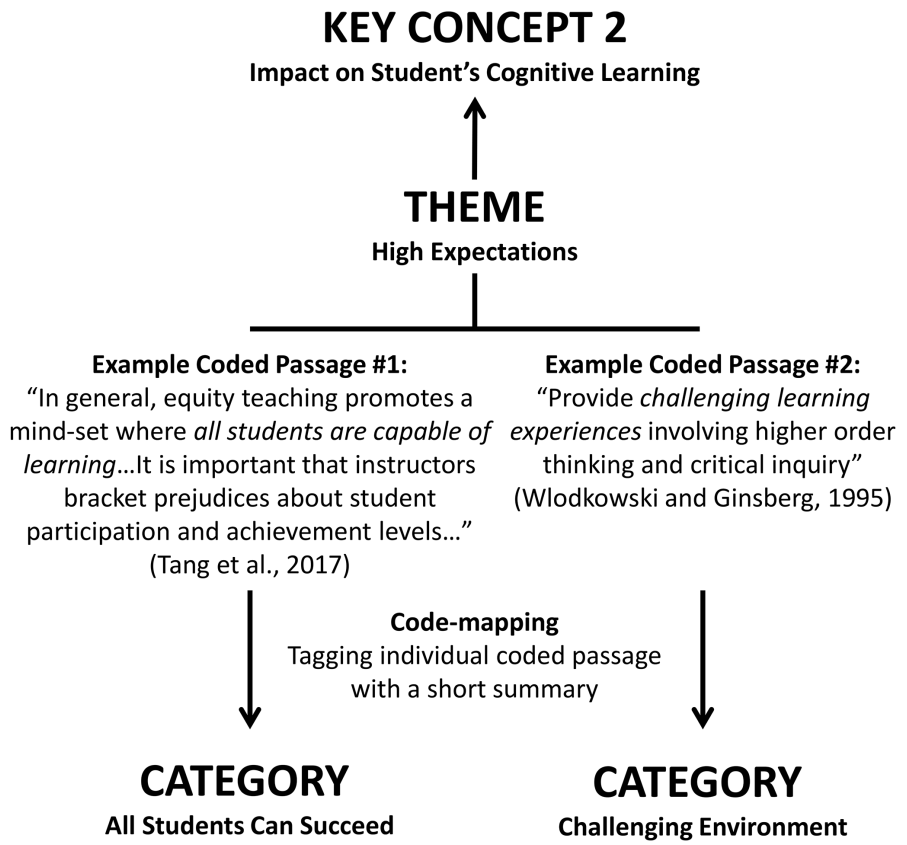

FIGURE 2
Example of Code-Mapping Process. Two example coded passages of the High Expectations theme for key concept 2: Impact on Student's Cognitive Learning are represented. During the code-mapping process, each coded passage was analyzed for key ideas that surfaced. Within the coded passages, these key ideas were "tagged" with a few words to represent a small summary, these tags are represented by italics in the figure. These tags were grouped together and represent the categories within each theme.

Authors have currently or previously taught STEM courses in higher education. These identities are a lens that informs our experiences and how we view our data and research.

Results

The goal of this meta-synthesis was to catalog and synthesize components of EI classrooms from published literature. We evaluated 61 articles and identified the major foci of the literature regarding EI in STEM higher education. Our data included all sections of the articles and incorporated results and interpretations made by authors. We organized the foci into four key concepts, which included 17 themes. Below, we describe the key concepts and detail the incorporated themes. For comparison, we determined the percentage each theme represents within its associated key concept and the percentage each theme represents in our full dataset. This information is included in Table 1.

Below, we summarize the features of a STEM higher education EI classroom. In describing our key concepts, themes, and categories, we used direct text excerpts from our corpus of articles to infuse the language and descriptors used by the authors but kept verbatim passages of text short to allow our synthesis to emerge. This leads to a combination of terms used in this manuscript (e.g., students, learners, instructors, teachers, etc.). The references that are cited within each theme are examples that highlight the ideas of the theme but do not include all references within that theme. The accompanying tables, however, list all references for each theme. The number of individual coded passages for each theme is noted in parentheses throughout the text and in tables. Categories, which help describe each theme, are indicated in *italics*.

With the goal of our analyzes to compile approaches that create environments where students can succeed and student growth and learning are positively impacted, the organization of the initial three concepts was guided by categories of learning and regulation described by Vermunt (1996): affective, cognitive, and metacognitive. While we used the domains of learning to organize our data, the focus remains on providing faculty with EI concepts that can be incorporated in the classroom and are broadly represented across the domains of learning. To meet the needs of students and maximize student learning, faculty can apply these key concepts to the approaches they use in the classroom. The fourth key concept, Faculty Agency and Action (FAA), compiled classroom approaches and reflective actions not directly related to student learning. This key concept is the most under faculty control and encompasses approaches to dismantle systemic oppressive and marginalizing systems within classrooms.

TABLE 1 Key concepts and themes.

		Themes	# of Coded passages	% of Key concept	% of Total coded Passages
Key concepts	Affective	Choice	27	13.8	3.6
		Competence	8	4.1	1.1
		Growth mindset	14	7.2	1.9
		Motivation	7	3.6	0.9
		Personal relevance	92	47.2	12.2
		Science identity	7	3.6	0.9
		Self-efficacy	10	5.1	1.3
		Sense of belonging	30	15.4	4.0
	Cognitive	High expectations	7	6.4	0.9
		Learner centered teaching	97	88.2	12.8
		Subject matter relevance	6	5.5	0.8
	Regulatory	Metacognition	8	100.0	1.1
	FAA	Classroom climate	118	26.7	15.6
		Classroom structure	128	29.0	17.0
		Faculty's cultural competency	123	27.8	16.3
		Microaggressions	39	8.8	5.2
		Stereotype threat and bias	34	7.7	4.5

Themes with the total number of coded passages in the data set, percentage of coded passages represented in each key concept, and percentage of coded passages represented in the full data set. Themes are presented alphabetically, grouped by key concept.

Key concept 1: impact on students' affective learning

Affective learning is defined as the emotional approach to learning, which may include students' "feelings, values, appreciation, enthusiasm, motivation, and attitude" about learning (Krathwohl et al., 1964). Our meta-synthesis suggests that EI environments are impacted by how students affectively learn and interact with content. This key concept incorporates eight themes identified during the coding process that involves student affective learning: choice, competence, growth mindset, motivation, personal relevance, science identity, self-efficacy, and sense of belonging. Affective learning represents 25.8% of the data in our meta-synthesis (195 coded passages). The themes are described below (listed in alphabetical order rather than frequency, to avoid overemphasizing themes that are simply more commonly mentioned, when all are critical elements of EI classrooms). The categories and references for each theme are listed in Table 2.

Choice (27)

The choice theme addresses the student's role in selecting materials and assignments, having the ability to make decisions, and having control in the classroom environment (Wlodkowski and Ginsberg, 1995; Considine et al., 2017). In addition, student choice can allow for increased student engagement and students feeling comfortable in the classroom (Considine et al., 2017), a positive outlook from students about learning (Wlodkowski and Ginsberg, 1995) and students who feel motivated and empowered in the classroom (Bayles and Morrell, 2018). This theme includes three unique categories (in italics) that further describe how incorporating student choice can create inclusive classrooms.

Considine et al. (2017) describe the impact of student choice as resulting in "positive outcomes, including increased engagement and inclusivity as students delve into issues relevant to them and their culture, feel more comfortable participating in discussion, and take greater ownership of their learning." Choice has an influence on whether a class is equitable and inclusive in multiple ways. Faculty can adapt *course design* to allow "students more choice and ownership of their own work" (Bernacchio et al., 2007), and adjust *evaluation/assessment* to reflect that "not all students' proof of achievement will be tied to traditional forms of assessment" (Booker and Campbell-Whatley, 2018). When connected with *power-sharing*, choice results in an empowering classroom environment (Bayles and Morrell, 2018). Dewsbury and Brame (2019) suggest that "a pedagogical choice can be active, but the degree to which it reflects the instructor–student dialog is what makes it inclusive." Quaye and Harper (2007) also recommend that "soliciting input from students of all backgrounds" about content can help faculty share authority, holding themselves accountable for choosing diverse course topics.

Competence (8)

We describe the competence theme as student possession of the knowledge and facility with STEM content and/or skills. This theme includes two unique categories.

Engendering student competence can "provide a boost to historically marginalized groups so that they can more effectively engage in the learning process" (Dewsbury, 2017). To influence competence, faculty can adapt aspects of *course design* by creating a variety of assessment methods, including "contextualized assessments,

TABLE 2 Key concept 1, impact on students' affective learning.

	Categories	References
Choice (27)	Course design (8)	Wlodkowski and Ginsberg (1995), Lage et al. (2000), Bernacchio et al. (2007), Penner (2018), and Harrison et al. (2019)
	Evaluation/assessment (12)	Wlodkowski and Ginsberg (1995), Lage et al. (2000), Bernacchio et al. (2007), Nuñez et al. (2010), Considine et al. (2017), Cotner and Ballen (2017), and Booker and Campbell-Whatley (2018)
	Power-sharing (7)	Lage et al. (2000), Bernacchio et al. (2007), Quaye and Harper (2007), Bayles and Morrell (2018), Graham (2018), and Dewsbury and Brame (2019)
Competence (8)	Course design (5)	Wlodkowski and Ginsberg (1995), Jett (2013), and Considine et al. (2017)
	Interactions (3)	Taylor (1997), Tanner (2013), and Tobin (2020)
Growth mindset (14)	Instructor mindset (9)	Bauer et al. (2020), O'Leary et al. (2020), and White et al. (2021)
	Student mindset (5)	Bauer et al. (2020), Johnson et al. (2017), and White et al. (2021)
Motivation (7)	Interest (5)	Wlodkowski and Ginsberg (1995), Case (2013), and Bayles and Morrell (2018)
	Positive reinforcement (2)	Wlodkowski and Ginsberg (1995) and Case (2013)
Personal relevance (92)	Cultural identities and perspectives (45)	McGee and Banks (1995), Wlodkowski and Ginsberg (1995), Bernacchio et al. (2007), Quaye and Harper (2007), Tanner and Allen (2007), Boutte et al. (2010), Nuñez et al. (2010), Powell and Lines (2010), Griner and Stewart (2012), Hernandez et al. (2013), Jett (2013), Charbeneau (2015), Hsiao (2015), Predmore et al. (2017), Bayles and Morrell (2018), Booker and Campbell-Whatley (2018), Horowitz et al. (2018), Penner (2018), Cook-Sather and Des-Ogugua (2019), and Haynes and Patton (2019)
	Student identities (47)	McGee and Banks (1995), Wlodkowski and Ginsberg (1995), Lage et al. (2000), Tanner and Allen (2007), Boutte et al. (2010), Hurtado et al. (2010), Nuñez et al. (2010), Powell and Lines (2010), Case (2013), Hernandez et al. (2013), Jett (2013), Considine et al. (2017), Predmore et al. (2017), Bayles and Morrell (2018), Booker and Campbell-Whatley (2018), Jenkins and Alfred (2018), Cook-Sather and Des-Ogugua (2019), and Dewsbury and Brame (2019)
Science identity (7)	Development (7)	Tanner and Allen (2007), Hurtado et al. (2010), Tanner (2013), Killpack and Melón (2016), Dewsbury and Brame (2019), Corneille et al. (2020), and White et al. (2021)
Self-efficacy (10)	Empowerment (5)	Case (2013), Jett (2013), Tang et al. (2017), Bayles and Morrell (2018), and Bauer et al. (2020)
	Self-concept (5)	McGee and Banks (1995), Zumbrunn et al. (2014), Dewsbury and Brame (2019), Corneille et al. (2020), and Theobald et al. (2020)
Sense of belonging (30)	Social belonging (12)	Tanner and Allen (2007), Nuñez et al. (2010), Zumbrunn et al. (2014), Predmore et al. (2017), Dewsbury and Brame (2019), Bauer et al. (2020), Theobald et al. (2020), and White et al. (2021)
	Supportive environment (18)	Tanner (2013), Zumbrunn et al. (2014), Dewsbury (2017), Bayles and Morrell (2018), Booker and Campbell-Whatley (2018), Penner (2018), Cook-Sather and Des-Ogugua (2019), Dewsbury and Brame (2019), Harrison et al. (2019), Aikens (2020), and White et al. (2021)

Themes (far left column) with accompanying categories. The number of coded passages is indicated in parentheses. References associated with each theme, listed by category, are presented in chronological order.

authentic assessment tasks, [and] portfolios" and the use of student self-assessment approaches (Wlodkowski and Ginsberg, 1995). Faculty can modify expectations and assessment by starting with "low stakes assignments to build confidence" in students (Considine et al., 2017), and evaluate assessments by critiquing for faculty bias (Wlodkowski and Ginsberg, 1995). By using scaffolding, faculty can enhance "what students already know" (Jett, 2013) and consider how the content is ordered in the course to "present concepts first" before "introducing (mathematical) tools for problem solving" (Considine et al., 2017) which can aid students to make connections and practice with introductory material. Another aspect for promoting competence is through "monitoring [faculty's] behavior" to promote "divergent" ways of scientific thinking in the classroom (Tanner, 2013). Faculty can monitor their *interactions* with students by creating a system to call on students instead of asking for volunteers which can "promote student preparation and engagement" and build "skill and confidence in oral and written communication" and ensure "the voices in the discussions mirror the population of the class" (Tobin, 2020). By evaluating interactions, faculty can also make sure that groups of students are not receiving "less attention and encouragement" compared with their peers (Taylor, 1997).

Growth mindset (14)

Dweck (2006) defines a growth mindset as the underlying belief that talents, such as intelligence, can be improved through practice and learning. A growth mindset can influence students' outlook on learning by affecting whether they or their faculty believe their "abilities can be developed through dedication and hard work" (Dweck, 2015). This theme includes two unique categories.

Equitable and inclusive classrooms foster a growth mindset and the "frequent use of growth mindset messaging" to students can "address the affective domain of learning" (Bauer et al., 2020).

Faculty can influence *student mindset* by "building assessments or interventions" that discuss growth mindset to "promote students' improvement" and "build students' self-efficacy" and "confidence in their ability to function as a scientist" (White et al., 2021). Another aspect of a growth mindset is the impact of the *faculty mindset* in the classroom. Faculty with a fixed mindset may "structure courses and communicate in a way that negatively influences students' motivation and achievement in their courses" (Bauer et al., 2020) when they believe that "students' intelligence and characteristics are innate and static" (White et al., 2021). Faculty with a growth mindset "accentuate their high standards while assuring students that they are all capable of meeting them" (O'Leary et al., 2020).

Motivation (7)

Ryan and Deci (2000) define motivation as being "moved to do something" and "energized or activated toward an end." Additionally, the elements of student motivation are "influenced by [faculty] coming to know [the student] perspective, by drawing forth who they naturally and culturally are, and by seeing them as unique and active" (Wlodkowski and Ginsberg, 1995). Student motivation is also impacted by the need for "competence, autonomy, and relatedness" (Zumbrunn et al., 2014). This theme includes two unique categories.

Faculty can use *positive reinforcement* to increase student motivation (Wlodkowski and Ginsberg, 1995). In addition, Wlodkowski and Ginsberg suggest that faculty should avoid negative labels of students where students are stereotyped as "incapable of self-motivation," which can create an environment where faculty do not "trust [students'] perspective(s)." Inclusive environments are those that are also "focused on respect" (Case, 2013) and are relevant based on student *interest* "to interpret and deepen their existing knowledge and enthusiasm for learning" (Wlodkowski and Ginsberg, 1995) and engage "an interest in the subject matter from and connected to their personal, family, and community experiences" (Bayles and Morrell, 2018). Inclusive learning environments positively influence student motivation, impacting student affective learning.

Personal relevance (92)

Relevance commonly occurred within the literature of our meta-synthesis. We divided relevance into two themes, the first being personal relevance described here in the affective learning key concept, and the second, subject matter relevance described later in key concept 2. We define personal relevance as teaching or pedagogical approaches relating to students' cultural and personal identities. This theme includes two unique categories.

To increase personal relevance for students in the classroom, faculty can incorporate *student identities* into instruction, which can be accomplished by including student "personal biographies, group and community contexts, and broader systemic institutions" (Nuñez et al., 2010). Employing cultural scaffolding (Booker and Campbell-Whatley, 2018) creates a relevant environment for students, bringing in student perspectives and personal experiences and using "inclusive examples" that "connect to students' own lives" (Cook-Sather and Des-Ogugua, 2019). Bayles and Morrell (2018) suggest connecting content with resources available to students, such as service-learning projects within the community or projects that use technology students have available. Personal relevance can be incorporated into student learning by holding students "accountable for their own learning" (Jett, 2013) while giving them agency to "engage in reflective, personalized learning" (Dewsbury and Brame, 2019). Examining the dominant identities represented in the course to incorporate various *cultural identities and perspectives*, can also provide personal relevance for students in the classroom. Faculty can "shift pedagogical culture" to ensure that "all students' perspectives are valued" (Haynes and Patton, 2019). Faculty are recommended to use the practice of "highlighting those outside the dominant norm" (Booker and Campbell-Whatley, 2018), incorporating "non-Western, indigenous, or other racial/ethnic traditions of knowing" into the course curriculum (Boutte et al., 2010). By creating "culturally relevant analogies" faculty can "bridge the gap" between course material and students' backgrounds and experiences (Horowitz et al., 2018). Evaluating how content is being presented to students is also essential for EI classroom environments. It is recommended that the lens of content should be focused on students as "novices attempting to enter our field from a culturally distinct and perhaps even a culturally hostile background" (Tanner and Allen, 2007). Personal relevance in EI classrooms also includes holistic teaching. This form of inclusive teaching is "unified and meaningful" for students in the classroom, which integrates "strong, meaningful" engagement with diverse student populations (Wlodkowski and Ginsberg, 1995). Finally, forming personal relationships with students by knowing "students and their backgrounds" and "connecting through culture" (Jenkins and Alfred, 2018) can create personally relevant environments for students.

Science identity (7)

Hazari et al. (2013) define science identity as how students think science is "related to who they think they are." This theme includes one unique category.

The *development* of students' science identity is necessary for them to feel a part of the course and the field. Students are typically introduced to research experiences at the undergraduate level, where many students learn that their identities (such as race or gender) are not thoroughly represented and "are not the norm in our fields" (Killpack and Melón, 2016). Inclusive environments incorporate "cultural relevance and diverse role models" (Tanner and Allen, 2007). "Impact(ing) self-schemas," which are the "internal structures and representations of one's ability" (Corneille et al., 2020), gives students recognition to further develop and embrace their identities (Hurtado et al., 2010). For example, "consistently reinforcing class content with the achievement of diverse chemists and scientists allows minoritized students to see themselves as capable and welcome members of the chemistry community" (White et al., 2021).

Self-efficacy (10)

Bandura (1977) defines self-efficacy as students' belief in their "ability to successfully perform a specific task or behavior." Self-efficacy is constructed from a "variety of informational sources" and can "influence several behavioral outcomes" (Bandura, 1977) and "academic engagement and achievement (Zumbrunn et al., 2014). This theme includes two unique categories.

Equitable and inclusive classrooms boost student self-efficacy by creating an environment that gives students a feeling of *empowerment* (Case, 2013) where students "learn about themselves" and their "academic *self-concept*" (McGee and Banks, 1995). Using "pedagogical practices that improve … self-efficacy help reinforce a classroom climate that is inclusive" (Dewsbury and Brame, 2019). Faculty that use modeling, can take the role of an "expert participant that guides students" which can "signal that students' thoughts, beliefs, and contributions are a valued part of the learning process" and that they belong (Tang et al., 2017).

Sense of belonging (30)

Hagerty et al. (1992) define a sense of belonging as "the experience of personal involvement in a system or environment so that persons feel themselves to be an integral part of that system or environment." Specifically, in STEM environments, "perceptions of belonging" have been related to motivation in the course (Zumbrunn et al., 2014), and "belonging to the scientific community has an important impact on persistence in STEM" (Killpack and Melón, 2016). This theme includes two unique categories.

A sense of belonging in EI classrooms is the "extent to which students feel accepted and supported by teachers and peers" (Zumbrunn et al., 2014). There is a "positive relationship between freshmen students' feelings of sense of class belonging and their subsequent academic self-efficacy and task value" (Zumbrunn et al., 2014). To improve students' sense of belonging and *social belonging*, EI STEM classrooms should "explicitly address the development of STEM identities" (Dewsbury and Brame, 2019). A classroom where students feel a sense of belonging is a *supportive environment* where "instructors establish a psychologically secure and safe space for learning to take place" (Booker and Campbell-Whatley, 2018). Penner (2018) recommends that faculty be "explicit about promoting equity and access to all students" to create a supportive climate. It is suggested to "encourage students to develop sociological awareness that can enable them to define their place in history" as students and professionals (Nuñez et al., 2010). For students to feel a sense of belonging, faculty should also "consider stereotype threat" that students may face, and address ways to avoid this in the classroom (Dewsbury and Brame, 2019). To foster a sense of belonging, "relationships between students and the instructor are… important" and instructors are encouraged to get to know their students (Cook-Sather and Des-Ogugua, 2019). "Strong instructor-student relationships improve student confidence, performance, retention and academic achievement" (White et al., 2021). For many students, their personal and cultural identities are not visible in STEM, and they must "abandon their own cultural identities and assume a cultural identity defined by science" (Tanner and Allen, 2007). To combat this deficit in student belonging, Predmore et al. (2017) suggest that instructors build a bridge between cultural contexts by creating a welcoming environment. Students also feel like they belong when instructors "form a multidimensional learning experience that encourages all levels of knowledge and experience" (Cook-Sather and Des-Ogugua, 2019).

Key concept 2: impact on students' cognitive learning

Bloom et al. (1956) define cognitive learning as learning "involving knowledge and the development of intellectual skills." Cognitive learning tasks include "remembering and recalling knowledge, thinking, problem solving, [and] creating" (Bloom et al., 1956). Therefore, it is important to understand how to create EI spaces that impact how students cognitive learning and acquiring knowledge. We found that faculty can use key specific cognitive strategies to be more equitable and inclusive by holding high expectations for all students, centering students in the learning process (employing active learning) and relating content to previous knowledge. Cognitive learning represents 14.6% of the data in our meta-synthesis (110 coded passages). These three themes (which appear in alphabetical order) are described below, with respective categories and references for each theme listed in Table 3.

TABLE 3 Key concept 2, impact on students' cognitive learning.

	Categories	References
High expectations (7)	All students can succeed (4)	Case (2013), Tanner (2013), Tang et al. (2017), and Theobald et al. (2020)
	Challenging environment (3)	White et al., 2021; Wlodkowski and Ginsberg, 1995
Learner centered teaching (97)	Engagement strategies (38)	Wlodkowski and Ginsberg (1995), Lage et al. (2000), Bernacchio et al. (2007), Tanner and Allen (2007), Hernandez et al. (2013), Jett (2013), Tanner (2013), Hsiao (2015), Ballen et al., 2017, Considine et al. (2017), Cotner and Ballen (2017), Tang et al. (2017), Bayles and Morrell (2018), Graham (2018), Jenkins and Alfred (2018), Ballen et al. (2019), Dewsbury and Brame (2019), Aikens (2020), Bauer et al. (2020), Dalton and Hudgings (2020), and White et al. (2021)
	Group work (21)	McGee and Banks (1995), Lage et al. (2000), Powell and Lines (2010), Case (2013), Considine et al. (2017), Johnson et al. (2017), Ballen et al. (2019), Dalton and Hudgings (2020), Theobald et al. (2020), Tobin (2020), and White et al. (2021)
	Limitations (9)	McGee and Banks (1995), Tanner (2013), Considine et al. (2017), Tang et al. (2017), Dewsbury and Brame (2019), Bauer et al. (2020), and Theobald et al. (2020)
	Multiple solutions and perspectives (5)	McGee and Banks (1995), Nuñez et al. (2010), Hsiao (2015), and Cook-Sather and Des-Ogugua (2019)
	Peer interactions (9)	Quaye and Harper (2007), Tanner and Allen (2007), Tanner (2013), Hsiao (2015), Considine et al. (2017), and Dewsbury and Brame (2019)
	Student-faculty interactions (15)	Lage et al. (2000), Powell and Lines (2010), Tanner (2013), Considine et al. (2017), Dewsbury (2017), Tang et al. (2017), Penner (2018), Ballen et al. (2019), Dewsbury and Brame (2019), and White et al. (2021)
Subject matter relevance (6)	Prior and real-world connections (6)	Hernandez et al. (2013), Jett (2013), Tanner (2013), Hsiao (2015), and Booker and Campbell-Whatley (2018)

Themes (far left column) with accompanying categories. The number of coded passages is indicated in parentheses. References associated with each theme, listed by category, are presented in chronological order.

High expectations (7)

High expectations create challenging learning environments that also provide opportunities for success. In addition to the "Pygmalion effect," whereby faculty behaviors may lead to self-fulfilling prophecies of student achievement in cognitive tasks (Chang, 2011), high expectations can lead to inclusive classroom climates where students meet their goals and develop cognitive skills and knowledge. This theme includes two unique categories.

Faculty should "[maintain] high expectations for all students" (Tanner and Allen, 2007) by "teach[ing] their content to the highest standards (Jett, 2013). To set high expectations in the classroom, faculty should have the "*belief that all students can succeed*" (Case, 2013) and facilitate *challenging environments* by creating "learning experiences involving higher-order thinking and critical inquiry" (Wlodkowski and Ginsberg, 1995). The idea that high expectations are set equally should be expressed as "intentional and deliberate" to students (Jett, 2013), and faculty should explicitly explain to students the reasoning and importance for holding high expectations (Hernandez et al., 2013). These expectations should be communicated with students (Hsiao, 2015) along with the faculty's "confidence in student's ability to meet them" (Theobald et al., 2020). Faculty can have equitable high expectations of students by deconstructing the norms of academia and embracing a "brilliance discourse" (Jett, 2013).

Learner-centered teaching (97)

We define the learner-centered teaching theme as a classroom that incorporates group work, student interactions, student engagement, active learning, and multiple perspectives, where faculty act as facilitators of student learning (Driessen et al., 2020). This theme includes six unique categories.

Learner-centered teaching "connects the strengths, interests, and preconceptions of learners to their current academic tasks and learning goals" (Smith et al., 2009) which creates learning that is "real and meaningful to students" (McGee and Banks, 1995). Environments with learners as the focus, construct the idea that "students' cultural backgrounds are resources rather than liabilities" (Nuñez et al., 2010), which encourages students to "generate *multiple solutions and perspectives*" (McGee and Banks, 1995). These classrooms also provide "various forums for participation" (Cook-Sather and Des-Ogugua, 2019) and validate other ways of knowing by using "non-traditional discourse styles" to allow learners to "communicate in culturally responsive ways" (Hsiao, 2015). Faculty can maintain a learner-centered classroom by using a wide variety of *engagement strategies* that "encourage equitable participation" (Ballen et al., 2019) such as allowing students to "reflect individually in writing first" to "think deeply about their own connections to the material" before having a group discussion (Dalton and Hudgings, 2020). EI classrooms also involve *peer interactions* where students "interact in the classroom in a noncompetitive situation" (Considine et al., 2017). These interactions incorporate *group work* "using cooperative learning to promote interaction[s] and enhance learning" (Case, 2013) which may be "instrumental for students from collectivistic or high-context cultures" (White et al., 2021). Learner-centered classrooms also require faculty to be mindful of *student-faculty interactions* by changing their "role from expert to facilitator of collaborative learning" and sharing authority by giving "voice and power" to students in their classroom (Considine et al., 2017). A learner-centered environment places emphasis on student responsibility where "students have access to and responsibility for their own learning" and can "safely challenge authority when necessary" (Bayles and Morrell, 2018). Faculty should be aware that learner-centered teaching does have *limitations*. Using cooperative learning strategies "without an awareness of contextual issues" can "reinforce stereotypes and inequality in the classroom" (McGee and Banks, 1995). If students are allowed to choose groups this can cause marginalized "students to feel left out" so faculty should try to create groups with "critical mass" and distribution so that students have less feelings of "isolation and exclusion" (Considine et al., 2017). Another limitation is faculty being "misled that students have had ample time to think" before moving into group discussion which can give an advantage to students that have more background knowledge in the content (Tanner, 2013).

Subject matter relevance (6)

As stated in key concept 1, we divided relevance into two themes, the first being personal relevance. The second theme that diverged from the larger topic of relevance is subject matter relevance, which we define as aspects of course content relevant to a student's previous knowledge and affects their cognitive learning. This theme includes one category.

We found that equitable and inclusive classrooms are environments that scaffold each student's knowledge with *prior and real-world connections*. Faculty can create subject matter relevance for students by "connecting what students were learning to professional goals" (Booker and Campbell-Whatley, 2018). Content should "build on students' background/prior knowledge [to make] science and math concepts accessible" (Hernandez et al., 2013). Hsiao (2015) encouraged faculty to "review and assess curricula" to determine "relevance to students' interests and instructional needs," making changes as necessary to increase relevance for students by presenting diverse examples (Booker and Campbell-Whatley, 2018). Booker and Campbell-Whatley (2018) also encourage faculty to be "deliberate in how they use language to convey appreciation of diverse opinions and experiences."

Key concept 3: impact on students' metacognitive learning

Metacognitive and regulative activities are those "directed at regulating the cognitive and affective learning activities" which can indirectly impact student learning (Vermunt, 1996). To be equitable and inclusive within the learning process, it is important to include activities that allow for student metacognitive processes and tasks. Regulatory learning appears in 1.1% of the total data in our dataset of 61 articles (8 coded passages). Metacognition is the only identified theme in this key concept and includes two unique categories, see Table 4.

Metacognition (8)

Flavell (1976) defines metacognition as "concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data." Metacognitive learning activities include "orienting on a learning task, monitoring whether the learning process proceeds as planned, diagnosing the cause of difficulties and adjusting learning processes when needed,"

TABLE 4 Key concept 3, impact on students' metacognitive learning.

	Categories	References
Metacognition (8)	Processing (4)	Wlodkowski and Ginsberg (1995) and White et al. (2021)
	Tasks (4)	Wlodkowski and Ginsberg (1995) and Penner (2018)

The single themes (far left column) with accompanying categories. The number of coded passages is indicated in parentheses. References associated with each theme, listed by category, are presented in chronological order.

including evaluation and reflection about the learning process (Vermunt, 1996).

Equitable and inclusive classrooms include opportunities for students to participate in metacognitive approaches, where faculty scaffold content and provide support for "metacognitive *processing*" (White et al., 2021). Metacognitive processes offer opportunities for student self-assessment and engaging students in self-regulation as "best practices to equatize learning opportunities" (White et al., 2021). Faculty can also implement "metacognitive structures" or *tasks* within assessment to "engender competence" and motivation in students (Wlodkowski and Ginsberg, 1995). These tasks provide frequent opportunities for "retrieval practice" of the content (Penner, 2018). Penner (2018) also recommends that faculty discuss Bloom's Taxonomy (Bloom et al., 1956) with students to give a "rationale" for course structure and support, which allows students to reflect on the learning process.

Key concept 4: faculty agency and action

The final and largest key concept, Faculty Agency and Action (FAA), is a compilation of the remaining themes related to faculty agency. We define FAA as the "influence of dynamic internal and external factors on faculty" (Beauchamp and Thomas, 2009), faculty "analyzing and being aware of experiences in the classroom" (Shellenbarger et al., 2005), and the created structure, policies, and managed climate of the classroom by faculty. FAA incorporates five themes identified during the coding process: classroom climate, classroom structure, faculty cultural competency, microaggressions, and stereotype threat and bias. These ideas emerged in 58.5% of the articles within our dataset and were more frequent over time, expanding across the entire dataset from 1995 to 2021 (e.g., 1990s, four articles; 2000s, six articles; 2010s, 38 articles; 2020s so far, eight articles). Our meta-synthesis underscores the importance of classroom climate and structure, such as ideas related to academic care, creating a welcoming and safe classroom climate, building community, and deconstructing curriculum to remove dominant narratives, making up 32.6% of our data (246 coded passages). Faculty cultural competency comprised 16.3% of our entire dataset (123 coded passages). The themes are described below (in alphabetical order), and the accompanying categories and references are listed in Table 5.

Classroom climate (118)

We define classroom climate as approaches faculty use to create a welcoming, trusting, respectful community and a safe space for students. This theme includes three unique categories.

Classroom climate is "the general temperament created in the course" due to factors in the classrooms including faculty "verbal interaction with students, and the structure of the interactions between the students" (Dewsbury, 2020). To facilitate an inclusive classroom climate, faculty can implement *academic care* by providing "non-verbal immediacy" (McCroskey et al., 1996), maintaining "positive, meaningful, caring, and trusting relationships" with students (Hsiao, 2015), and including diversity statements in their syllabi (Butterfield et al., 2018). An inclusive climate is "caring, supportive, and connected" (Graham, 2018), where students feel "psychologically safe" (Jenkins and Alfred, 2018), and are treated "with dignity and respect" (Theobald et al., 2020). Faculty who form meaningful *relationships* with students create a climate that "infuses learning with the emotional sentiments of care and respect" (Sánchez, 2007). Faculty should be "deliberate" in allowing the "personal, intellectual, and the experiential" components of relationships to connect and create and "inclusive multidimensional learning experience" within the classroom (Cook-Sather and Des-Ogugua, 2019). Trust can also be a "critical component of a successful student–instructor relationship" (White et al., 2021), which can be achieved by "faculty members sharing their own experiences with students" (Cook-Sather and Des-Ogugua, 2019) and becoming self-aware about the "context of what they bring to the classroom" (Dewsbury, 2020). Facilitating opportunities for peer interactions to "focus on collective work, responsibility, and cooperation" (Hsiao, 2015) can "build a sense of *community* within the class" (Powell and Lines, 2010) and are also a "key part of a positive classroom climate" (Dewsbury and Brame, 2019). A supportive community also includes how faculty engage in classroom conflict and are encouraged to use conflict in a "transformative manner" to support learning and growth in the classroom community (Pasque et al., 2013).

Classroom structure (128)

We describe the classroom structure theme as classroom patterns, layouts, and organizations (including student navigation, available resources, demystifying the syllabus, classroom norms, and explicit presentation and description of learning objectives). This theme includes five unique categories.

An EI classroom follows *organization* that is "flexible" in which "diverse learners can engage [with] the curriculum in their own unique ways" (Bernacchio et al., 2007). The organization of the "course design and the classroom environment" should "promote an inclusive learning experience that can be accessed by all students in the class" (Penner, 2018). Faculty should also consider that the physical space such as "room configurations" (White et al., 2021) and the size of the classroom (Ballen et al., 2018) can impact the types of interactions occurring within the classroom. EI classroom structure also encourages faculty to *demystify* the college process to "reveal the secrets to success" (Harrison et al., 2019); for example, "explain[ing] the purpose and value of office hours to students and mak[ing] deliberate efforts to encourage attendance" (White et al., 2021). Faculty can also communicate explicit *expectations* that are "clear with students from the beginning so as to minimize surprise or confusion" (Booker and Campbell-Whatley, 2018) and will set "students up for

TABLE 5 Key concept 4, faculty agency and action.

	Categories	References
Classroom climate (118)	Academic care (41)	McCroskey et al. (1996), Quaye and Harper (2007), Sánchez (2007), Tanner and Allen (2007), Case (2013), Zumbrunn et al. (2014), Hsiao (2015), Considine et al. (2017), Dewsbury (2017), Bayles and Morrell (2018), Booker and Campbell-Whatley (2018), Butterfield et al. (2018), Graham (2018), Horowitz et al. (2018), Penner (2018), Dewsbury and Brame (2019); Aikens (2020), Theobald et al. (2020), and White et al. (2021)
	Community (24)	Taylor (1997), Powell and Lines (2010), Case (2013), Hernandez et al. (2013), Pasque et al. (2013), Hsiao (2015), Considine et al. (2017), Booker and Campbell-Whatley (2018), Butterfield et al. (2018), Graham (2018), Cook-Sather and Des-Ogugua (2019), Dewsbury and Brame (2019), Harrison et al. (2019), and Dewsbury (2020)
	Relationship (53)	Wlodkowski and Ginsberg (1995), Quaye and Harper (2007), Sánchez (2007), Tanner and Allen (2007), Powell and Lines (2010), Case (2013), Hernandez et al. (2013), Jett (2013), Hsiao (2015), Considine et al. (2017), Dewsbury (2017, 2020), Tang et al. (2017), Bayles and Morrell (2018), Booker and Campbell-Whatley (2018), Graham (2018), Jenkins and Alfred (2018), Cook-Sather and Des-Ogugua (2019), Dewsbury and Brame (2019), Harrison et al. (2019), and White et al. (2021)
Classroom structure (128)	Curriculum representation (28)	Wlodkowski and Ginsberg (1995), Bernacchio et al. (2007), Quaye and Harper (2007), Tanner and Allen (2007), Powell and Lines (2010), Jett (2013), Tanner (2013), Hsiao (2015), Considine et al. (2017), Bayles and Morrell (2018), Booker and Campbell-Whatley (2018), Butterfield et al. (2018), Ceo-DiFrancesco et al. (2019), Cook-Sather and Des-Ogugua (2019), Dewsbury and Brame (2019), Aikens (2020), O'Leary et al. (2020) and Tobin (2020)
	Deconstructing (26)	Lage et al. (2000), Bernacchio et al. (2007), Quaye and Harper (2007), Sánchez (2007), Case (2013), Jett (2013), Killpack and Melón (2016), Considine et al. (2017), Graham (2018), Jenkins and Alfred (2018), Harrison et al. (2019), Haynes and Patton (2019), Corneille et al. (2020), Dalton and Hudgings (2020), and White et al. (2021)
	Demystifying (21)	Bernacchio et al. (2007), Quaye and Harper (2007), Jett (2013), Tanner (2013), Hsiao (2015), Killpack and Melón (2016), Tang et al. (2017), Bayles and Morrell (2018), Booker and Campbell-Whatley (2018), Penner (2018), Ceo-DiFrancesco et al. (2019), Harrison et al. (2019), and White et al. (2021)
	Expectations (20)	Wlodkowski and Ginsberg (1995), Bernacchio et al. (2007), Case (2013), Hsiao (2015), Dewsbury (2017), Booker and Campbell-Whatley (2018), Graham (2018), Penner (2018), Ceo-DiFrancesco et al. (2019), Cook-Sather and Des-Ogugua (2019), and Dewsbury and Brame (2019)
	Organization (33)	Wlodkowski and Ginsberg (1995), Lage et al. (2000); Bernacchio et al. (2007), Powell and Lines (2010), Case (2013), Pasque et al. (2013), Zumbrunn et al. (2014), Ballen et al. (2018), Booker and Campbell-Whatley (2018), Butterfield et al. (2018), Jenkins and Alfred (2018), Penner (2018), Cook-Sather and Des-Ogugua (2019), Dewsbury and Brame (2019), Bauer et al. (2020), Dewsbury (2020), and White et al. (2021)
Faculty's cultural competency (123)	Cultural scaffolding (17)	Tanner and Allen (2007), Harper (2009), Colbert (2010), Griner and Stewart (2012), Case (2013), Hsiao (2015), Considine et al. (2017), Dewsbury (2017, 2020), Booker and Campbell-Whatley (2018), Cook-Sather and Des-Ogugua (2019), Dewsbury and Brame (2019), and White et al. (2021)
	Dominant narratives (30)	Quaye and Harper (2007), Tanner and Allen (2007), Colbert (2010), Case (2013), Gay (2013), Charbeneau (2015), Killpack and Melón (2016), Dewsbury (2017), Predmore et al. (2017), Booker and Campbell-Whatley (2018), and Jenkins and Alfred (2018)
	Learning about students (23)	Wlodkowski and Ginsberg (1995), Taylor (1997), Quaye and Harper (2007), Tanner and Allen (2007), Booker and Campbell-Whatley (2018), Dewsbury and Brame (2019), Lowell and Morris (2019), Dewsbury (2020), and White et al. (2021)
	Privileged identities and reflection (53)	McGee and Banks (1995), Wlodkowski and Ginsberg (1995), Quaye and Harper (2007), Harper (2009), Colbert (2010), Nuñez et al. (2010), Case (2013), Gay (2013), Hernandez et al. (2013), Pasque et al. (2013), Charbeneau (2015), Killpack and Melón (2016), Dewsbury (2017, 2020), Booker and Campbell-Whatley (2018), Butterfield et al. (2018), Jenkins and Alfred (2018), Cook-Sather and Des-Ogugua (2019), Dewsbury and Brame (2019), Haynes and Patton (2019), and O'Leary et al. (2020)
Microaggressions (39)	Professional development (5)	Murray-Johnson (2013) and Berk (2017)
	Recognizing (27)	Berk (2017), Ceo-DiFrancesco et al. (2019), and O'Leary et al. (2020)
	Self-reflection (7)	Murray-Johnson (2013) and Berk (2017)
Stereotype threat and bias (34)	Impacts (21)	Tanner and Allen (2007), Gay (2013), Tanner (2013), Killpack and Melón (2016), Considine et al. (2017), Dewsbury (2017), Johnson et al. (2017), Penner (2018), Ballen et al. (2019), Dewsbury and Brame (2019), Bauer et al. (2020), Theobald et al. (2020)
	Self-reflection and practice (13)	Tanner and Allen (2007), Killpack and Melón (2016), Considine et al. (2017), Jordt et al. (2017), Ceo-DiFrancesco et al. (2019), Aikens (2020), O'Leary et al. (2020), and White et al., 2021

Themes (far left column) with accompanying categories. The number of coded passages is indicated in parentheses. References associated with each theme, listed by category, are presented in chronological order.

success" (Penner, 2018). Inclusive faculty are mindful of *curriculum representation* when planning their courses. Quaye and Harper (2007) recommend that faculty "interweave multicultural perspectives into classroom discourse." Incorporating multiple perspectives and "culturally diverse examples and role models" (Aikens, 2020) can "cultivate discussion of divergent ideas in the classroom" (Tanner, 2013) and create "identity-safe learning environments" (O'Leary et al., 2020). *Deconstructing* the content and format of a course is also important for an inclusive classroom structure. Instructors can deconstruct their course by "search[ing] for silences and exclusions in both content and pedagogy" and also look for "unconscious biases and assumptions that may be culturally normative and thus oppressive" (Bernacchio et al., 2007). Bayles and Morrell (2018) mention that deconstructing norms in the classroom can create a space that "does not expect students to conform to current educational practices as a default."

Faculty cultural competency (123)

Livingstone (2014) defines faculty cultural competency as the "ability to understand, communicate with and effectively interact with people across cultures." By having cultural competence, faculty can reflect and "become more informed about the history and culture of groups" and "know what is appropriate and inappropriate behavior and speech in cultures different from [their] own" (Davis, 1993). In addition, when faculty are culturally competent, they are "aware of one's own world view," which allows for them to think positively about cultural diversity and learn about "different cultural practices and world views" (Livingstone, 2014). This theme includes four unique categories.

Faculty cultural competence plays a role in facilitating EI environments. By using *cultural scaffolding*, faculty can have "socio-cultural consciousness" with a positive view of "students from diverse backgrounds" (Colbert, 2010), be "committed to culturally relevant andragogy" (Booker and Campbell-Whatley, 2018), and develop "intercultural knowledge" (Dewsbury, 2017). White et al. (2021) encourage the adoption of the "cultural wealth model" which recognizes cultural capital as a student success strategy. By "connecting culturally responsive teaching to specific subjects" (Gay, 2013) and recognizing that science is "dominated by white, male culture" (Tanner and Allen, 2007), faculty can deconstruct *dominant narratives* within the content of the course. Faculty should also *learn about students* to meet their needs and understand that "students of today are very different from students of the past" (White et al., 2021). Tanner and Allen (2007) also discuss that interweaving student identities impacts cultural competence by creating inclusive environments for students. The literature encourages faculty to consider questions such as "how multicultural groups experience a common learning environment" (Booker and Campbell-Whatley, 2018), whether you are asking "one person to speak on behalf of their entire" culture (Case, 2013) or are "recognizing and appreciating in-group differences" (Considine et al., 2017), are extending an "individualistic worldview" (White et al., 2021), or perpetuating the concept of "science as a meritocracy that is neutral to race, ethnicity, and gender" (Tanner and Allen, 2007).

Self-awareness is "the degree to which the instructor has an understanding of [themselves] in the context of what they bring to the classroom" (Harper, 2009). The "social positioning of the instructor" goes beyond their knowledge of course content and is a "function of their individual histories, and the ways in which those histories informed their development of a science identity" (Harper, 2009). Faculty should be conscious of their *privileged identities and reflect* how their "personal biases and stereotypes" can impact relationships and interactions with students (Harper, 2009). Killpack and Melón (2016) acknowledge the difficulty of "taking stock of all of our unearned advantages" while stressing its importance for creating EI environments and Dewsbury and Brame (2019) recommend faculty "critique their own beliefs about culturally diverse students." When faculty acknowledge their privileged perspectives, it allows for "socio-cultural consciousness" (Colbert, 2010) and reflection on how beliefs of "culturally diverse students affect their instructional behaviors" (Gay, 2013).

Faculty may not "feel equipped to construct learning environments that support the participation and engagement of students from diverse backgrounds and may find themselves and their students' resistant to discussing 'hard topics' such as sexism and racism" (Booker and Campbell-Whatley, 2018). "(R)ace-consciousness requires replacing confessions of inadequacy…with committed efforts to remediate personal and professional shortcomings" by for example "reading the student engagement literature, attending conferences where practical suggestions for engaging diverse student populations are offered, seeking corrective assistance from experienced colleagues, and pursuing instructive insights and creative techniques from high-performing institutions that effectively engage racial minority students" (Harper, 2009). Faculty "should also set aside time to immerse themselves in readings about race and racism [as well as other -isms], particularly those that illuminate whiteness and White privilege [and other types of privilege and power] while grappling with the experiences of minoritized groups" (Haynes and Patton, 2019). "The goal is for faculty who wish to promote and practice expansive views of equality…to learn more about themselves" (Haynes and Patton, 2019).

Microaggressions (39)

Pierce (1974) first defined microaggressions as "black-white racial interactions [that] are characterized by white put-downs, done in an automatic, preconscious, or unconscious fashion." Furthering this definition, Sue (2010) defines microaggressions as "brief, everyday exchanges that send denigrating messages to certain individuals based on their group membership." Equitable and inclusive faculty need to become aware of microaggressions and learn how to avoid and respond to them. This theme includes three unique categories.

An EI environment consists of faculty *recognizing* and "interrupting microaggressions when they occur" in the classroom (O'Leary et al., 2020). "[F]ailing to learn to pronounce or continuing to mispronounce the names of students," "hosting debates in class that places students from groups who may represent a minority opinion in class in a difficult position," "assigning student tasks or roles that reinforce particular sex roles," and "continuing to misuse pronouns" (Berk, 2017) are examples of microaggressions. To recognize and avoid these types of behaviors, faculty can engage in *professional development* opportunities (Berk, 2017) and continue to "build strategies" to aid with these types of discussions (Murray-Johnson, 2019). Berk (2017) also encourages faculty to use *self-reflection* to analyze the "flaws each of us must address in ourselves and how they relate to microaggressions," which can lead to an understanding of "identity and values, biases and prejudices" that faculty might hold.

Stereotype threat and bias (34)

Stereotype threat is defined as the "threat that others' judgments or their own actions will negatively stereotype them in the domain" (Steele, 1997). Greenwald and Banaji (1995) define implicit bias as "the unconscious attribution of particular qualities to a member of a certain social group." These biases, or stereotypes, are "shaped by experience and based on learned associations between particular qualities and social categories, including race and/or gender" (Greenwald and Banaji, 1995). This theme includes two unique categories.

Unconscious biases that faculty bring to the classroom may *impact* their expectations of students because of "inaccurate judgments" (Killpack and Melón, 2016) of students' motivation, preparation, and abilities (White et al., 2021) which can result in reduced achievement. Lowered expectations can also "trigger stereotype threat" in students, where they feel the need to "disprove negative stereotypes about their abilities in a particular domain" (Johnson et al., 2017), and "may feel unsure about whether they will be fully included or that their contributions will be valued" (Bauer et al., 2020). *Self-reflection* allows faculty to "acknowledge and confront implicit biases" as well as "mitigate stereotype threat in classrooms" (Killpack and Melón, 2016). Considine et al. (2017) recommend adjusting *practice*, such as evaluation and assessments, and include low-stakes and multiple opportunities for mastery, to increase confidence in students who experience stereotype threat.

Comparing the data to reference articles

We selected the top six most cited articles in our dataset to use as benchmarks with which to compare our data, see Figure 3 for the citation counts of the reference articles. This process aided in furthering our sense-making of the meta-synthesis data. For comparison, we determined the number of coded passages within our dataset found in the reference articles. From this count, we determined the percentage of coded passages in each theme represented in the reference articles standardized by the number of total coded passages in each theme, indicated in Table 6.

The results of this comparison indicated how the data aligned with recommendations found within the reference articles and to what degree the ideas found in our meta-synthesis were not represented and underrepresented. We discovered that the reference articles contain most, but not all themes. Growth mindset, metacognition, and microaggressions were not found in the reference articles. Further, in some cases the reference articles overrepresent themes that were not coded as frequently in other sources (e.g., competence, science identity, self-efficacy, and high expectations) and underrepresent themes coded frequently in the remaining dataset (e.g., personal relevance and faculty cultural competency).

Key concept 1: affective learning

Affective learning focuses on how the classroom impacts students emotionally. While affective learning is not a novel topic to EI literature, our meta-synthesis expands on topics reported by the six reference articles by highlighting growth mindset concepts. Mindset, especially growth mindset, emerged as a significant influence on affective learning, with faculty mindset playing an essential role in student success (Bauer et al., 2020; White et al., 2021). When students believe they can succeed and faculty create an environment that fosters a growth mindset, it greatly impacts student motivation and achievement (Dweck, 2015).

The six reference articles did not mention mindset, meanwhile, all seven other affective learning themes in our findings were noted in the reference articles. These data suggest that instructors sharing control of learning, providing choice in how learning is assessed, and paying attention to how the materials align with the identities and cultures of the students are broadly seen as relevant to developing EI classrooms.

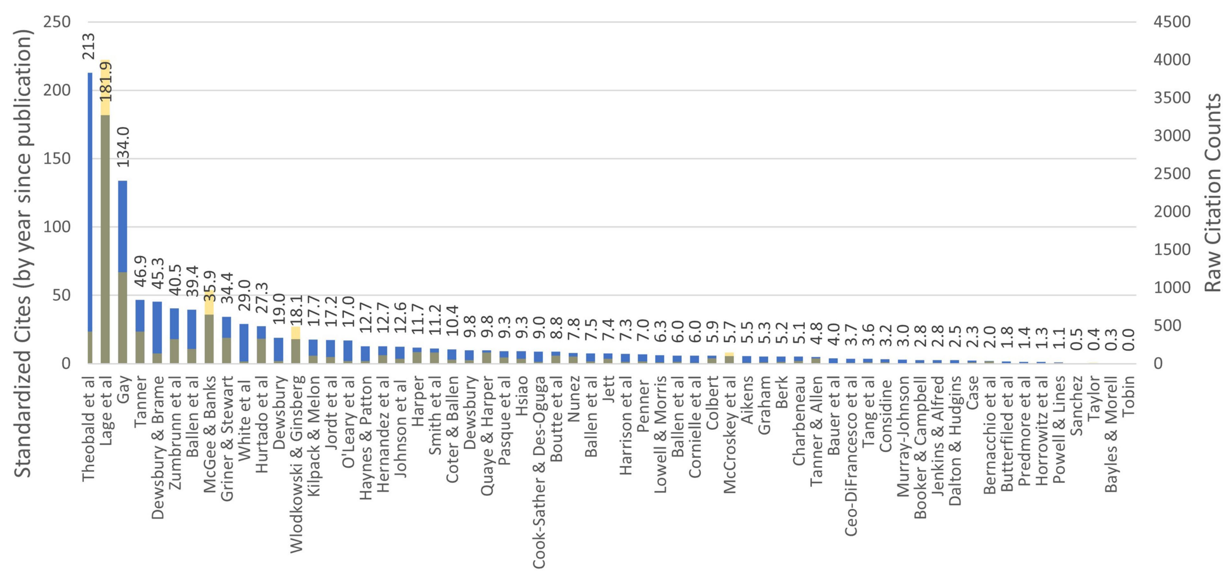

FIGURE 3
Graph of Raw Citation Count and Standardized Citation Count of Reference Articles. Authors of articles on the bottom axis, number of times cited in Google Scholar on the right axis (yellow bar), and standardized citation count on the left axis (blue bar).

TABLE 6 Coding comparisons with reference articles.

			Coded passages within reference articles							
		Themes (number of coded passages)	Th	L	G	Ta	DB	Z	Total	%
Key Concepts	Affective	Choice (27)		6			2		8	29.6
		Competence (8)				2			2	50.0
		Growth Mindset (14)							0	0
		Motivation (7)						1	1	14.3
		Personal Relevance (92)		2			3		5	5.4
		Science Identity (7)				1	1		2	28.6
		Self-Efficacy (10)	1				2	1	4	40.0
		Sense of Belonging (30)	1			2	9	6	18	60.0
		Key Concept 1: Affective (195)							40	20.5
	Cognitive	High Expectations (7)	1			1			2	28.6
		Learner Centered Teaching (97)	4	8		9	10	2	33	33.0
		Subject Matter Relevance (6)				1			1	16.7
		Key Concept 2: Cognitive (110)							36	32.7
	Regul-atory	Metacognition (8)							0	0
		Key Concept 3: Regulatory (8)							0	0
	FAA	Classroom Climate (118) and Structure (128)	1	3		3	10	4	21	8.5
		Faculty's Cultural Competency (123)			2	1	3		6	4.9
		Microaggressions (39)							0	0
		Stereotype Threat and Bias (34)	1		2	1	1		5	14.7
		Key Concept 4: FAA (442)							32	7.2

Themes with (total number of coded passages in the dataset) and the number of coded passages in each reference article, (Lage et al., 2000; Gay, 2013; Tanner, 2013; Zumbrunn et al., 2014; Dewsbury and Brame, 2019; Theobald et al., 2020). Themes are presented alphabetically, grouped by Key Concept. Total number and percentage of coded passages in each theme represented by the reference articles (Total and % far right columns). Entries that are grayed out indicate themes that were not represented in the reference articles.

However, the reference articles represented only 20% (40 coded passages) of the 200 coded passages in the affective learning key concept, and no single reference article mentioned all seven themes. Further, our most common affective theme (i.e., personal relevance) was highly underreported by the reference articles, only mentioned in less than half of them.

Key concept 2: cognitive learning

Cognitive learning, the development of knowledge and specific intellectual skills, is impacted by learner-centered teaching techniques. Such pedagogies center students in the learning process and have, over more than a decade, amassed strong evidence of positively impacting student learning (e.g., American Association for the Advancement of Science, 2011; Granger et al., 2012; Freeman et al., 2014). The findings in this key concept, themes of high expectations, learner-centered teaching, and subject matter relevance are represented within the reference articles.

Within the reference articles, there was a significant focus on learner-centered teaching, representing 91.9% (34 coded passages) of the reference article coding related to this theme. We also noted uneven coverage of this key concept in the six reference articles. Gay (2013) contained no coded passages in this key concept, while Tanner (2013) included coded passages from all three cognitive learning themes.

Key concept 3: regulatory learning

By helping students understand what they know through self-assessment, regulatory learning is a powerful tool, especially when coupled with cognitive learning influencers such as high expectations and subject matter relevance. While this key concept is rare within our dataset and not seen in the reference articles, metacognitive strategies can improve student learning and retention, allowing for greater student success and achievement from students marginalized and oppressed in STEM classrooms, such as first-generation students (Franklin et al., 2018). Regulatory learning is not noted in any of the six reference articles.

Key concept 4: faculty agency and action

FAA includes faculty identification, reflection, and classroom organization (notably classroom climate and structure). The critical difference between faculty-centered (key concept 4) and student-focused approaches (key concepts 1–3) is that FAA requires faculty to explore personal changes and identities in addition to reflecting on elements in the classroom.

While most of the reference articles included two to three of the FAA themes, no single article referenced all four. Microaggressions, a theme within FAA that is not described in any of the six reference articles, makes up 5% of our data (39 coded passages). Although microaggressions is not described in any of our reference articles, our data highlights the role of faculty in recognizing and managing microaggressions in creating EI classroom environments. The reference articles include topics related to the other three FAA themes, with 7% of our data coded from the reference articles (32 coded passages). Many ideas within the reference articles center on classroom climate and structure (21 of 109 coded passages). Faculty cultural competency represented 4.7% of coded passages found in the reference articles (6 coded passages). Finally, 14.3% of our coded passages from the stereotype threat and bias themes were included within our reference articles (5 coded passages). These concepts are frequently discussed in the six reference articles, including recognizing, reflecting, and exploring the impacts of biases and stereotype threats.

Limitations to this study

The methods and design of this study have limitations that may impact the results we found. For example, we only accepted articles that have been peer-reviewed, which does not include books, dissertations, proposals, or theses. Further, the databases selected can bias for what published literature was available for inclusion in this study. We also excluded direct quotes used in our articles from our coding, and it is possible these voices were not otherwise included in our dataset.

Final thoughts

Equity and inclusion are widely discussed topics within higher education institutions as shown in our meta-synthesis, demonstrating that many faculty are aware of the importance of creating equitable and inclusive environments for STEM students (e.g., Killpack and Melón, 2016; Dewsbury and Brame, 2019). When faculty create EI spaces, all students have the opportunity and resources to succeed, and they see themselves in the field of study, and do not feel excluded from the classroom or course content (e.g., Graham et al., 2013; O'Keeffe, 2013; Hales, 2020). Through our analytical approach, we systematically expand on ideas to emphasize concepts that are, and are not, common in the EI literature by comparing our results to reference articles. While many of the themes we identified (i.e., themes in affective and cognitive learning) are included in the reference articles, several ideas and practices are under-reported. By exploring these themes, we highlight authors throughout the STEM higher education literature in addition to those most cited.

Our meta-synthesis suggests that creating equitable and inclusive classrooms in STEM higher education necessitates faculty implementing EI teaching approaches that center students and their identities in the learning process and are reflected in the classroom and curriculum. Incorporating classroom-focused approaches to create environments that enhance, and support students' learning is essential. We also found that faculty identification, reflection, and classroom organization (FAA) are essential for faculty to dismantle marginalizing and oppressive policies, structures, and practices within the classroom.

While recognizing the need for EI classrooms and being motivated for change is essential, it takes knowledge and effort for faculty to create these environments, and it can be challenging to know what changes to make (Considine et al., 2017), in addition to the numerous barriers faculty may already face during curricular changes (e.g., Brownell and Tanner, 2012; Kezar et al., 2015; Cooper, 2017). With the breadth of literature available, the work we have completed will aid faculty in knowing where to begin when implementing EI classroom approaches. We invite the reader to use this meta-synthesis as a guide to their learning and as a resource to create an action plan for moving toward EI classrooms. We further recommend that faculty reference the articles compiled in this study to find specific strategies regarding these topics.

Author contributions

VD, EH, and SK contributed to conception and design of the study. SK and VD performed the qualitative coding and analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Note: coded articles denoted by *, reference articles denoted by **.

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