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Countering Systemic Racism in Infrastructure Education: A Group Concept Mapping Study on Priorities for Educating Future Engineers

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Countering Systemic Racism in Infrastructure Education: An Opportunity to Apply the Group Concept Mapping Method to Understand Priorities for Educating Future Engineers

Abstract

This paper addresses a crucial need in civil and environmental engineering (CEE) education: integrating diversity, equity, inclusion, and justice (DEIJ) principles to counter systemic racism when teaching the infrastructure lifecycle. The research team piloted the Group Concept Mapping (GCM) methodology to identify and prioritize actionable strategies that can guide the education of future engineers in addressing racial inequities in infrastructure projects. The findings from this pilot study demonstrate that GCM is feasible, and valuable results are likely to be obtained from a more extensive study. A total of 15 participants contributed to GCM activities in this pilot study. Forty statements generated by the participants were clustered and rated by the participants to create concept maps to understand the importance, implementation feasibility, and potential effectiveness of the strategies. Key findings indicate strong agreement among participants on the importance and feasibility of specific actions, suggesting a clear alignment between what is needed and what can be practically implemented within the CEE community. The analysis also consistently identified specific actions as highly important, feasible, and transformative. In particular, participants agreed that it is essential to integrate social context into technical assignments, such as using GIS to map census data, and CEE faculty should receive training on facilitating difficult conversations about racism, as this is often outside traditional engineering instruction. Developing and using case studies that highlight successful DEI initiatives, including infrastructure projects that correct past racist designs, can serve as powerful teaching tools. The roadmap developed from this work offers actionable insights for educators and institutions seeking to equip future engineers with the knowledge and skills to address systemic racism in their professional practice. As a pilot study, the process and outputs offered an understanding of the feasibility and effectiveness of the GCM approach for obtaining valid and reliable results from a more extensive study. Furthermore, the research team learned how to facilitate participant engagement better to achieve higher participation levels. Overall, this pilot study demonstrated the value of GCM as a tool for conceptualizing DEIJ integration in CEE education.

Introduction

Public infrastructure services, including public education, transit, housing, energy, and access to clean drinking water, are funded by taxpayers. Indeed, the United States of America made a historic investment commitment to infrastructure through the Infrastructure Investment and Jobs Act (IIJA, also known as the Bipartisan Infrastructure Law) and the Inflation Reduction Act. However, laws that protect (or are perceived to protect) individuals' access to public infrastructure are limited, and historically, they have been mainly designed to mitigate discrimination rather than proactively eliminate inequities [1]. Given that multiple categories of our nation's infrastructure are graded in the C and D range [2] and the disproportionate burdens and underinvestment in historically marginalized communities, educating the infrastructure workforce in the future to effect change is essential to creating more equitable infrastructure. Through integrating diversity, equity, and inclusion (DEI) into their teaching, research, and service commitments, Civil and Environmental Engineering (CEE) faculty members are positioned to be the change agents who catalyze the transition of our nation's inequitable infrastructure into equitable infrastructure. Despite the current political context, in which efforts to promote diversity, equity, inclusion, and justice are being targeted for elimination, the need to educate civil engineering students about the impacts of inequitable infrastructure and to empower them to create a more just future not only remains strong, but it has also taken on increased importance. Simmons [3] provides evidence and actionable recommendations for educators to utilize their agency to help students develop crucial competencies needed to address global challenges. These challenges include deteriorating infrastructure, environmental issues, and ensuring access to housing, water, and health care for a rapidly growing population [4].

The Center for Infrastructure Transformation and Education (CIT-E, pronounced 'city') is a thriving community of practice (CoP) comprising more than 200 infrastructure engineering educators invested in transforming infrastructure education. Its members have developed a model introductory infrastructure course that is available for any faculty member to use or modify. More than ten years after its founding through National Science Foundation (NSF) funding, this CoP is looking to understand better issues of equity and systemic racism in infrastructure education and is committed to enacting the AAAS National Agenda for undergraduate STEM education. The CIT-E CoP has evolved into a community that can comprehensively serve CEE faculty members in their efforts to integrate DEI into infrastructure education. It has successfully demonstrated that undergraduate education can be transformed by supporting faculty professional development. Through this work, the CIT-E CoP is creating a broader network of institutional support for improving in- and out-of-classroom transformation for workforce development. This institutional support is critical to Simmons and Groen's Building Undergraduate Interventions for Learning and Development (BUILD) model [5].

As part of a recent NSF project, a CIT-E core research team comprising members from four institutions in four states has sought to bridge the gap in CEE programs between disciplinary infrastructure-focused knowledge and DEIJ knowledge. The authors agree that 'equitable infrastructure' requires an inclusive decision-making process compensating for historical systemic inequities, such as systemic racism [6]. The project expanded the CIT-E CoP's institutional capacity to support faculty in their efforts to teach DEIJ principles in concert with teaching students about civil infrastructure. Wenger [7], who introduced and developed the concept of CoP, provides evidence of its implications for learning, meaning, and identity formation. Wenger's original work laid out the theoretical underpinnings of CoPs as social structures facilitating learning, which has influenced various educational contexts [8]. The intent is to go far beyond ensuring that an individual classroom offers an inclusive and welcoming environment to transform the profession. Thus, as members of the CEE education community, faculty members have an opportunity not only to educate in an equitable manner, but also to prepare civil engineering, environmental, and construction professionals to develop inclusive public policies and equitable infrastructure.

As part of these efforts, the research team piloted the Group Concept Mapping (GCM) methodology to identify, cluster, and prioritize ways of integrating DEIJ into CEE education to amplify the voices of multiple perspectives within the CEE education community. The overall objective was to evaluate the potential of GCM to create a series of interconnected maps to serve as the foundation for an actionable roadmap. GCM is a participatory mixed-methods approach well-suited for capturing the complexity of social phenomena and fostering equitable collaboration [9]. Its structured, consensus-building process allows participants to independently sort and rate statements, minimizing "groupthink" or peer pressure risks and ensuring that less-dominant voices are not overshadowed. This makes GCM particularly effective for engaging civil engineering faculty, including those from minoritized backgrounds, in co-creating knowledge and amplifying diverse perspectives within an inclusive framework. Using group concept mapping within and across a CoP helps to organize the process of developing a collective voice for domain setting [10] and transformation [11]. While many CoPs exist in education, they typically follow a leadership-oriented development model, which has the potential downside of too many decisions being made behind closed doors. Furthermore, open forums in academia often become debate tables that can work against equitable decision-making efforts when a winner is declared [11].

Through this pilot project, the CIT-E research team sought to determine how GCM could be scaled up and leveraged in the future to more fully engage the community to collectively map the needs and desires of the community for equitable infrastructure education. This paper summarizes the results of piloting the GCM methodology.

Background

Diversity, Equity, and Inclusion (DEI) are interlinked concepts that spur ironically polarizing conversations about workforce development. When DEI *professional actions* are well-executed, they deliver tremendous benefits for a collective workforce community [12,13,14]. For the purpose of this paper, the authors commit to the National Academy of Engineering's definitions of embracing diversity, seeking equity, and driving inclusion [15]:

- *Embracing diversity*—recognizing that talent is broadly distributed in society and that unique perspectives drive innovation, appreciating the broad dimensions of identity, and confronting historic barriers and contemporary hurdles that shape and distort participation and success in engineering education and the profession;
- *Seeking equity*—removing barriers, promoting access, and supporting positive working, convening, and social environments; and

- *Driving inclusion*—celebrating multiple approaches and points of view to develop optimal solutions, building capacity to strengthen the engineering profession, and building and encouraging relationships in the NAE's working, convening, and social environments.

The term DEIJ extends DEI to include the term "justice," and the research team uses the definition from the American Society of Civil Engineers (ASCE) that is included in Policy Statement 417 [16]:

- *Justice*—dismantling barriers to resources and opportunities in society so that all individuals and communities can live a full and dignified life.

An array of forces influencing public infrastructure planning, design, construction, maintenance, operation, and education encourages a more comprehensive treatment of DEIJ in infrastructure education. For example, creating a diverse STEM workforce is codified in law (Public Law 96-516 sections 1885a and 1885b). Unfortunately, bias and racism have a direct impact on the preparation of a representative CEE workforce. Qualitative data has shown educational disparities for years in higher education, and a recent PNAS (Proceedings of the National Academies of Science) Nexus publication provided stark evidence that even when engineering students enter college with equal qualifications, the required introductory STEM courses disproportionality weed out Black students [17].

Accreditation agencies also highlight the importance of DEIJ in education policy. Moving beyond encouraging equal participation, in 2016, ABET added a new criterion for civil engineering curricula to define an engineering team as being "…more than one person working toward a common goal and should include individuals of diverse backgrounds, skills, or perspectives" [18]. Despite ABET's recent purging of the words diversity, equity, inclusion, and access from all accreditation criteria, the organization has stated that it remains committed to these principles. Furthermore, regional accreditation bodies such as the Higher Learning Commission (HLC) require universities to demonstrate that their "processes and activities demonstrate inclusive and equitable treatment of diverse populations" [19]. Previous studies also provide examples of success in meeting new criteria and curriculum expectations [20] and [21].

As one of the oldest and largest communities of infrastructure professionals, ASCE promotes DEI in both infrastructure and education policies. The ASCE Code of Ethics explicitly states that engineers must "acknowledge the diverse historical, social, and cultural needs of the community, and incorporate these considerations in their work" [22]. Thus, by improving the diversity of the CEE workforce and cultivating an inclusive culture, civil and environmental engineers can fulfill their responsibility of being stewards of equitable infrastructure. ASCE recently updated Policy Statement 417 – Justice, Equity, Diversity, and Inclusion. This policy states that "currently, more efforts are needed to fully realize inclusive and equitable practices in our profession, to assure representation of the rich diversity of our global communities, and to produce just societal outcomes from our work" [23].

In response to this alignment of policies, law, and research findings, CEE stakeholders seek clear guidance on implementing and evaluating DEIJ efforts. For example, in a survey of CEE faculty members, 68% of respondents said they were either 'somewhat likely' or 'very likely' to use a module (i.e., a collection of fully-developed lessons) on the intersection of systemic racism and public infrastructure [24]. This interest in shared materials also suggests that our CEE colleagues may feel ill-equipped to address DEIJ issues in their curricula and in the delivery of individual courses. CEE faculty members lack knowledge of DEIJ principles in general and the skills needed to explore these topics in a classroom; further, in recognizing these gaps, their attitudes may lead to reluctance to address these DEIJ topics, particularly given the sensitive nature of these topics and our increasingly polarized society.

Group Concept Mapping (GCM) Method

GCM is a participatory, mixed methods approach used extensively in behavioral and social research for over 35 years. The GCM method has enabled evidence-based advances in fields such as medicine, psychology, and civil engineering [10], [25], and [26]. One example of these advances is the needs assessment of the Science of Team Science (SciTS) field in 2010, a well-established research community of practice [27]. Another example is the advance of theoretical frameworks, such as the Social Sustainability Framework for Construction Projects [28] and [29]. GCM also has supported university planning, curriculum development, and equity-related initiatives [9] and [30].

In applying GCM, researchers collect ideas from a group of participants who ascertain how they interpret the relationship between the ideas they collectively generate and how they value each idea relative to the others [26]. These activities can be completed via the online GCM software, which translates the qualitative data collected from participants into quantitative data [31]. The software can then convert participant data into a series of visual maps through automated statistical operations (i.e., similarity matrix, multidimensional scaling, and hierarchical cluster analysis) that facilitate data analysis (Kane & Trochim, 2007). The three primary stages of any structured GCM process include: (1) generating ideas through brainstorming, (2) structuring ideas through sorting and rating, and (3) the analysis of the visual representation of ideas represented in a series of related two-dimensional maps [10] and [32]. The added value of GCM for this study lies in its pragmatic and stepwise approach to explaining and modeling unevenly distributed knowledge among participants. Kane and Trochim [33] emphasize the value of GCM as an approach for applied research activities that include the development of theory, social interventions, development of measures and scales, and program evaluation.

For this preliminary study, a subset of participants from the CIT-E Community of Practice was invited to participate in three activities: idea generation, idea sorting, and idea rating. These activities were completed using the online GCM software groupwisdomTM. To facilitate the pilot, participants were recruited based on the current list of CEE network members. The research team selected 100 participants based on geographical location, type of institution, and discipline background in an effort to recruit a diverse pool of participants based on the current CIT-E membership. Team members sent an email invitation to potential participants, who then opted into the research activities if they were interested. Fifteen individuals started with the brainstorming phase. Of the 12 individuals who completed this phase and engaged in the data collection process, 11 participants completed all three activities (brainstorming, rating, and sorting). Several background questions were posed to those completing the data collection activities to better describe the make-up of the pilot participant group. Twelve participants completed the background questions. These characteristics and responses are shown in Table 1.

Participants' principal field or discipline of teaching included: Infrastructure Management; Civil - Structural Engineering; Civil Engineering, Structural engineering; Transportation and infrastructure systems; Construction Engineering; Environmental engineering; Alternative Project Delivery Methods Research Methods for Construction Heavy Civil Construction; Civil Engineering/Construction; Structural Engineering and Environmental engineering, and Construction Engineering and Management.

The participants in this study were drawn from a variety of institutions across the United States, reflecting a broad geographic distribution. These institutions are located in Colorado, Nebraska, New York, North Carolina, Ohio, Oregon, Pennsylvania, Texas, Utah, and Virginia. This diverse representation spans multiple U.S. regions, including the Northeast, Southeast, Midwest, Mountain West, and West Coast, suggesting a sample that mirrors a national distribution. Types of institutions represented include public and private, small and large, those granting graduate degrees and predominantly undergraduate, and research-intensive and teaching-focused.

It is important to highlight that, as a group conceptualization method, GCM captures a shared mental model based on participant input [10]. It is inherently group-dependent, meaning that rather than claiming generalizability, the researchers focus on the feasibility of the method and the transferability of concepts. While participants represented 10 different states, this is not intended to suggest the universality of results but rather to reflect a multiplicity of thought shaped by varied experiences and backgrounds. The framework that emerged is specific to this group of participants, offering insights and ideas to be considered in the broader effort to integrate DEI into infrastructure education.

Table 1. Background characteristics of participants.

	Number	Percent
Academic rank or position		
Instructor	1	8.3
Assistant Professor	6	50.0
Associate Professor	5	41.7
Total	*12*	*100.0*
Gender identity		
Woman	4	33.3
Man	7	58.3
Non-binary	1	8.3
Total	*12*	*100.0*
Important to talk about racism		
Important	5	41.7
Very important	7	58.3
Total	*12*	*100.0*
Racism is an important problem		
Disagree	1	8.3
Neutral	4	33.3
Agree	4	33.3
Strongly agree	3	25.0
Total	*12*	*100.0*

In the first activity, participants responded to the focus prompt, “to educate future engineers on countering systemic racism throughout the infrastructure lifecycle, a specific thing the CEE Community must consider or do is...” participants generated multiple ideas that were subsequently refined for clarity and used for sorting and rating in the following activities. In the second data collection activity, the participants organized the content by sorting the ideas into categories in a way that made sense to them. The research team sent the participants the 40 statements generated during brainstorming and suggested that they familiarize themselves with the statements before logging into the virtual platform. The statements were not listed in any particular order and were randomized for each participant.

The last activity asked the participants to independently rate each idea based on importance, feasibility, and transformative potential for students using a 5-point scale. The three scales used during the rating phase were:

- How important do you think this action or statement must be considered or done by the CIT-E CoP? (1 = Not at all Important; 2 = Slightly Important; 3 = Moderately Important; 4 = Very Important; 5 = Extremely Important)
- How feasible is it to take this action/statement by the CIT-E CoP? (1 = Not at all feasible; 2 = Slightly Feasible; 3 = Moderately Feasible; 4 = Very Feasible; 5 = Extremely Feasible)
- Of these actions or statements, which can be most transformative for CEE students? (1 = Not at all Transformative; 2 = Slightly Transformative; 3 = Moderately Transformative; 4 = Very Transformative; 5 = Extremely Transformative)

Six thematic clusters, representing key areas of focus for DEI integration, were identified through multidimensional scaling and hierarchical cluster analysis. The researchers also utilized pattern-matching and go-zone visualizations to interpret the relationships between ideas and participants' prioritization. These results are presented in the next section.

Results & Analysis

As described, the GCM process occurred in a series of three data collection activities conducted via the groupwisdom virtual platform. This allowed participants to log in and complete activities from their computers, enabling the research team to reach participants nationwide. In the first activity, participants responded to the focus statement: “*To educate future engineers on countering systemic racism throughout the infrastructure lifecycle, a specific thing the CEE Community must consider or do is…*”, providing as many ideas as they wished. This brainstorming process resulted in 39 responses to the focus prompts from 15 individuals. The researchers reviewed the entire set of responses, noting that several of the responses included multiple ideas. They refined the set by separating complex entries into uniquely specific ideas, removing any duplicate ideas, and employing minor editing for clarity. **Appendix A** includes the final set of 40 ideas on educating future engineers on countering systemic racism throughout the infrastructure lifecycle for participants to consider in subsequent activities. They are organized based on the cluster analysis described in the next section.

In the second data collection task, 12 participants organized the content by sorting the 40 ideas into categories that made sense to them. Then, 11 participants rated the ideas on a scale of 1-5 based on their level of confidence in the information or the source of information.
The point map was constructed using sorting data from the 12 participants who completed the sorting activity. To begin this process, the sort data from the 12 participants were aggregated into a similarity matrix—a 40 x 40 table of values indicating the number of times participants sorted ideas together. Multidimensional scaling (MDS) was applied to the similarity matrix, and a two-dimensional point map was produced.

In the point map shown in Figure 1, the 40 statements, marked by numbered points, were plotted in relation to each other based on the number of times statements were sorted together. Those that appear closer together were paired together more often by participants, and statements that are further apart were paired together less regularly or not at all. This "network of ideas" reflects the judgement of participants as to the relative similarity of ideas to one another. GCM creates a point map where the distance between points shows how closely ideas are related. The exact scale of the map is not important because it is meant to highlight patterns and groupings of ideas, not precise measurements. This makes it helpful in understanding relationships without focusing on exact distances [10].

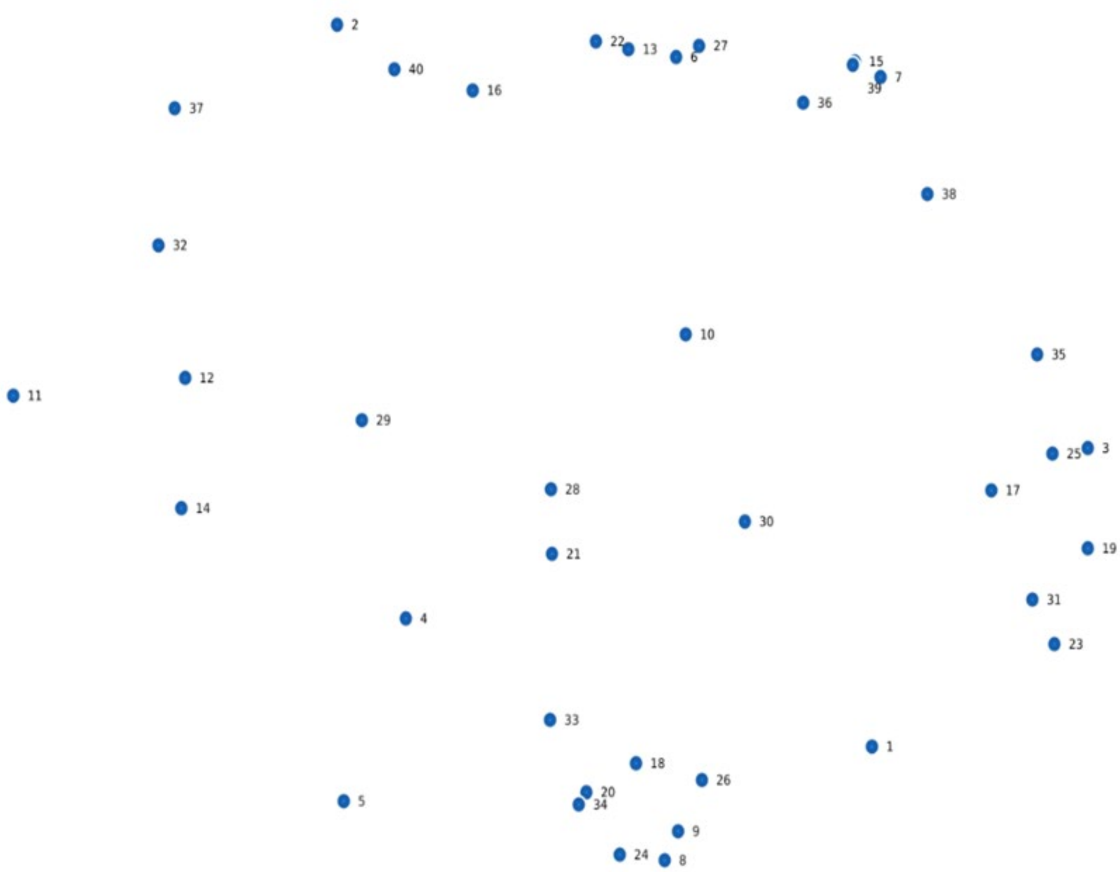

Figure 1. Point map for the 40 statements listed in Appendix A.

Six cluster solution

Next, the coordinates of each point from the point map were used as input for the Hierarchical Cluster Analysis (HCA) to identify groupings or clusters of ideas belonging together. The non-overlapping clusters of ideas reveal a structure that enabled the research team to identify six emergent concepts among the 40 ideas. Figure 2 displays the point cluster map showing the 40 items distributed across six clusters identified using HCA. Each cluster was labeled by the research team, with suggested labels for groups of items coming from participants. **Appendix A** includes the specific ideas in each cluster-by-cluster name. The clusters identify broader concepts within a CEE framework that reflect emergent constructs based on related statements.

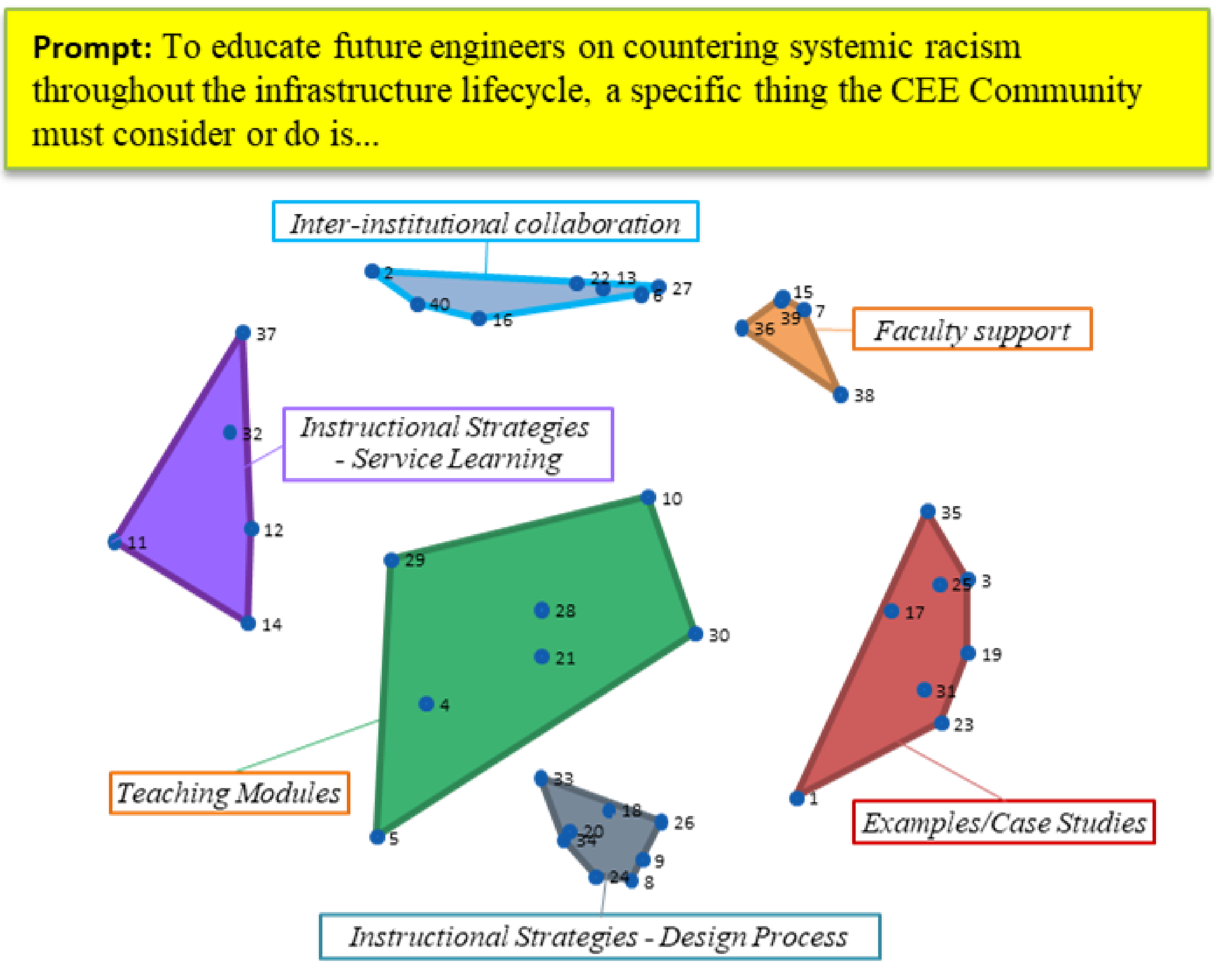

Figure 2. Point-cluster map showing six clusters. Refer to Appendix A for each of the 40 statements.

Pattern match

Pattern matches compare ratings between two scales or two groups of participants on the same scale. For the GCM pilot project, three scales were used, resulting in pattern matches that compare importance, feasibility, and transformation ratings of each cluster as well as by participant groups. Pattern matches display a list of clusters and related ratings in descending order. In reviewing the pattern match for all three ratings, the cluster *Example Case Studies* was rated on the higher end of each respective scale. Thus, as a key feature of the framework, the ideas represented in this cluster were viewed as relatively important, feasible, and transformative for CEE students. In contrast, the cluster *Inter-institutional Collaboration* was viewed as the relatively least important and least transformational element in the framework, although it was seen as slightly more feasible to take action.

The pattern of average cluster ratings on the scale of importance was similar to the pattern of average cluster ratings on the scale of feasibility (r =.89). This suggests strong consistency between what is viewed as important and what is feasible for action. The pattern of average cluster ratings on the scale of feasibility was moderately similar to the average cluster ratings for how transformative the concept was for CEE students (r =.59). Thus, despite the strong agreement between importance and feasibility for action of these concepts, participants saw the transformative nature of the concepts slightly differently. Finally, the pattern of average cluster ratings on the scale of importance was not similar to the pattern of average cluster ratings on the scale of transformation (r =.75). Again, these patterns suggest those elements of the framework viewed as important were also viewed as transformative for CEE students.

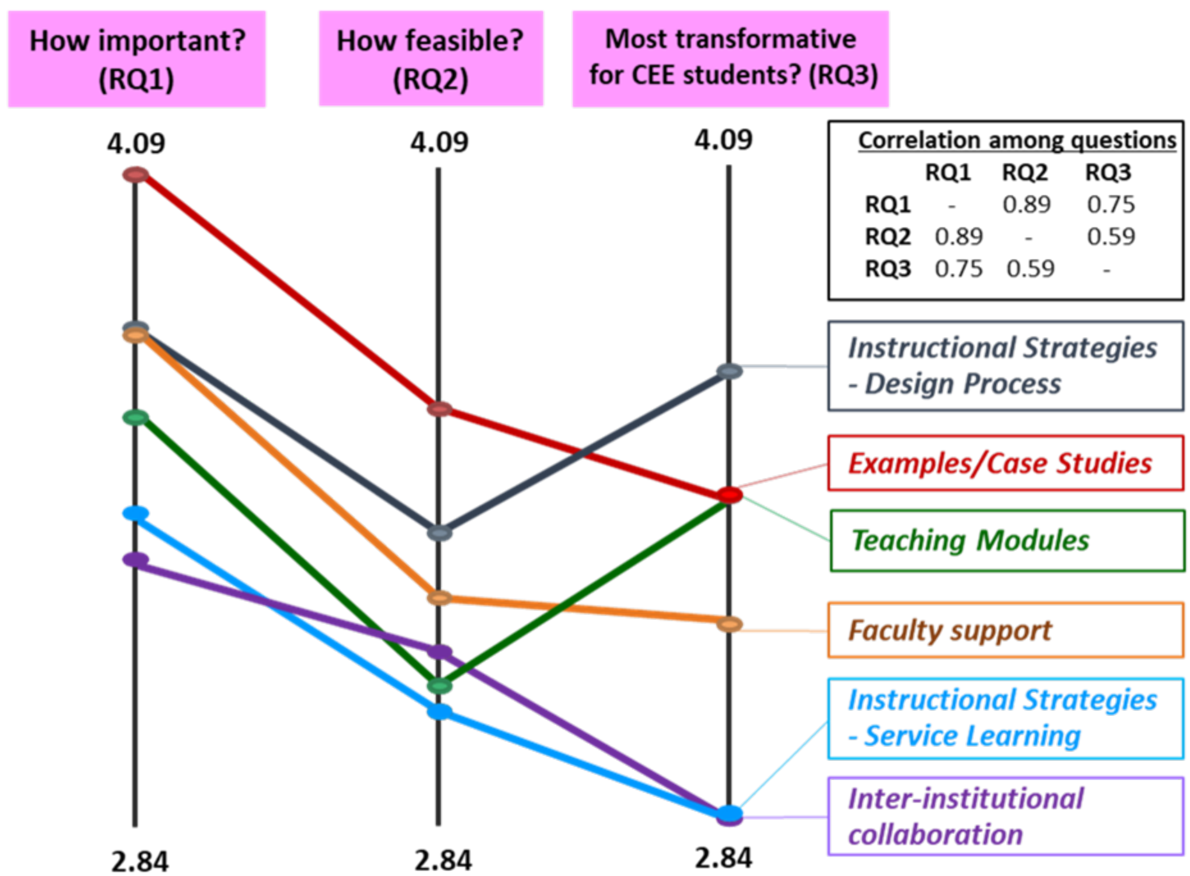

Figure 3. Absolute pattern match across three rating questions. Refer to Appendix B for each of the statement clusters.

Go-Zones

The Go-Zone is a scatterplot picture that uses the same rating used in pattern matches to evaluate the importance, feasibility, and transformative potential of each statement. The scatter plot is divided into quadrants based on the average for each contrasted rating. The quadrants are then color-coded to easily identify the distribution of points based on two rating values. The green area contains ideas that are above average for both the contrasted ratings. The yellow and orange quadrants are the "gap" areas, with one rating higher on average than the other rating. The grey/blue area contains ideas that are below average for both the contrasted ratings.

Figure 4 shows the Go-Zone for all 40 items denoted by cluster color, comparing the average ratings of Importance and Feasibility from all participants. Fourteen items were located within the green zone, indicating this set of statements had both above average Importance and above average Feasibility. Participants agreed that these items, distributed across different clusters, were relatively important and actionable. Fifteen items were in the gray zone, indicating this set of statements had both below average Importance and below average Feasibility. Again, items in this area reflect agreement on the part of participants that these items across the various clusters were relatively less important and actionable.

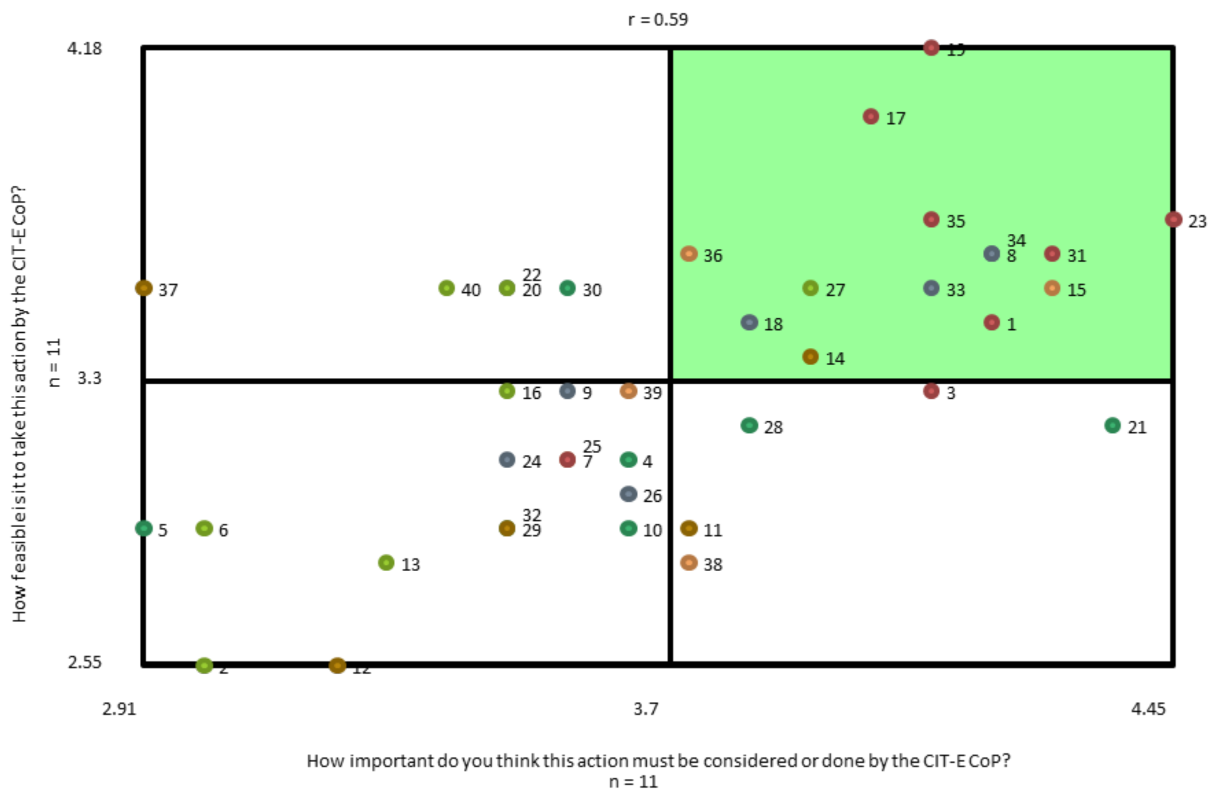

Figure 4. Go-zone comparison of Importance vs Feasibility ratings.

Figure 5 again shows the Go-Zone for all 40 items denoted by cluster color, this time comparing the average ratings of Importance and Transformation from all participants. Eleven items were located within the green zone, indicating this set of statements had both above average Importance and above average Transformation. Participants agreed these items, distributed across the different clusters, were relatively important and potentially transformative for CEE students. Eleven items were in the gray zone, indicating this set of statements had both below average Importance and below average Transformation. Again, items in this area reflect agreement on the part of participants that these items across the various clusters were relatively less important and had lower potential to be transformative for CEE students.

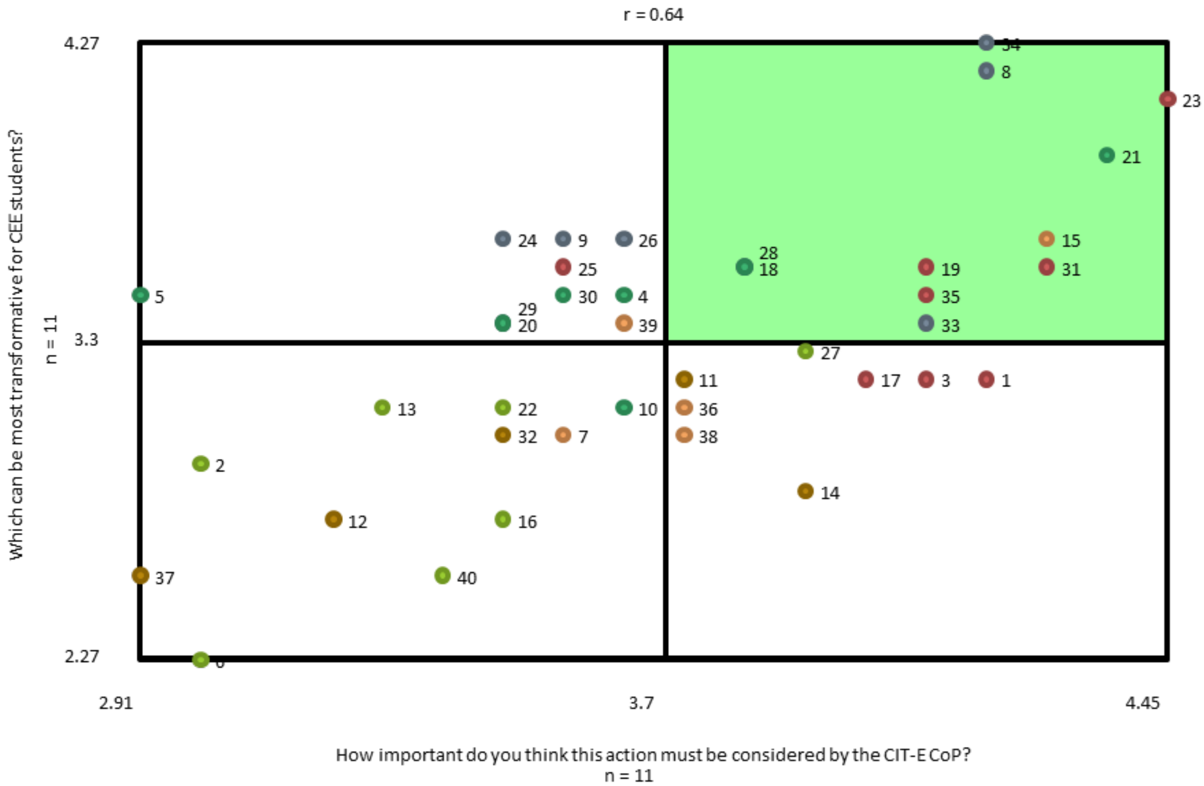

Figure 5. Go-zone comparison of Importance vs Transformation ratings.

Top Go-zone items

From the results of the go-zone analysis, a subset of items was identified as having above average values on each of the three ratings. These 16 items, extracted from the green shaded areas of the go-zones, were perceived by participants to be important, feasible, and transformative elements in the education of future engineers on countering systemic racism throughout the infrastructure lifecycle.

Table 2. Above average rated items from go-zone comparisons.

#	Statements	Important Average	Feasible Average	Transformative Average
1	Acknowledge and teach our profession's active and complicit roles in past racism	4.18	3.45	3.18
8	Incorporate context and social data into assignments. For example, when teaching GIS, show students how to map census data.	4.18	3.63	4.18
14	Follow the lead of those who know more, through both their professional expertise and their lived experience, and have told us what steps to take, e.g. blackinengineering.org/action-item-list/ and onlinelibrary.wiley.com/doi/abs/10.1002/jee.20363	3.91	3.36	2.82
15	Provide training and resources to faculty on having difficult conversations about racism in the classroom, as this may look very different than anything they have experienced themselves in an engineering classroom.	4.27	3.54	3.64
17	Developing case studies that exemplify successful institutional efforts, faculty interactions, and civil infrastructure projects that positively impact DEI.	4.00	4.00	3.18
18	Include consideration of social impacts as a specific step within the engineering design process	3.82	3.45	3.54
19	Provide examples of current projects that address past racist infrastructure design.	4.10	4.18	3.54
21	Consider how issues of systemic racism and social (in)justice can be addressed in ALL engineering courses and should not be decoupled from technical content.	4.36	3.18	3.91
23	Provide examples of how racial equity design concepts have been applied in real life problems, both to act as exemplars to strive towards and to serve as the basis for faculty in to develop learning activities on the topic.	4.45	3.73	4.10
27	Facilitating workshops to help CIT-E members translate information into institutional change.	3.91	3.54	3.27
28	Promote the integration of social/economic/environmental justice into canonical engineering curricula (e.g., engineering mechanics).	3.82	3.18	3.54
31	Identify engineering case studies of when systemic racism clearly manifested in the infrastructure lifecycle to develop a common understanding of what systemic racism in infrastructure can look like.	4.27	3.64	3.54
33	Recognize the bias and all humans bring into processes, so that we can recognize those biases and take corrective actions when appropriate.	4.01	3.54	3.36
34	Teach engineering students that they are not "dissociated" from the society they serve through their engineering efforts.	4.18	3.63	4.27
35	Know and understand the history of systemic racism in infrastructure, so faculty can best communicate it to their students.	4.09	3.72	3.45
36	Share resources for becoming an antiracist engineering educator	3.72	3.63	3.09

Conclusion and Future Work

This part of the CIT-E NSF project piloted the use of the GCM methodology to characterize the relationships among DEI concepts as they relate to infrastructure education. The pilot sought to conceptualize the specific ways diversity, equity, and inclusion concepts and methods can be incorporated into the infrastructure curriculum, how feasible it is to take action, and the approaches or steps that can be most transformative for students. Based on the GCM pilot study results, the research team will use this experience to implement a larger, more robust conceptualization process to produce a comprehensive, current, and inclusive picture of the priorities related to DEI in CEE education. This work has taken on increased importance considering the current political environment in which diversity, equity, and inclusion programs have been targeted for elimination.

Although this application of the GCM approach was small, the experience and results of the pilot suggest the approach could be scaled up for broader inclusion. GCM pilot studies typically involve fewer participants and smaller statement sets, as their primary goal is to test feasibility rather than produce definitive conclusions. In this case, the pilot successfully demonstrated the viability of 1) crafting a focus prompt that yields meaningful content, 2) engaging participants in conceptualizing relationships among statements, and 3) eliciting relevant ratings from participants. GCM captures a shared understanding based on participant input and is shaped by the group involved. Rather than aiming for generalizability, this study highlights the transferability of ideas. While participants came from 10 states, this was not to suggest universal findings but to reflect diverse perspectives shaped by different experiences. The resulting framework offers valuable insights to consider when integrating DEI into infrastructure education.

GCM offers several features that align with future research by addressing complex topics in engineering education and social problems related to equitable infrastructure. GCM provides a platform to situate a social issue within a specific context, such as the participants' environment, and to gather their perceptions into a common conceptual framework. The authors chose GCM for this pilot study because it effectively engages geographically dispersed participants across different time zones. A future study with more participants will allow us to better understand how participants individually and collectively perceive the changes necessary for a more equitable infrastructure education across various geographic contexts. In addition, future studies could use GCM methodology to evaluate changes in perspectives and priorities over time.

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Appendix A: Final Statements by Cluster

Cluster name: Examples/Case Studies

1 Acknowledge and teach our profession's active and complicit roles in past racism
3 Knowledge building on what types of racism can be found in infrastructure life cycle, their impact, etc.
17 Developing case studies that exemplify successful institutional efforts, faculty interactions, and civil infrastructure projects that positively impact DEI.
19 Provide examples of current projects that address past racist infrastructure design
23 Provide examples of how racial equity design concepts have been applied in real life problems, both to act as exemplars to strive towards and to serve as the basis for faculty in to develop learning activities on the topic.
25 Provide a database of "hidden" stories that should be told relating to engineering failures and successes as they relate to racial (in)justice.
31 Identify engineering case studies of when systemic racism clearly manifested in the infrastructure lifecycle to develop a common understanding of what systemic racism in infrastructure can look like.
35 Know and understand the history of systemic racism in infrastructure, so faculty can best communicate it to their students.

Cluster name: Inter-institutional collaboration

2 Fund CIT-E fellows who are knowledgeable in the practice of DEIJ education and making change at their home institutions
6 Become a support hub for anti-racism in civil infrastructure education in higher education
13 Develop a mentorship program where experienced members guide new or less experienced members in integrating DEI practices into their teaching and professional work.
16 Amplify its messaging through synergistic outlets focused on civil engineering faculty professional development (e.g., ASCE ExCEEd, KEEN Faculty Development Workshops, ACI Professor's Workshop, ASEE Delta Institute, etc.).
22 Keep organizing summer workshops focusing on equitable infrastructure
27 Facilitating workshops to help CIT-E members translate information into institutional change.
40 Enhancing the overall user experience, accessibility, and design practices for accessing CIT-E resources, such as teaching modules

Cluster name: Faculty support

7 Help faculty see their agency with regard to leading programmatic curricular change
15 Provide training and resources to faculty on having difficult conversations about racism in the classroom, as this may look very different than anything they have experienced themselves in an engineering classroom.
36 Share resources for becoming an antiracist engineering educator
38 Provide faculty and students tools and strategies they can use if they are doing work in states with legislations restricting how racism can be discussed in the classroom or in public work.
39 Provide faculty with knowledge and skills need to lead curricular change at their institution

Cluster name: Teaching Modules

4 Teach effective community engagement strategies (and biases inherent in traditional approaches)
5 Partner with librarians and historians to help students explore and develop local case studies.
10 Consider the Truth, Racial Healing and Transformation process to help reconcile past harms (e.g., ecl-usa.org/engineering-equitable-communities-workshop-explores-the-role-of-the-engineering-community-in-creating-more-just-and-equitable-communities/)

21 Consider how issues of systemic racism and social (in)justice can be addressed in ALL engineering courses and should not be decoupled from technical content.
28 Promote the integration of social/economic/environmental justice into canonical engineering curricula (e.g., engineering mechanics).
29 Develop learning outcomes associated to countering systemic racism that can eventually evolve into ABET Student Learning Outcomes for programs to adopt.
30 Creating new infrastructure education modules that illustrate the intersection of CEE and DEIJ

Cluster name: Instructional Strategies - Design Process

8 Incorporate context and social data into assignments. For example, when teaching GIS, show students how to map census data.
9 Use data and numbers to show students- quantitatively how systemic racism creates inequitable outcomes.
18 Include consideration of social impacts as a specific step within the engineering design process
20 Consider humanity in teaching design -- not only who may be impacted but also who developed the codes or standards
24 Ask students to create stakeholder maps and look for inequity based on data they have collected. This strategy is very empowering for the students and it feels self-led.
26 Make visible to engineering learners the specific tools and techniques to challenge systemic racism in their present and future lives (i.e., to empower change-agents).
33 Recognize the bias and all humans bring into processes, so that we can recognize those biases and take corrective actions when appropriate.
34 Teach engineering students that they are not "dissociated" from the society they serve through their engineering efforts.

Cluster name: Instructional Strategies - Service Learning

11 Partner with community organizations, sociologists, ethicists, and other professionals and experts who know far more than we do about meeting the needs of communities, including the specific communities affected by specific infrastructure projects
12 Work with ASCE and ABET to provide PEVs tools for evaluating civil engineering program's efforts around racism as a component of the diversity, equity, and inclusion requirements.
14 Follow the lead of those who know more, through both their professional expertise and their lived experience, and have told us what steps to take, e.g. blackinengineering.org/action-item-list/ and onlinelibrary.wiley.com/doi/abs/10.1002/jee.20363
32 Promote and support collaborative research projects that involve multiple CIT-E members and potentially other disciplines to address systemic racism in infrastructure.
37 Recognize and celebrate the contributions of community members who have made significant strides in promoting DEI and addressing systemic racism, thereby fostering a culture of appreciation and motivation