Diversity and inclusion in engineering and computing: A scoping review of recent FIE papers

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***Abstract*—This Full-Length Research Paper presents findings from a scoping review of diversity research in engineering and computing education in the 2019-2020 FIE conference proceedings. The purpose of this review was to determine present-day themes and contributions of diversity research and identify opportunities for further research. Through the scoping review process, we identified 21 out of 776 papers that focused on a diverse population in engineering or computing, utilized an established methodology, and presented results. From these selected papers, three themes emerged. The first was about minority student experiences of discrimination and biases, and their resulting feelings of inclusivity and belonging. Results showed that these experiences and feelings negatively impacted success factors such as GPA and graduation in engineering or computing. A second theme was that financial need is a substantial deterrent to degrees in engineering and computing. Lastly, there were several investigations of the experiences of diverse students during active learning interventions in the classroom. The mixed results do not present a clear picture of how active learning might impact minority student success. Based on the existing work, we make recommendations for future diversity research. In general, much more quantitative, intervention-based research is needed. Several difficulties have been established, but almost no solutions have been identified.**

Keywords—diversity, engineering and computing education, scoping review, underrepresented minorities (URM), gender, race, income.

I. Introduction

Lack of diversity has been identified by many scholars as a major challenge in computing and engineering education [1]–[6]. As a result, there has been an increased effort by computing and engineering researchers and educators to promote diversity awareness and inclusive practices. Various techniques such as project-based learning and peer-mentoring [3], communal goal-oriented programs [2], service learning [1], robotics [7] & [8], etc., have been implemented and used as means to promote diversity. Despite these concerted efforts, the lack of diversity in engineering and computing is still widely acknowledged as persistent problem.

The benefits of a diverse population engineering and computing profession are many. Diversity fosters innovation [9], which is vital for our quality of life, economic competitiveness, and national security. Diverse teams have unique sets of skills, abilities, and interests that only together can help in both identification of real-world problems and solutions. Additionally, the educational benefits of a diverse student population include practical competence and social development [10]. Although diversity and inclusion play important roles in pedagogy, recent studies show that engineering and computing are far behind other disciplines in recruiting and graduating underrepresented minorities (URMs) [11], [12].

In order to support the current effort to increase diversity, this paper performs a critical analysis of existing studies in diversity of engineering and computing education. We synthesize the current research in the recruitment and graduation of diverse students and faculty. Hence, we examine the following research question:

> *What are the recent research contributions in diversity for students or faculty in engineering and computing?*

To answer this question, we performed a scoping review of contributions from the last 2 years at the Frontiers in Engineering Education (FIE) conference, see Fig. 1. FIE showcases the work of practicing engineering and computing educators that encourage minority engineering students on the frontlines. This international conference acts as a discussion hub where researchers are encouraged to report difficulties as well as successes, in the hopes of reaching a group understanding that is greater than that of individuals. Thus, many novel, innovative ideas are put forward. A scoping review methodology was intended to identify and review this body of work.

The remainder of this paper is organized as follows: Section 2 provides the definition of diversity and reviews related work. In Section 3, the research methodology is described. The results are presented in Section 4, and the conclusion and future work can be found in Section 5.

II. Literature Review

A. Overview of Diversity and Inclusion

Varying definitions of diversity and inclusion exist in literature. For the purpose of this research we adopt the definitions given by the American Society of Mechanical Engineers (ASME) and Higher Education Academy, both of which are adopted from the work of Delaine et al [13]. ASME defines "diversity" as the inherent differences and/or similarities between people or organizations, and how these differences and similarities can foster the achievement of commonly agreed outcomes [13]. This definition relates to the explanation of the foundational idea behind diversity, i.e., the inherent differences in culture, experience, skills, interests, or identities of individuals and how these can contribute multiple perspectives to achieving a common goal [9]. Both Higher Education Academy and ASME agree that "inclusion" involves enabling or allowing participation of every individual in all educational or professional activities [13]. However, the ASME definition is more elaborate as it includes two important concepts: (1) the creation of opportunities to facilitate the participation of every individual, and (2) the removal of barriers that hurt or hinder such participation.

B. Related Work

Although diversity and inclusion have been extensively discussed in literature, and are actively receiving attention, it is difficult to find studies that articulate the current contributions in diversity research, especially in engineering and computing education. As diversity research in engineering and computing education continues to increase, it is important to take a critical look into the current research contributions to synthesize what has already been done and identify the gaps that exist in research. This will ensure that future research contributions can focus on areas of need, and will assist in the development of a more robust research agenda.

There are a few related studies that reviewed existing literature in diversity and presented some interesting findings. For instance, one systematic review [14] examined the extent to which massive open online courses (MOOC) support inclusion and participation of underrepresented minorities. Although this systematic review provides a critical perspective, the focus is very narrow and does not provide a picture of all diversity and inclusion research. Another broader study reviewed 116 empirical research papers to synthesize the experiences of women of color in STEM [5]. Wright, Espinosa and Orfield [5] found that women are still largely underrepresented in STEM despite concerted efforts to increase participation. Indeed, this study makes some useful contributions to diversity, albeit it fails to consider other aspects of diversity such as race and social economic status. The work presented in [15] made a very good attempt to synthesize diversity literature and examine the gaps, challenges, and findings of existing studies in diversity. However, the authors narrowed the scope of their research contribution to workplace diversity.

One major limitation of existing studies in diversity is the narrow perspective with which they approached the problem of diversity and inclusion. The majority of existing research in diversity within computing and engineering education focus on promoting gender and racial diversity, for instance [1]–[4]. Authors such as Pournaghshband and Medal [4] have noted the disadvantages of this narrow focus and stresses the need to adopt a multi-dimensional approach to diversity research.

Our aim in this paper is to synthesize recent contributions in engineering and computing education so that it will be easier to understand the current research gaps and future research directions. Our approach is different from existing studies because it considers diversity and inclusion from multiple perspectives. We highlighted other areas of diversity that have been understudied in literature and analyzed the current findings, gaps and challenges of diversity in computing and engineering education.

III. Methodology

Through this paper, we aim to evaluate the current contributions in diversity research, identify critical themes and present opportunities for further research. Although we considered other research methodologies (e.g., thematic analysis and systematic literature review), we determined that a scoping review was best suited for our study purposes. Grant and Booth, in their description of different types of reviews [16], stated that a scoping review is used for assessing or evaluating the scope of existing research contributions in a given area to synthesize the "current state of knowledge" and identify priorities for further research. Accordingly, we performed a scoping review to determine recent contributions in diversity and inclusion research in engineering and computing.

The methodological steps of a scoping review (according to [17]) are as follows:

Stage 1: Refine the research question

Stage 2: Search for relevant studies

Stage 3: Select studies

Stage 4: Chart the data

Stage 5: Collate, summarize, and report the results

All methodological steps are described in detail in the proceeding sections, as transparently as possible, to both justify findings and allow for possible replication.

A. Stage 1: Refining the research question

The research question was developed over multiple iterations, both prior to and alongside the search for papers. The research question is stated again here, with important pieces underlined and defined below:

> What are the recent <u>research contributions</u> in <u>diversity and inclusion</u> for <u>students or faculty in engineering and computing</u>?

Most importantly, the review was intended to address research contributions to "diversity and inclusion." Based on the ASEE and Higher Education Academy definitions, our working definition for diversity consisted of all underrepresented populations, including gender, race, socioeconomic status, disabled, and neurodiverse populations. Our definition for inclusion was the intentional effort to allow participation of a minority population equally to a majority population.

The participants of interest for this paper were "students or faculty in engineering and computing." Using the FIE database was logical, in order to focus on the primary conference topics of engineering and computing. Filtering down to students or faculty meant that publications about industries or industry professionals were excluded.

Lastly, the review was intended to summarize "research contributions," which was defined as findings or results from studies with established qualitative or quantitative research methodologies. Research contributions included observations, results from experimental interventions, and identification of challenges, methods, or approaches.

B. *Stage 2: Searching for relevant studies*

The search was limited to IEEE FIE conference proceedings in 2019 and 2020. An iterative approach was taken to develop the search terms, beginning with initial words "diversity," "URM," and "minority." After looking at several papers and noting additional terms used to describe diversity research, more terms were added. The following is the exhaustive list of the search terms used for this scoping review:

Diversity OR Diverse OR Equity OR Equality OR Inclusion OR Inclusive OR Inclusivity OR Minority OR Minorities OR URM OR Underrepresented

The online IEEE publication portal (https://ieeexplore.ieee.org/) was used to search for papers, looking for the words above in the title and abstract fields. This search returned a total of 123 papers from the 2019 and 2020 IEEE FIE conferences (60 and 63 papers respectively). Full-text PDF files of these articles were downloaded from the website for further review.

C. *Stage 3: Initial Screening Criteria*

The full-text files were initially screened based on the definitions described above. The criteria were as follows:

1. Focused on diversity.
2. Addressed students or faculty in engineering or computing.
3. Presented any type of research contribution.

Although 123 papers had one or more of the search terms in either the title or the abstract, many of these papers did not fit into the project scope. A total of 49 papers (24 in 2019, and 25 in 2020) met the three criteria listed above.

An important note: FIE includes many publications about STEM in general, and for the purposes of this review, these papers were retained to determine potential relevance.

D. *Final Inclusion Criteria*

The remaining papers were reviewed in detail, and again an iterative approach was taken to developing final inclusion criteria. For quality purposes, we developed five key criteria for inclusion these include the focus, population, paper category, quality and results or contributions of the paper, see Table 1.

A set of 21 papers (8 from 2019 and 13 from 2020) met these criteria (Fig. 1).

E. *Charting the data*

The scoping review process was charted in a flow diagram (Fig. 1). The diagram illustrates the narrowing of the search from the initial restricted scope (FIE publications in 2019 and 2020), through search term identification, initial screening, and final inclusion.

TABLE 1:FINAL INCLUSION CRITERIA

Criteria	Description
Focus	The paper must focus on diversity and inclusion
Population	The paper must address students or faculty in engineering, computing and/or STEM
Category	Was a Work-In-Progress (WIP) or Full Paper (excluding proposals for panels, special sessions, or preconference workshops)
Quality	The paper must use an established research methodology and clearly explain the data collection and analysis approach
Result	Clearly presented findings in a results, discussion, or conclusions section

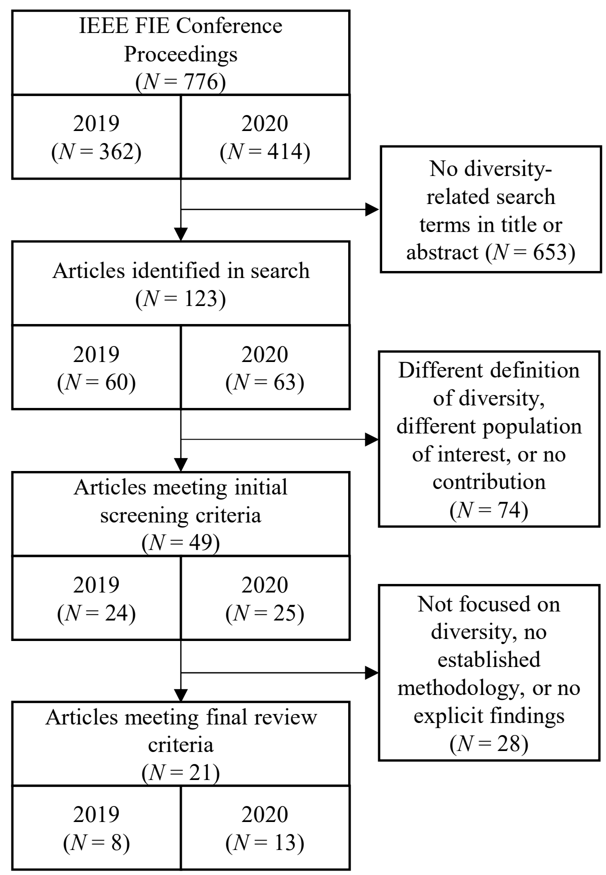

Fig. 1: A diagram of the scoping review search and selection criteria and results. Of 776 publications in two years of conference proceedings, 21 were applicable to our research question about diversity of students and faculty in engineering and computing.

F. *Collating and summarizing the data*

The following information was manually extracted from the full texts of the selected papers:

1. Information
    a. Title
    b. Author(s)
    c. Year
    d. Type of paper (Full/WIP)
2. Focus
    a. Discipline (engineering/computing/STEM)
    b. Population (e.g., undergraduates)
    c. Diversity focus (e.g., gender minority)
3. Methodology
    a. Data collection method
    b. Analysis type
4. Primary findings

During data collection, words were copied into a table verbatim. The basic information and focus of the papers were often available on page 1. However, the full text was often needed to identify methodologies and primary findings. Researchers first looked for methodology information in methods sections, and secondly looked in results sections. Findings were identified primarily in the abstract, results, discussion, and conclusions sections.

Following the data collection, researchers counted the number of papers that fell into generalized categories for focus and methodology. The number of papers per category was tallied. A paper that fell into multiple categories was tallied multiple times. For example, if a paper considered both Engineering and Computing students, it would be represented in both engineering and computing discipline categories. The numbers therefore do not always add up to the total number of papers.

Thematic analysis was performed to detect common themes within the primary findings of the selected papers. Researchers followed best practices for thematic analysis as outlined in [18]. Themes were developed iteratively. First, possible thematic words were generated for all findings individually. Following the coding of individual paper findings, researchers reviewed all papers again using the available codes to detect common overlapping themes.

IV. RESULTS & DISCUSSION

Fig. 1 illustrates the results of the search and selection process. Of the 776 articles presented at the IEEE FIE conference in 2019 and 2020, 21 were applicable to our research question, describing a research contributions in diversity for students and faculty in engineering and computing.

Primary descriptive information for the selected papers is presented in Table 3, and the following three subsections describe the (a) focus, (b) methodologies, and (c) contributions of the selected papers.

A. *Focus of FIE diversity research*

A majority of the papers were full-length (14), with half as many WIPs (7). Many focused on the discipline of Engineering (12), followed by Computing or Computer Science (6) or STEM (4). The papers primarily studied undergraduates (15), followed by K-12 (3), graduate students (2), faculty (1), and role models and mentors (1).

The predominant focus on engineering undergraduates is typical for FIE publications as a whole. Many FIE attendees are engineering instructors who are trying to improve their classrooms. Computing is also a large part of FIE, and it is a little surprising that there weren't more studies about diversity in computing. The underrepresentation of females is stark in computer science and computing, so much more work is needed there.

In terms of the diverse populations of interest, papers looked primarily at the underrepresentation in gender (14) and race (12), and a few considered minorities in socioeconomic status (4), first-generation (1), foreigners (1), and latent diversity (i.e., diversity of attitudes; 1). There were no selected papers that looked at disabled or neurodiverse populations. This distribution matches that of the broader diversity literature. As mentioned in the introduction, Pournaghshband and Medal [4] called upon researchers to consider underrepresented groups other than gender and racial minorities because greater diversity is needed to stay competitive in technology and other industries.

B. *Methodologies of FIE diversity research*

Data was primarily collected through surveys as well as interviews and focus groups. However, other qualitative methods (content analysis, observations, and written narrative profiles) as well as secondary data analysis were also used. One paper did not specify how the data was collected. The methods categories and the corresponding papers are listed in Table 2.

TABLE 2. DATA COLLECTION METHODS

Method	***N***	**References**
Survey	11	[19], [22], [39], [24], [25], [27], [29], [30], [33], [34], [36]
Interview/Focus Group	7	[20], [23], [32]–[35], [38]
Other Qualitative Method	3	[28], [31], [35]
Secondary Data Analysis	2	[26], [37]

The reliance on surveys for researching diversity is not surprising. Many scales that measure topics related to diversity (e.g., inclusivity and belonging) have been validated in the undergraduate university context and are good tools to detect opinions about a given environment or set of student experiences. However, not all studies used validated scales, and instead created their own questionnaires. Additionally, the analysis of survey data varied widely. While some papers performed established statistical methods (e.g., analyses of variance, i.e., ANOVAs), others merely reported descriptive statistics. Research quality is not in the scope of this review. However, it should be noted that there is a wide range of research quality in the selected papers, and results of the current study should be interpreted accordingly.

TABLE 3. SELECTED PAPERS

Title	Authors	Year	WIP/Full	Discipline	Population tier	Diverse population	Ref
A Snapshot of Mental Health and Wellness of Engineering Students Across the Western United States	Danowitz, Beddoes	2020	Full	Engineering	Undergraduates	Gender, Race	[19]
Challenges in STEM PhD Programs: Biased Mentoring	Howell, Merriweather, Sanczyk, Douglas	2020	WIP	STEM	Graduate students	Gender, Race, Age	[20]
Critical Analyses of Outcomes of Marginalized Undergraduate Engineering Students	Bowen, Johnson. Powell	2020	Full	Engineering	Undergraduates	Gender, Race, Socioeconomic status	[21]
Do students from underrepresented groups feel integrated into engineering degrees?	Baltà, Olmedo-Torre, Peña	2020	WIP	Engineering	Undergraduates	Foreigners	[22]
From Outsider to Advocate: The Experience of Shame as a Minority Student in Engineering Education	Sharbine, Huff, Sochaka, Walther	2020	Full	Engineering	Undergraduates	Gender, Race	[23]
Gaming4All: Reflecting on Diversity, Equity, and Inclusion for Game-Based Engineering Education	Harteveld, Javvaji, Machado, Zastavker, Bennett, Abdoun	2020	Full	Engineering	Undergraduates	Gender, Race	[24]
In Depth Exploration of Added Course Expenses on Students of Various Socioeconomic Status	Danowitz, Benson, Hummel, Callenes, McKell	2020	Full	Engineering	Undergraduates	Socioeconomic status	[25]
Intersectionality at minority-serving institutions (MSIs): A longitudinal analysis of female student participation within engineering and computing	Fletcher, Green, Quintero, Arroyo	2020	Full	Engineering & Computing	Undergraduates	Gender	[26]
Protection factors self-efficacy and causal attributions related to academic performance, personal characteristics and life at university at engineering education	Schirichian, Grimoni, de Paula	2020	WIP	Engineering	Undergraduates	Race, Socioeconomic status	[27]
Tackling Gender Stereotypes in STEM Educational Resources	Dele-Ajayi, Bradnum, Prickett, Strachan, Alufa, Ayodele	2020	Full	STEM	Grades 1-5	Gender	[28]
Understanding the Experiences that Contribute to the Inclusion of Underrepresented Groups in Computing	Kargarmoakhar, Ross, Lunn, Hazari, Christensen, Zahedi, Weiss, Solis	2020	Full	Computing	Undergraduates	Gender, Race	[29]
What do Female Students in Middle and High Schools Think about Computer Science Majors in Brasilia, Brazil? A Survey in 2011 and 2019	Holanda, Mourao, von Borries, Ramos, Araujo, Walter	2020	Full	Computer Science	Middle and High School	Gender	[30]
Work-in-Progress: Emergent Themes from "High Impact" Role Model and Mentor Narratives	Trenshaw, Rushton, Miskioğlu, Asare	2020	WIP	STEM	Role Models and Mentors	Race	[31]
A Qualitative Investigation on the Effectiveness of a Computing Identity Development Emailing List for African American Computer Scientists Hopper Celebrations of Women in Computing	Nelson, Cummings, Gosha	2019	Full	Computing	Graduate students, Faculty	Race	[32]
An Early Adaptation of Identity Trajectory to Understand the Identities of Undergraduate Engineering Students	Benedict, Verdín, Rohde, Brown, Baker, Thielmeyer, Godwin	2019	WIP	Engineering	Undergraduates	Latent diversity (diverse attitudes)	[33]
An initial exploration of the perspectives and experiences of diverse learners' acceptance of online educational engineering games as learning tools in the classroom	Cook-Chennault, Villanueva	2019	WIP	Engineering	Undergraduates	Intersectional (women of color in engineering)	[34]
Computation, Gender, and Engineering Identity Among Biomedical Engineering Undergraduates	Shoaib, Cardella, Umulis, Madamanchi	2019	Full	Engineering	Undergraduates	Gender	[35]
Exploring Underrepresented Student Motivation and Perceptions of Collaborative Learning-Enhanced CS Undergraduate Introductory Courses	Cintron, Chang, Cohoon, Tychonievich, Halsey, Yi, Schmitt	2019	Full	Computer Science	Undergraduates	Gender, Race	[36]
Factors Influencing Computer Engineering Student Success	Marbouti, Ulas, Thompson	2019	Full	Computer engineering	Undergraduates	Part-time, Race, Gender, first generation, Socioeconomic status	[37]
"I feel like I've found where I belong." Interviews with Black engineering students who change majors	Brent, Mobley, Brawner, Orr	2019	WIP	Engineering	Undergraduates	Race	[38]
The Nexus of Confidence and Gender in an Engineering Project-Based STEM Camp	Vela, Caldwell, Capraro, Capraro	2019	Full	STEM	Middle and high school	Gender	[39]

There are a good number of papers based on interviews and focus groups. Because we are only beginning to understand the experiences of diverse students and faculty, qualitative research that is based on such data collection methods can be valuable. However, it is critical that this type of work also follow established methodologies for data interpretation such that findings are both valid and relevant [40]. The qualitative studies in the selected papers utilized the following interpretive methodologies: the constant comparative method, content analysis, grounded theory, interpretative phenomenological analysis, narrative analysis, and thematic analysis.

C. Contributions of FIE diversity research

The selected papers presented many interesting and important findings regarding diversity in engineering and computing. There were three topics that were addressed by multiple papers: discrimination, biases, inclusivity, and feelings of belonging (9 papers), financial need (4 papers), and the effects of collaborative or game-based activities on diverse populations (5 papers). Findings range from fine-grained, single-student experiences to coarse demographic factors predicting student retention.

i. Discrimination, biases, inclusivity, and feelings of belonging

Many FIE diversity researchers illustrate identity-based discrimination in minority students' engineering and computing educational environments. The research shows that biased interactions lead minority students to hold lower perceptions of inclusivity and belonging than majority students in these programs, which can result in students changing majors or leaving college altogether.

This set of selected papers presents an interesting depiction of discrimination and biases for females over time. Young students are first exposed to stereotypes in their STEM textbooks that consist of higher numbers of male images than female images [28]. Middle and high school girls then believe that fields like computer science have mostly male students, and their decision to enter such fields is highly dependent on family influences [30]. Once enrolled, females' perceptions of inclusivity differ by their individual experiences; females that participate in tutoring, become learning assistants, obtain job offers, or have good job experiences perceive higher levels of inclusivity for the field [29]. Further on in graduate school, URM doctoral students in STEM experience biases, and faculty are generally unaware that they are not being inclusive [20]:

> *Faculty seemed at a loss for how to attend to problematic gender-based issues or to understand the nuanced challenges of students' lives that extended beyond a particular field assignment or experiment.* [20]

However, some rare faculty members are strong advocates for diverse students. High impact role models and mentors tend to describe their experiences of handling biases and discrimination in greater detail than lower impact role models, are more likely to acknowledge their failures, and take more responsibility for incident outcomes [31].

Students in racial minorities have similar experiences as females, experiencing biases and reporting lower perceptions of inclusivity than majority students [20], [22], [29]. Racial minority students perceive discrimination primarily in academic activities from professors and peers, and the perception of discrimination is correlated with satisfaction, and later, dropout [22]. On the other hand, at an HBCU, race was found to play a role in students' choice of institution but not in their decision to leave a degree program such as engineering or computing [38]. These complimentary results show that minority students experience computing and engineering programs differently, and that being in the minority affects the likelihood of graduation.

One paper described a female American Indian's experience in an engineering program [23]. Mano (a pseudonym) entered engineering with a strong and a desire for success, wishing to overcome what she considered a limited upbringing. However, her high expectations resulted in feelings of insecurity, exclusion, and shame as she interacted with students who had had stronger pre-engineering experiences (e.g., programming practice at home). Her negative feelings reinforced themselves; the feelings were demotivating, she fell behind in her studies, and she considered leaving engineering. Only after a positive and encouraging conversation with her mother did her attitude change for the better. Her mother helped her see that her diversity was an asset rather than a failure to meet expectations. This paper illustrates how perceptions of low inclusivity are developed in engineering and computing, providing a personal example for the other quantitative findings described above.

Perhaps due to discrimination and low perceptions of inclusivity, mental illness is prevalent for minority populations in engineering programs [19]. Female students reported higher rates of mental illness than males, and there were similar differential effects between racial minorities and majorities. Although this paper did not directly discuss biases, it is likely that negative experiences of students, even if they are caused by failure to meet self-imposed high expectations, can lead to serious clinical problems.

ii. Financial need

Findings from the selected research papers reveal a negative effect of financial need on success in engineering and computing [21], [27], [37]. For example, having primary education in a public school in Brazil that was associated with socioeconomic disadvantages showed a negative relationship with academic performance [27]. Another study found that income level was a stronger deterrent of graduation than gender or race [21].

One qualitative paper investigated students' experiences of unforeseen course expenses (e.g., broken lab equipment, supplemental software) and unpredictable laptop problems (e.g., lack of laptop, broken laptop, or underperforming laptop) [25]. These expenses are often out-of-pocket because they are not covered by financial aid. Students reported that given the choice, they would use additional money on housing and living expenses rather than fix their computers. The dependency on computers and lab equipment in engineering and computing could be a significant burden to low-income students.

It is argued by many that increasing the success of low income students in engineering and computing will have a large impact on our society [41]. The current FIE research provides a baseline, and states that financial need is a problem. However, there were no papers that assessed methods for mitigating the effects of financial need. Many more studies are needed to determine what can be done for low-income students.

iii. Active learning

Several papers investigated minority students' perceptions and outcomes following various active learning interventions. Interestingly, results were mixed. In some cases, the active learning experience appeared to be positive for both minority and majority participants. In other cases, minority students' perceptions of the activity were different than majority students' perceptions.

For example, there were no significant differences in learning across gender or race following a geotechnical engineering game [24]. Researchers noted that females performed better than males (but not significantly) and noted that success in this game could encourage females to continue in engineering and computing. However, they also found lower performance in racial minorities (but not significantly). Another paper did a similar study, surveying gender and racial minority and majority students and conducting focus groups after students played a educational game on trusses [34]. Although there were a variety of responses to the question "This game reflected aspects of my culture and/or identity," most students – even minorities – did not expect nor want the game to do so. On the other hand, students did request things like feedback, opportunities to review evidence, and to have access to explanations of engineering content. Authors noted that the students more familiar and experienced with video games were white males, and more experienced students were more inclined to continue to play given a competitive extra credit opportunity. Opportunities for extra credit from extra play time therefore may introduce bias in the classroom.

Researchers looking at a course-wide intervention of collaborative learning in an introductory computer science course detected significant differences underrepresented minority and majority students' perceptions [36]. Minority students perceived lower instructor support and had lower opinions of collaborative learning. Another negative impact was detected from a week-long STEM camp for middle and high schoolers: Males' confidence in designing and building innovative products increased from the beginning to the end of the camp, whereas females' confidence declined [39].

These negative results do not support recent findings in the literature that active learning can decrease minority achievement gaps [5]. It is possible that the effects are dependent upon implementation procedures, such that only well-designed activities (perhaps with inclusive practices embedded into the instruction) create opportunities for minorities to perform well. It is critical that both positive and negative impacts of active learning approaches are reported and discussed. Although active learning methods have great potential to improve learning and interest in engineering and computing, these methods vary along many factors, and these results indicate that it is possible to introduce biases through these activities that could deter minority students. It is critical to continue this research on various types of active learning and their impact on diversity.

D. Summary and recommendations for future work in diversity

This scoping review identified 21 papers about diversity in the 2019-2020 FIE proceedings that matched the final screening criteria. Many were focused on female or racially diverse undergraduate students in engineering and computing programs. Three major themes were detected in the contributions of these papers. The first theme was discrimination and biases in engineering and computing education that reduce feelings of inclusivity and belonging negatively affect degree completion. The second theme was financial need, and how substantial this difficulty is with respect to graduation. The third theme was the equality of active learning approaches across minority groups, with some instances showing positive results and others negative.

The methodologies and focus of the papers in our review helps us identify gaps in diversity research. The trends, gaps, and recommendations are as follows:

- **Focus**: Most of the diversity research in recent FIE publications was descriptive of existing problems and difficulties, rather than looking at the impacts of potential improvements. We recommend that more research look at possible interventions and actions that can recruit and retain more minority students and improve diverse student experiences and performance.
- **Techniques for improving diversity:** There are not many techniques discussed for increasing diversity or improving performance. Some papers looked at teaching with games and with collaboration, described in the active learning section, but results were mixed. Much more of this kind of research is necessary to make any conclusions about the ability of active learning to enhance diversity. In addition, further research is needed to evaluate other instructional methods that could improve diversity or diverse student performance.
- **Methodologies**: There was very little quantitative work in the selected papers. Qualitative work is extremely important because it helps to reveal underlying problems and elements of human experience that are not perceptible in quantitative work. However, qualitative work can be subject to bias, and does not produce generalizable results. Quantitative studies can be used to test cause-and-effect relationships, such as potential benefits of interventions or inclusive practices on diversity. We recommend that more researchers engage in quantitative diversity research.
- **Population Tier**: According to our review, the diversity population tier under discourse is usually gender and race. More work is needed socioeconomic status and other types of diversity, as reported in [4].

E. Limitations of this scoping review

One limitation of this study is the number of years included in the search. With additional years, other themes may be identified. However, even if this scoping review did not provide an exhaustive list of themes, it did satisfy its purpose by identifying several areas for further work. Perhaps a larger limitation is that this scoping review did not include a quality assessment of the work. It is possible that many of the reviewed studies have limitations, yet their findings have been recorded here at face value. However, the authors believed this to be a good step forward towards the synthesis of a burgeoning body of work that is worth disseminating.

V. Conclusions & Future Work

This scoping review of current diversity research identified 21 papers from the 2019 and 2020 FIE conference proceedings. While each paper presents its own individual contribution to diversity research, this scoping review identified three major themes that help to synthesize these findings. There is currently discrimination and bias in engineering and computing, and this results in lower perceptions of inclusivity and feelings of belonging. In addition, financial need is a substantial deterrent to graduation in these fields. Lastly, some active learning studies that have attempted to capture minority students' opinions have revealed both positive and negative results, indicating that there is much more work to do to improve the experiences of a diverse student population.

The future work for this project is to broaden the scope of the review to include three more years, for a total of 5 years of research. We anticipate that more themes will emerge, and that more gaps will become clear. We would also like to recommend that researchers perform more quantitative, experimental, or mixed-methods research to measure minority learning and perceptions of inclusivity based on classroom or co-curricular interventions.

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