



# Building and Sustaining Ethnically, Racially, and Gender Diverse Software Engineering Teams: A Study at Google

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## ABSTRACT

Teams that build software are largely demographically homogeneous. Without diversity, homogeneous perspectives dominate how, why, and for whom software is designed. To understand how teams can successfully build and sustain diversity, we interviewed 11 engineers and 9 managers from some of the most gender and racially diverse teams at Google, a large software company. Qualitatively analyzing the interviews, we found shared approaches to recruiting, hiring, and promoting an inclusive environment, all of which create a positive feedback loop. Our findings produce actionable practices that every member of the team can take to increase diversity by fostering a more inclusive software engineering environment.

## CCS CONCEPTS

• **Human-centered computing** → **Computer supported cooperative work**; **Empirical studies in collaborative and social computing**; • **Software and its engineering** → **Collaboration in software development**; • **Social and professional topics** → **Employment issues**.

## KEYWORDS

software engineering, teams, diversity, inclusion

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## 1 INTRODUCTION

While the evidence for the benefits of team diversity are mixed [2], in collaborative software engineering settings, research has shown that diverse teams can have significant benefits over homogeneous teams. For instance, Pretorius and colleagues found that diverse cognitive styles helped increase novelty of features during software design [42]. Vasilescu and colleagues found that gender and tenure diversity were positive and significant predictors of productivity [52]. Likewise, Catolino and colleagues found that the presence of women on software engineering teams generally reduced the amount of ‘community smells’, i.e., “sub-optimal circumstances and patterns across the software organizational structure” [10]. Wang and Zhang found that software engineering teams with higher gender diversity tended to reduce team members’ gender biases [53].

Accordingly, many software companies have publicly committed to improving their workforce diversity by increasing representation of traditionally underrepresented groups (URGs).<sup>1</sup> For instance, Microsoft has committed to “double the number of Black and African American and Hispanic and Latinx people managers, senior individual contributors, and senior leaders in the US” [34]. Google intends to improve “leadership representation of underrepresented groups in the U.S. by 30%” [17]. Meta aims to “raise the number of underrepresented people to at least 50% of [its] global workforce” [15].

Unfortunately, there exists few studies about what practices could yield the diversity that these companies strive for, as we detail in Section 2. Instead, “[best] practices in a field are often derived through systematic and careful reflection on hard-won practical experience...[relying] on brief case studies or anecdotal stories to support the authors’ assertions” [30]. Thus, there exists a gap between diversity commitments and evidence-backed diversity practices.

To fill this gap, in this paper we seek to understand software engineering team diversity, along the dimensions of race, ethnicity, and gender. Our insight is that whatever exceptionally diverse teams have done to build and sustain their diversity can presumably be used by other team builders that wish to do the same. We took a qualitative approach to learn from engineering teams about the challenges they faced in creating and sustaining highly diverse

<sup>1</sup>While there is no perfect way to refer to a group of people without reducing their experiences to limited facets of them as beings [54], the term ‘underrepresented’ seems most apt here because representation is central to this research.

teams, and how their attitudes and behaviors help overcome these challenges. Throughout this research, we center:

- *The experience of underrepresented developers.* Representation is a challenge across the industry, but it is especially acute in technical roles like software engineering [3, 15, 17, 34].
- *Contrasting cases.* Many of our informants had experiences on teams with high diversity and on teams with low diversity, enabling them to contrast the two cases.
- *Practices from direct experience.* We examine what practitioners have used to build diverse engineering teams.

To collect rich in-depth understanding, we conducted 20 interviews with members of highly diverse software engineering teams (11 engineers from URGs and 9 managers), analyzed the data thematically [18], and validated our findings through member-checking [9]. Interviewees were engineers at Google, a large (100K+ employees) US-based software company founded in 1998.

The contribution of this paper is the first study of the practices used to build and sustain highly diverse software engineering teams. We present two main themes: first, recruiting and hiring practices, and second, building an inclusive culture by developing *technical allyship*, a newly identified concept that refines the more general concept of allyship [29, 35]. From these findings, we identified actionable implications for software engineering members across levels (from individual contributors to management) who wish to improve diversity on their teams.

## 2 RELATED WORK

A rich literature empirically explores diversity in software engineering and beyond. Our work can broadly be characterized as contributing to the area of *diversity management*, which “refers to the systematic and planned commitment by organizations to recruit, retain, reward, and promote a heterogeneous mix of employees” [26].

Yadav and Lenka’s recent literature review of diversity management finds that most research in the area focuses on *consequences* of diversity [56], that is, what benefits and drawbacks arise when diversity is present. In software engineering, researchers have demonstrated several consequences of increased diversity, including increasing innovation and productivity [49, 57], reducing turnover and conflict [52], and producing more user-friendly software [22].

Rather than focusing on consequences, the present paper focuses on *antecedents* to diversity; that is, practices that lead to diversity. For a summary of antecedents in the diversity management literature, a “comprehensive literature review, a detailed analysis of the writings of five diversity experts, and interviews with an additional 14 experts” [30] synthesizes nine diversity management practices, including linking diversity to performance and diversity training [40]. We contextualize our findings in these broad diversity management practices in Section 4 in order to explain how our findings relate to prior work beyond the software engineering literature.

Related to diversity antecedents, significant prior work in software engineering investigated challenges faced by software developers from URGs [44], including explicit bias [7], implicit bias [53], discrimination [13, 48], isolation [45, 48], impostor syndrome [11, 50],

lack of recognition [50], devaluation of feminine attributes or qualities [16, 20], and lower acceptance rate of contributions [37, 38, 47], as well as stereotypes embedded in tools [4, 23, 32, 33], documentation [19, 43], and job advertising [28]. Although not evaluated directly in this prior work, solving these problems could improve representation and increase diversity in software teams.

Finally, in perhaps the most related work to ours, Qiu and colleagues interviewed six women and nine men about five hypothetical choices to join several real open source projects, finding that participants’ joining decisions were negatively influenced by some projects’ lack of gender balance and use of gendered language [43]. Our study builds on Qiu and colleagues’s findings by focusing on lived experiences encountered by software engineers from URGs on diverse teams, as well as on the managers of those teams.

## 3 METHOD

We used a qualitative approach to examine the open research question “*what leads to diversity in software engineering teams?*” Our research stance is constructivist, meaning that our findings are inseparable from the human context in which they occur [14].

We interviewed US-based engineers and team managers from diverse teams at Google to learn about and compare their diversity-related practices, perspectives, and experiences in the workplace. We chose to interview managers because their goals and actions have been shown to influence team diversity and culture [24, 25, 36]. We chose to interview engineers because their experiences on teams may inform their choices about what teams to join or leave and, therefore, could have direct implications for team diversity. We used semi-structured interviews to allow for consistency across interviews while allowing for important, but unanticipated themes to emerge.

The proposal for this research was reviewed by the company’s employee privacy working group, which is somewhat similar to an Institutional Review Board.

### 3.1 Matching Engineers with Teams

At Google, at the time of this study, engineering teams could hire either external job candidates or existing employees from other teams:

- External candidates could apply through a role-based job posting, such as for software engineering. Once candidates passed a screening and interview process, they proceeded to a team matching process, where candidates were matched with open roles on specific teams. Hiring managers sometimes had multiple candidates to choose from simultaneously, and candidates sometimes had multiple hiring managers to choose from.
- Existing employees could also choose to transfer teams within Google, by browsing job listings on an internal site and applying to open roles on specific teams directly; internal transfers could often browse some information about the hiring managers (and team members) before they applied, such as internal company profiles or some recent code changes and docs.

### 3.2 Team Selection

We aimed to select interviewees from diverse teams who could speak to how diversity is successfully nurtured. We defined teams as groups of engineers who reported directly to a manager. To improve the odds that we selected meaningfully diverse teams, we used the following criteria to refine our list of candidate teams:

- (1) We selected teams where the number of engineers ranged from 5 to 15. The lower bound helped to exclude very small teams where a measure of diversity would be unreliable. The upper bound helped to exclude very large teams where the manager-report relationship may be tenuous or superficial; such teams are also very rare at Google.
- (2) We selected team managers who have been managing for more than four years, to ensure that managers had significant management experience spanning before, during, and after Covid-19 work from home policies.
- (3) We selected teams with diversity in terms of race/ethnicity and gender. We used these dimensions of identity because this pre-existing, self-reported data is complete for most US-based employees at the company. We only used data for US employees because the US has the most employees of any country and also because some other countries use incomparable race/ethnicity categories or do not collect race/ethnicity data at all. Using this data, we determined that a team is sufficiently diverse for interviewing when both of the following two conditions were met:
  - **Race/Ethnicity:** at least four race/ethnicities on the team, a metric sometimes referred to as richness [1]. Available categories were: White; Asian; Hispanic or Latinx; Black or African American; and Native American, Hawaiian, or Pacific Islander. Employees could choose one or more race/ethnicity categories. We used a high richness threshold here to increase the odds that the selected teams were intentionally, rather than incidentally, diverse.
  - **Gender representation:** We measured gender diversity using the Gini-Simpson index, sometimes called the Blau index, defined as the probability of sampling two team members of different genders, with replacement [1]. The maximum value of this index was 0.5, since the pre-existing demographic data we used only represented gender as a binary (Male and Female). In our sampling, we selected teams with a Gini-Simpson index greater than 0.4. We used a high diversity index threshold for the same reason we used a high race/ethnicity richness threshold.
- (4) At least one engineer from an URG had been on the team for more than two years and was promoted during this time. By a person from an URG, we mean someone who identified as a woman and/or someone who identified as a race/ethnicity other than White or Asian. We used the minimum two-year reporting threshold as a signal that the team was not only able to recruit but also retain underrepresented talent. We used the promotion criteria as a signal that underrepresented talent could grow on the selected team.

### 3.3 Interviewee Selection

After applying the list of stringent criteria above, we produced a list of highly diverse candidate teams. From this list, we aimed to interview team members from two different perspectives: managers and software engineers.

**Managers:** looking at the list of candidate teams, we prioritized managers who had longer tenure at the company, as they would be more likely to have previously managed other teams and therefore be able to contrast their experiences.

**Software engineers:** we used the following criteria for prioritizing engineer interviewees from candidate teams:

- Identify as belonging to one or more URGs.
- Work on a different team from other engineer interviewees; for transferrability, we chose to favor breadth across teams over focusing on individual teams.
- Work on the team for longer periods of time and had longer tenure at the company (for the same reason stated for managers).
- To increase credibility, we aimed to create a sample of engineers that is diverse in its representation of race/ethnicity and gender.

Using these criteria, we selected eight software engineers from URGs as invitees to be interviewed.

However, we noted two main shortcomings in the process described above. First, because our demographic data source represented gender as binary, we would miss the perspective of non-binary engineers as well. To correct this, we used an internal company list, visible to all employees, of people whose gender expression is non-conforming or transgender. People on this list self-select to make themselves available to answer questions about their experiences. We systematically searched the list to find software engineers who work on teams that met as many of the criteria we defined for diverse teams. We identified two additional engineers to interview this way.

Second, our sample was also missing an engineer who identified as Native American, Hawaiian, or Pacific Islander. Therefore, to ensure we learn from engineers who share this perspective as well, we used the same internal company demographic data. However, we had to relax the previously used team selection criteria to find them since their representation amongst employees is substantially lower than for other groups [17]. We sampled one such engineer who met partial criteria.

We conducted pilot interviews with two engineers from URGs and three managers whose teams shared some of our selection criteria. One pilot participant described particularly rich experiences with what worked and did not work in improving diversity on the teams she was on, so we included her data in our analysis after receiving her consent to participate in the study.

After piloting, we sent email invitations to 22 potential participants (11 engineers from URGs and 11 managers) with the subject line: “Research about building diverse and inclusive teams”. All were interested in participating with a response rate of 100%. Due to scheduling conflicts, we scheduled nine interviews with managers, and ten interviews with engineers.

When reporting our findings, we use pseudonymized participant identifiers to help improve traceability, using the prefix ‘M’ to

denote a participating manager (e.g. M12) and the prefix 'E' to denote a participating engineer (e.g. E2). In practice, a few of the software engineer participants were managers as well.

While we do not provide individual participants' demographics to protect their privacy, we summarize their demographics as follows:

- **Engineer** interviewees represented a variety of race/ethnicity and genders. Four engineers identified as White+ (the '+' indicates that employees can identify as multiple races/ethnicities), one as Asian+, two as Hispanic or Latinx+, three as Black or African American+, and one as Native American, Hawaiian, or Pacific Islander+. Three engineers identified as men, seven as women, and one as non-binary. Two identified as transgender. Five engineers identified as belonging to two or more URGs.
- **Managers** were largely men and White or Asian, except two women and one manager who identified as Black or African American.

All interviewees were working in the US.

### 3.4 Interviews

The first author completed all semi-structured interviews via teleconference. Each interview took approximately 60 minutes to complete, except one 30 minute interview.

The interview questions were refined over multiple cycles. First, we generated a list of questions about hiring and recruiting practices from the perspective of how diversity can be improved. Then, the researchers' colleagues suggested changes and additional questions. In the next round of iterations, the first author added questions that relate to practices of "great" engineering managers [27], as we anticipated there may be overlaps between those and inclusive practices. The first author conducted five pilot interviews with managers and engineers to evaluate the list of questions, structure, and time frame of the interview guides. Finally, based on the pilot interviewees' reflections and suggestions, we finalized the interview guides.

The semi-structured interview protocol included an introduction to the project, asking for permission to record the interview, and describing how interviewees' identities will be protected. We purposefully asked interviewees open-ended questions, rather than asking about specific practices described in the diversity and inclusion (D&I) literature (such as diversity training [40]), to avoid priming participants with socially desirable answers. We developed two interview guides, one for Managers and one for Engineers, available in full in the appendix.

**Manager interview guide:** We asked about their current team and teams they managed or were part of in the past. The questions started with high-level reflections on diversity on their teams and their goals/principles to build a diverse team. Then we asked about specific actions they take when recruiting and hiring engineers (e.g., *What's the most effective thing you've done to increase diversity on the team(s) you've led?*). Finally, we asked general questions about communication with reports and the team's culture (e.g., *What do you do to make your team members feel that you trust and support their decisions?*)

**Engineer interview guide:** We asked about interviewees' current and previous teams with regards to their experiences and

diversity (e.g., *If you've been in less diverse teams in the past, than the team you're on now – can you reflect on the differences between more diverse teams and less diverse teams?*). We asked them about their reasons for joining or leaving a team and what makes them feel like they belong to a team (e.g. *Which relationship in your team makes you feel most comfortable or well supported? What do they do to support you?*).

### 3.5 Data Analysis

Following established practices [18], we thematically analyzed the data from 20 semi-structured interviews. The first author transcribed the recordings with an automated tool and manually treated transcriptions to remove details that could reveal interviewees' identities. The first author performed inductive open coding through several rounds to develop the codebook, i.e. a compilation of a number of codes [18]. As more data was collected, codes were refined and sometimes merged. Five researchers met multiple times to discuss the codes as the codebook was being developed. The first author continued to iterate and rearrange the codes leading to the core insights. The researchers met to discuss these insights to identify the main themes. After multiple rounds, no further codes emerged and our understanding of them stabilized, and both code and meaning saturation [21] was reached.

To establish resonance in our findings, we shared the intermediate, summarized results with interviewees to perform member-checking [9]. We created private copies for interviewees to comment, reword or suggest edits if they thought something was misinterpreted in their own responses. We also asked them to add "+1" in a comment if they found things from others' responses that resonated with them, and welcomed them to add comments if they wanted to share any similar experiences. Seven out of the 11 engineers and four of the nine managers responded. After gathering their feedback, we added the interviewees' identifiers who noted resonance on findings to the relevant paragraphs; we reworded three quotes to match interviewees' comments; added two examples (vignettes), and corrected minor mistakes in interviewees' quotes (e.g., typos due to transcription errors).

### 3.6 Self-Disclosure

Finally, congruent with Bardzell and Bardzell's feminist HCI methodology [6], our position (the authors) in the world should be disclosed. Specifically, at the time of the study, all authors were employees of the same company from which research participants were sampled. Although we believe we had sufficient autonomy to perform this research in a relatively unbiased way, our ability to perform and publish this research is necessarily dependent on our ability to maintain good relations with the company's employees and leadership. Thus, our research findings are likely shaped by our employment context, even if implicitly and unintentionally.

## 4 FINDINGS

Through semi-structured interviews, we heard from managers about effective practices to grow and sustain diversity on their teams. Engineers also shared their perspectives on diversity on engineering teams and surfaced the challenges they experience, as



well as what others—engineers and managers—do to create a more inclusive environment for them.

Tables 1 and 2 summarize our findings, including each practice, a supporting example, and links to prior work. In particular, for a high-level perspective, we link our practices to general diversity management practices [40], distilled from “a comprehensive literature review, a detailed analysis of the writings of five diversity experts, and interviews with an additional 14 experts” [30]. For a lower-level perspective, we link our practices to Kalliamvakou and colleagues’s findings about what makes a great software engineering manager, drawn from 37 interviews and 123 surveys with Microsoft engineers and engineering managers [27].

We organize the findings into two subsections that mirror the two tables. In Section 4.1 and Table 1, we describe recruiting and hiring practices. Then in Section 4.2 and Table 2, under an overarching theme of *developing technical allyship*, we describe inclusive practices that impact the experiences of engineers from URGs, which can contribute to these engineers choosing to join or stay on a team. In each subsection and table, we enumerate the practices, illustrated with example vignettes from the interviews. Each vignette is linked to a code in our codebook. For example, the first row of Table 1 summarizes the practice of “Self-Empowering Hiring Managers”, and illustrates the practice with a vignette about M20, which is linked to a code called “Manager’s Impact”.

## 4.1 Recruiting and Hiring

In this section, we describe how individual managers improved team diversity by empowering themselves as agents of change, growing the pool of candidates while pruning back their own assumptions, showing their commitment to diversity, and establishing guidelines and accountability.

**4.1.1 Self-Empowering Hiring Managers.** While it may be easy to blame diversity issues on the leaky pipeline [12, 51, 55] there are concrete ways managers acted to grow diversity on their teams. One engineer who also has experience in hiring explained that it starts with developing a mindset of “I can do this. The odds may be stacked against me, but I can do this” (E11). Managers grew aware of the lack of diversity on engineering teams and self examined their own practices and their teams’ demographic makeup. Recognizing there is a gap was their first step. Then, changing their perspective—realizing that they themselves could take actions to influence the representation on their teams—allowed them to successfully cultivate diversity on their teams (M15, M19, M20).

**4.1.2 Growing the Pool and Pruning Back Assumptions.** Managers (E11, M12, M13, M15, M16, M19, M20) mentioned they proactively learned about and followed practices for improving diversity, including growing the pool of available job candidates and checking their own assumptions about the qualifications for success for an engineer on their team.

Managers mentioned how they work with engineers from URGs on their team by asking them to reach out to their external networks (M15) or how they advertise to mailing lists “to get the word out” (M17). Other managers mentioned long term strategies like connecting with external candidates via involvement with mentorship programs (M13, M19). More narrowly, prior work notes that

formal relationships with a wide range of educational institutions helps broaden the recruitment pipeline [40].

Many of the managers (E11, M13, M15, M17, M19, M20) took the time needed during the hiring process to help the recruiting message reach candidates from a wider range of backgrounds (e.g. “post the role for a certain amount of time, and take the time to gather those candidates” (M17)) and provided ample time for them to apply. While it took more time to find “the best fit” instead of settling for “first fit”, managers found the additional effort worthwhile. During this process, managers also checked on their own assumptions, such as about what skills are truly necessary to succeed in an open role (M19).

**4.1.3 Ongoing Commitment to Diverse Candidates.** Interviewees explained that hiring managers can demonstrate an ongoing commitment that goes beyond lip service (E4, E5, E7, E11, M13, M15, M19, M20). One way is by investing in existing resources like early career training programs where engineers from URGs or non-traditional backgrounds participate in rotations on different teams. Managers who host engineer-trainees on their teams could help with their training and then hire those engineers when they graduate from these programs (M15). Another way is by actively learning about experiences of engineers from URGs, for example through events and conversations with ally groups. Managers can mention to candidates how they take concrete action to foster inclusive environments for the engineers on their teams. If their team is not yet very diverse, managers can at least acknowledge how they are trying to improve it. Here are vignettes of this practice from the interviews:

E1 checked managers’ publicly-viewable calendars to see if they had allyship or diversity and inclusion (D&I)-related events scheduled. She explained this gives her a signal about how “open-minded” and “aware” the manager is.

E5 said her manager made it “really easy to see how [she] could succeed [on the team]” when he brought up another engineer from an URG in their conversation and explained how he was supporting her career growth on his team. When there are no engineers from URGs, E5 suggested managers should acknowledge the problem and demonstrate they are “actively trying to fix” diversity on their teams.

Over time, hiring managers successfully fostered a diverse team makeup and an inclusive culture (E11, M13, M14, M15, M17, M19, M20). Then, prospective engineers from URGs took notice and became interested in joining those teams – more diversity was seen as a positive signal. This created a virtuous circle.

E7 looks at signals for a potentially inclusive environment. They said: “I definitely do look at diversity and [...] if there are more women on the team, or if the manager is not a white man I consider it a positive signal.”

Interviewees appreciated it when their organization had diversity goals but wished that it would not end at merely setting intentions (E4, M17). Prioritizing D&I is the first step, but managers should

**Table 1: A summary of Recruiting and Hiring practices, example supporting evidence, and related practices from the great managers [27] and diversity management [40] literature.**

Practices	Example Evidence as Vignettes	Related Practices from [27] and [40]
<b>Self-Empowering Hiring Managers</b> (Section 4.1.1). Recognize there is a gap; Realize managers can take action to influence the representation on their teams.	M20 used to think that individual managers did not have much power to impact diversity, but once he changed his perspective and became proactive, he successfully grew representation on his team over five years. He recommends that managers start by reflecting on what incentives and biases led them to create homogeneous teams in the first place, followed by creating a plan to improve diversity.	<i>Employee involvement</i> —"employee's contributions in driving diversity throughout an organization" [40].
<b>Growing the Pool and Pruning Back Assumptions</b> (Section 4.1.2). Work with teammates from URGs to reach out to their external networks; Connect with external candidates via mentorship programs; Ensure the recruiting message reaches candidates from a range of backgrounds.	M19 had an open role to fill, so he asked himself, "What are the real requirements?" He then included only core skills needed in the job posting. When interviewing 20-30 people, he tried "to be very picky" when making a selection. Rather than trying to fill the role as quickly as possible, he took the time to intentionally check his own assumptions to understand what his mental image of an engineer is. He reflected that "the person that [he] might think is the best may not [match the] mental image [he has] of that person."	<i>Recognizes individuality</i> —"to understand each engineer's strengths and weaknesses, value diverse perspectives in the team, and fine tune the definition of success to each individual's talent and interests." [27]; <i>Recruitment</i> —"the process of attracting a supply of qualified, diverse applicants for employment." [40]
<b>Ongoing Commitment to Diverse Candidates</b> (Section 4.1.3). Invest in resources like early career training programs; Actively learn about experiences of engineers from URGs; Mention to candidates how you foster an inclusive team environment for engineers.	M15 deliberately created a diverse and inclusive team. Reflecting on his process he said: "[once] we had two women and one man...folks on the team also encouraged me to make sure that we were hiring from a diverse pool...Once we got to the team size of maybe five, [engineers from URGs] started coming to me saying, 'Hey, I'd like to work on your team.'"	<i>Grows Talent</i> —"to provide opportunities for challenging work, suggest training for the engineer to gain industry relevant skills, and provide actionable feedback to improve engineer performance" [27].
<b>Establish Guidelines and Accountability</b> (Section 4.1.4). Leadership institutes top-down accountability measures for the hiring process, emphasizing the importance of diversity.	In E11's organization, leadership made it mandatory for every hiring manager to go through a specific process when hiring for every level. Hiring across the team was managed tightly, which resulted in inclusive hiring practices and increased representation. However, E11 reflected: "a combination of top-down guidance and bottoms-up 'get it done' are required to have a positive impact on increasing a team's representation."	<i>Top leadership commitment</i> —"a vision of diversity demonstrated and communicated throughout an organization by top-level management"; <i>Diversity as part of an organization's strategic plan</i> —"a diversity strategy and plan that are developed and aligned with the organization's strategic plan" [40]; <i>Accountability</i> —"the means to ensure that leaders are responsible for diversity by linking their performance assessment and compensation to the progress of diversity initiatives." [40]

"also be accountable for it" not just at the "surface level" like simply requiring diversity training, said E4.

**4.1.4 Establishing Guidelines and Accountability.** Having described recruitment and hiring practices that worked well for interviewees, in this section we describe how making such practices known and established in an organization had a positive impact. Participants reported that managers in leadership positions – *leadership* refers to the employees who decide on the values, strategy and direction that guides the company – instituted ways to keep hiring managers accountable to follow these practices, contributing to a lasting effect on the diversity in their teams (E11, M13, M19, M20).

Interviewees discussed the role of managers at leadership positions (Director level and up) in growing diversity on engineering teams, congruent with prior work's findings about the importance of "top leadership commitment" [40]. Our participant sample implied a connection between diversity and leadership too: while our sampling strategy could have yielded random teams around the company, we instead found two groups of participants clustered under two Vice Presidents (VPs). In one group, managers mentioned that their leadership emphasizes the importance of diversity by instituting top-down accountability measures for the hiring process. As managers, they are required to consider multiple candidates, and they need to justify their hiring decision to the Vice President. Instituting this process makes hiring managers seriously consider more candidates, which means there is a greater chance

candidates from URGs will be considered in the process too. Also, if there are conscious or unconscious biases that affect the hiring manager's selection process, they will become more apparent and can be mitigated. Although the majority of hires still come from overrepresented groups, the accountability and due diligence in the hiring process helps make sure that engineers from URGs were also hired.

On M20's team, for "every single hire or transfer [...] the hiring manager has to present [pros and cons for each candidate] to the VP." Hiring managers need to present a standard number (e.g. at least five) of candidates that they considered for every level they hire.

The leadership requiring managers to justify their selection in writing ensures that this practice is implemented all the way through. Top-down accountability measures are necessary, but interviewees explained they need to be combined with bottom-up intentions and efforts from managers during the hiring process (E11, M16, M17, M19, M20). Interviewees also reflected that not all managers recognize the need to grow diversity on their teams and therefore D&I training needs to focus on those who need convincing (E4, E5, E8, E11, M12, M16).

M19 said: "Our VP [...] has goals for increasing diversity [...]. I try, but you know there's obviously rules about how you can

hire or not hire. So I focus on getting the people, casting a wide net and looking to find people that have the best fit for the roles and make sure that we're not excluding people that we don't need to be excluding."

While inclusive hiring processes like those instituted by M19's leadership can be impactful, interviewees reflected that leadership should also provide assurance for hiring managers that they can follow the process without risking losing open roles on their teams (E3, M13, M17). Managers reflected on the challenges they faced when they tried to follow encouraged processes such as taking more time in hiring. As hiring managers, they often face pressure from their managers to fill the open roles quickly. One suggestion was that leadership could provide security, ensuring that hiring managers have time to follow the preferred processes once a role opens up:

M17 said "there's huge, huge tension between the really equitable hiring process and the hiring structure." As a manager, she is pressed by business needs and if she doesn't fill the role quickly, she risks "losing the headcount" on her team. M17 suggested leadership can develop a process to reassure hiring managers they have time to follow the proper process, even at times of hiring slowdowns. She said that providing a guarantee to hiring managers that once a role is open, they are allocated predetermined time to fill it without the risk of the role being retracted, will make managers confident they can follow the slower, more equitable, and more inclusive hiring process.

## 4.2 Developing Technical Allyship

In addition to the recruiting and hiring practices mentioned in the prior section, *technical allyship* emerged as an overarching theme. Based on the interviews, we define technical allyship as a practice with three properties: (1) it is performed by a team member of an engineer from an URG; (2) it is grounded in actions that improve equity by addressing potential sources of inequity, beyond simply expressing support; and (3) it bolsters confidence in the technical skills possessed by engineers from URGs, or advocates for them when their technical expertise is being undervalued due to their racial, ethnic, or gender identity. Technical allyship is a more specific form of the existing concept of allyship, the practice of helping someone from a marginalized group by identifying and amplifying the concerns that person faces, when the person helping does not identify as a member of that group [29, 35].

We next unpack the actions of technical allies organized in three levels. First, in Section 4.2.1, we describe how managers act as technical allies to combat biases and create a more inclusive space on their team. Second, in Section 4.2.2, we describe what managers in leadership positions do from the top down. Finally, in Section 4.2.3, we describe how individual coworkers (e.g. engineers on teams) acted to inspire technical confidence in engineers from URGs.

**4.2.1 Managers.** With attention to biases, creation of growth opportunities, and active attempts to build confidence and trust, managers can act as technical allies to support their engineers from URGs.

**Evaluating performance after diligently gathering information:** there are many moments where managers' actions can have a long lasting influence on engineers' technical career development. Managers on diverse teams acted as technical allies by actively seeking growth opportunities for their engineers from URGs (E5, E11, M15, M17, M19, M20). Managers were mindful of conscious and/or unconscious biases which may sometimes lead them or others on the team to unintentionally overlook engineers' technical skills (E11, M14, M15, M19, M20). They recognized that a lack of this awareness could run the risk of making their engineers feel "pigeonholed" (M17) or stereotyped into less technical roles, which could then hinder, derail, or discourage further development of the engineers' technical career, as several engineers described:

E10 felt that a team lead overlooked her software engineering skills when he asked her to delay her departure from the team for the sake of keeping up team morale, later admitting that he did not have further technical work for her to complete.

As a woman engineer, E3 noticed she may have been undervalued and underestimated because when she finally got promoted, others on her team were surprised that she was not already a couple levels higher.

E6 felt she gets "typecasted a bit as a female front-end engineer." She said it is frustrating since front-end work is not seen as difficult and is often more associated with women. In another case, E6's previous manager gave her an unsolicited suggestion to switch to a "less technical ladder" despite fully knowing E6 was actively working on an advanced degree in computer science. E6 was particularly upset by this because her manager at the time appeared to be dismissing her technical skills even as she demonstrated her commitment to being an engineer by pursuing a more advanced degree in the field.

**Creating "stretch opportunities" and recognizing that skill development requires trial-and-error:** once managers have diversity on their team, they should "give equal opportunities to those people from URGs to grow and thrive, and make sure that they're not just getting lost" (E5). Impostor syndrome is one of the challenges that could interfere with engineers' confidence to contribute to their team (E5, E6, E8, E9, M14). For example, engineers from URGs hesitated to ask questions when starting on their team; as E8 said, she was "very afraid of saying anything wrong or coming across like [she] didn't know what she was doing." M14 noticed that impostor syndrome could even influence how others on the team treated underrepresented engineers, such as "not trusting them with interesting work and [not] treating them as an equal peer."

To combat this, managers proactively try to find development opportunities for their engineers (E2, E4, E5, E8, M15, M17, M19, M20), called "providing opportunities for challenging work" in Kalliamvakou et al. [27]. When member-checking, E8 wanted to

**Table 2: A summary of Developing Technical Allyship practices, example supporting evidence, and related practices from the great managers [27] and diversity management [40] literature.**

Practices	Example Evidence as Vignettes	Related Practices from [27] and [40]
<b>Manager practices</b> (Section 4.2.1). Evaluate performance after diligent information gathering; Create “stretch opportunities” and recognize that skill development requires trial-and-error; Encourage a culture of mutual respect.	M15 said, “You’ve got to take a chance and give the folks who are from these traditionally underrepresented backgrounds a chance to fail on projects. You might find skills there that you didn’t appreciate or see.” He gave an example of a junior engineer who got an opportunity to demonstrate that she was “exceptionally good” at leading engineers who were much more senior than her. He suggests managers avoid “protecting” people from URGs by keeping growth opportunities away from them.	<i>Enables autonomy</i> —“to provide freedom on how engineers work, show trust and support for their decisions, and help engineers be independently responsible [27]; <i>Supports Experimentation</i> —“to encourage the engineer to try out new things, and signal a safe environment for unsuccessful attempts” [27]; <i>Grows talent</i> (see Table 1) [27]; <i>Build a relationship with team members</i> —“to take an interest in the employees’ life outside work, and care about them as a person.” [27]
<b>Leader practices</b> (Section 4.2.2). Recognize the lack of diversity in engineering management roles and need to proactively increase it.	M20, an engineering director from an overrepresented group, reflected that “everyone needs to see their own representation and at all different levels of management.” He believes that more representation in management would demonstrate to junior engineers that they have a career path in engineering. M20 said that managers should be very deliberate about making a change and be aware that statistically, when they recruit and hire for higher management positions, the candidate pool will skew to the overrepresented groups in engineering (White/Asian and men). Finally, M20 reflected that more representation at the leadership level will also have a trickle down effect on diversity in the organizations—he “found that it’s a faster path to [grow diversity on engineering teams by] just creat[ing] a leadership team that has strong representation.”	<i>Top leadership commitment</i> —“a vision of diversity demonstrated and communicated throughout an organization by top-level management” [40]; <i>Diversity as part of an organization’s strategic plan</i> —“a diversity strategy and plan that are developed and aligned with the organization’s strategic plan” [40]; <i>Succession planning</i> —“an ongoing, strategic process for identifying a diverse talent pool and developing them into an organization’s potential future leaders.” [40]
<b>Coworker practices</b> (Section 4.2.3). Explicitly recognize others’ technical contributions and be generally open and supportive; Cultivate a sense of team ease and security to mitigate the effects of impostor syndrome; Care about mentorship; Be aware of biases that can negatively impact engineers’ career development; Express empathy with technical challenges.	E8 commented, “Respectful and constructive code reviews make me feel supported and more confident. Particularly, when a teammate asks questions and opens up the floor for a productive discussion about design decisions rather than assuming their point of view must be correct and demanding things be changed a certain way.” E8 added: “when my [coworkers] would explicitly thank me for my work and emphasize [when presenting to others] that they thought it was important and well-done [...] it made me feel way more confident about speaking up and putting myself out there.”	<i>Employee involvement</i> —“employee’s contributions in driving diversity throughout an organization” [40]; <i>Diversity training</i> —“organizational efforts to inform and educate management and staff about diversity’s benefits to the organization.” [40]

“emphasize that it’s not that the manager needs to push the engineer to make up for lacking skills, but rather that the manager trusts the engineer to complete difficult work well and learn new skills quickly.” Managers worked with their engineers to make plans for their career growth and encouraged underrepresented engineers by creating “stretch opportunities” (M15) so the engineers could grow confidence in their abilities:

When E5 chose to join her current manager’s team, she did this because “It felt like a place where I could succeed and the manager would push me and raise me up.” E5 said she wanted to be challenged in the right way and valued choosing a manager who had a plan for her career growth.

When member-checking, E8 commented: “By assigning the engineer a stretch project, the manager shows they have confidence in the engineer’s potential and gives them an opportunity to demonstrate that, instead of assuming they would prefer less challenging work. My manager assigned me L4-scoped<sup>2</sup> projects right away when I joined the team as an L3, which allowed me to grow a lot faster and demonstrate my technical skills to everyone on the team, and I think this helped me avoid being typecast or assumed to be less technical than anyone else.”

**Encouraging a culture of mutual respect:** healthy team culture can encourage participation from everyone (E1, E4, E6, E7, E8, E10, M15, M18, M19). Managers emphasized building teams where engineers value learning from each other rather than competing, and when feedback is given, it is constructive and respectful.

M15 gave an example of a non-diverse sibling team where “conflict was definitely a part of their culture, people would yell at each other.” This was not productive, and “women engineers in particular just [...] couldn’t see themselves participating in that kind of decision-making.” He believes that the few engineers from URGs on that team left due to this culture. When building his team, he developed the team’s culture in reaction to these really competitive aspects of “the default engineering culture [in tech].” On his team, engineers want to spend time teaching and helping each other grow. He describes it as having “a really good teacher culture of both teaching and learning things going in both directions.”

M19 said it is important to have good mentors on the team who can also mentor engineers from underrepresented backgrounds. When hiring engineers, he evaluates if they would “invest in other people and not just think about their own

<sup>2</sup>L4 refers to a technical level in the company’s career ladder. L4 is a more advanced level than L3. Work at higher levels requires more skills and responsibilities.



personal growth,” checking their code review communication styles and asking himself: “Are they polite? Do they typically give constructive feedback [...]?” This helped him identify and hire good mentors in the past.

While not strictly limited to technical discussions, managers can also learn from the experiences of the underrepresented engineers on their teams by seeking feedback from them (E9, M19). This could also help make the engineers feel valued and build their self-confidence.

E9 suggested that managers should ask their reports for feedback in one-on-one conversations. He said this could help build trust, especially when done informally and not on official records, and this practice would emphasize to their reports that their voices matter. It could “really [be] empowering and also make [managers] build a lot of trust with [engineers from URGs].”

Another way managers can inspire confidence in engineers from URGs is by opening up channels of discussion across technical levels to build trust. For example, M19 mentioned that his manager makes herself available and approachable across levels to help engineers from URGs feel welcomed. M19’s reports meet with M19’s manager regularly and directly reach out to her. M19 was content about his reports having another channel of communication with their management. He said “there’s lots of channels for [my reports to ask] questions, and sometimes they tell [my manager] things they won’t tell [me].”

**4.2.2 Leaders.** Managers at higher levels of leadership are in a good position to affect the representation of URGs in those management roles. The lack of diversity on teams and higher management levels bothered engineers from URGs (E1, E3, E4, E5, E6, E7, E8, M17). Engineers from URGs wanted and asked to see more representation in leadership levels (E3, E4, E5, E6, E7, M17).

Technical allies recognized the lack of diversity and explained that more representation of engineers from URGs in management roles will help grow engineers’ confidence in their future career paths. Since fewer engineers from URGs are in the hiring pipeline, leaders need to proactively increase representation in management roles (E11, M15, M17, M19, M20).

**4.2.3 Coworkers.** Coworkers can have a large impact as technical allies by explicitly recognizing others’ technical contributions and being generally open and supportive. Engineers described how their coworkers encouraged their contribution to the team with explicit recognition and constructive feedback (E1, E3, E5, E6, E8). These positive actions were particularly important given potential negative past experiences, as described by a few engineers:

As a member of an URG in college, E6 needed to “blend in as one of the guys in order to survive” and she “still has some of those experiences as baggage”. While E6’s engineering experience is better on her current team than it was when she was in college, her “baggage” is that in college her ideas were automatically disregarded.

E6 previously worked with a more senior tech lead on her team who was from a majority background. When E6 took a leap of confidence and suggested an idea on his code change, he explicitly accepted and praised the idea as a really good one. This built her confidence in contributing to others at higher technical levels. She mentioned that beyond this specific exchange, this tech lead was also involved with D&I efforts.

People from URGs may experience elevated impostor syndrome also due to the lack of representation in the field [8]. By cultivating a sense of ease and security on their team, coworkers mitigated the potential harmful effects of impostor syndrome (E5, E6, E7, E8).

When first starting on the team, E5’s assigned “tech mentor” was vital to her success. He validated her technical confidence by explicitly praising her work or affirming her questions. She felt comfortable asking him the questions she might have worried would sound stupid to others.

Managers also recognized that coworkers who care about mentorship can cultivate a culture of teaching and learning on the team, thus positively encouraging engineers from URGs to participate in the work (M15, M19). In contrast, when engineers feel less confident on a team, they may prefer to work with near-peers. Since in the current state of the field, there are fewer like-peers to engineers from URGs, this preference could steer them away from potential collaborations with their coworkers. However, once engineers from URGs established their technical confidence, they felt more at ease working with engineers from all backgrounds.

E6 reflected on how when she first started to work on engineering teams, she preferred working with women. However, since she now has an official tech lead role and her technical contributions continue to be rewarded, she has less impostor syndrome and feels “more comfortable working with other people” too.

Coworkers practicing technical allyship were aware there are biases which, if unattended, could negatively impact engineers’ long term career development, like promotion opportunities. Therefore, they were attentive and advocated for URGs in the background too, as noted by one of the managers:

M19 noticed an engineer from an underrepresented group was really talented. He recalled: “I was doing a [code] review for her [...] I left a note in the [performance review that she should be promoted]. Then I was always advocating for her growth and support in the backchannels.”

Finally, coworkers who simply commented and expressed empathy in response to technical challenges were also helping engineers from URGs feel more at ease and help develop their technical confidence. As E1 described: “it’s nice to see when I’m like... ‘I don’t know what I’m doing’ they’re like: ‘same’, so it’s nice to see people that are different than you also have the same [technical] struggles as you”. E8 explained: “It’s nice when people admit and laugh

about their own mistakes, and even talk about their own imposter syndrome, so I feel like I fit in more!"

## 5 DISCUSSION

We posit in this paper that the practices used by highly diverse teams can be transferred to other teams to help them increase their diversity. One might argue, however, that diversity is a zero-sum game because the pool of engineers from URGs is fixed; that is, if one team can increase their diversity by applying these practices to attract an engineer from an URG, that engineer's prior team by definition becomes less diverse. We view this argument as a cop out, enabling teams to avoid responsibility for providing an inclusive environment and instead shifting blame for low diversity to further upstream in the recruiting pipeline. The engineering talent pool may indeed be of fixed size at any given instant, but over the long term, the pool is both absorbent and leaky, and those with the power to influence cultural and structural changes at each phase of the pipeline – parents, educators, governments, and organizational leaders – bear responsibility for implementing that change. In this paper, we have collected diversity practices at the professional software engineering team stage.

While we believe that the practices used by the teams described in this paper can be applied in other engineering teams, we expect that doing so is not easy. One reason is that the practices entail trade offs; for instance, enabling managers to retain open positions for a long period of time reduces organizations' ability to reallocate resources in an agile way, in response to changing market conditions. Another challenge to applying these practices is that it was clear from our interviews that these managers were committed and felt personal responsibility towards increasing diversity; we expect that managers who do not feel such a duty, are not fully bought-in to organizational diversity priorities, or are using these practices in a perfunctory manner will see less success in increasing diversity.

We were initially somewhat surprised that team member retention did not emerge as a frequently mentioned theme in the interviews. Our surprise probably stems from a conceptualization of retention issues as being solved primarily when a manager convinces an employee, who has a competing offer in hand, to stay on the manager's team. As an experienced engineering manager, Lopp [31] refers to this situation as *The Diving Save*, noting that in his experience it is "usually a sign of poor leadership". In retrospect, we were naive to equate retention with *The Diving Save*. When we examine the few cases where interviewees discussed retention, it seems that people left teams due to cultural issues, rather than some specific catalyzing event before a team member left. For instance, M15 reflected on a sibling team who had a hard time retaining engineers from URGs due to the teams' aggressive culture.

Throughout Section 4, we showed how the practices we uncovered resemble those of 'great software engineering managers' [27] and those recommended by the broader diversity management literature [40], adding to previous findings' reliability. However, some practices in this prior literature were not mentioned by our participants, such as great managers "facilitating external communication" [27]. Likewise, our participants mentioned practices that did not emerge in this prior work. For example, managers combating bias by evaluating performance only after diligently gathering

information, and encourage culture of mutual respect to grow a team where engineers learn from each other, rather than compete (Section 4.2.1). In addition, our findings highlight the important role coworkers can play in reifying an inclusive culture. Coworkers have the ability to uplift engineers from URGs through acts of technical allyship. These include showing awareness and empathy by explicitly recognizing others' technical contributions, being generally open and supportive (e.g., providing constructive feedback), practicing respectful code review, and being attentive and advocating when necessary to help combat biases (Section 4.2.3).

## 6 IMPLICATIONS

Here, we summarize implications based on our findings for engineering team members as a call to action to help team leaders recruit and retain engineers from URGs. Even though leadership can institute practices towards this goal, managers and engineers have the power to affect change too. Every person can play a role in creating inclusive engineering teams.

### 6.1 Engineers

- Act as a technical ally: help build others' confidence in their skills. Whenever possible, assure others that their technical contributions are valued and advocate on their behalf when necessary.
- Be attentive to disparities in workload and wary of typecasting people into roles. Proactively ensure that non-technical work, like organizing and note-taking, is being distributed fairly amongst your colleagues.
- Make efforts towards changing the status quo by being vocal about asking for more representation of engineers from URGs. Further, you can ask your managers for more transparency in their hiring and promotion decisions.

### 6.2 Managers

- Individually investigate and evaluate the diversity and inclusion practices on your team: be honest with yourself about your decision making processes.
- Develop your awareness and empathy by self educating (e.g., through joining allyship groups and events), to develop your understanding of the broad range of life experiences.
- Empower your reports by seeking informal feedback from them. Listen and actively try to improve your practices towards a more inclusive working environment.
- Follow inclusive hiring processes, such as taking more time to grow their candidate pool and examine your biases when considering candidates.
- Evaluate your reports' performance not just by following your intuition or first impressions. Diligently gather information and question your decisions at every step of the process.
- When talking to potential candidates from URGs, make it clear you are committed to helping them grow their careers (e.g. by mentioning how you support engineers on your team).
- Make sure stretch opportunities are given to all the engineers in your team. Be careful to not "protect" engineers who are

from URGs, accidentally keeping them from challenges that would actually help them develop their skills. Recognize that skill development requires trial-and-error, and create an environment where engineers feel secure to explore new challenges.

### 6.3 Leaders

- Engineers from URGs mentioned they are looking for diversity in their managers (at different levels). Therefore, you should aim to grow diversity at the leadership level of management.
- Establish required practices that managers should follow in the recruiting, hiring, and promotion processes. For example, require your managers to interview at least five potential candidates before choosing who to hire.
- Institute accountability measures. For example, ask hiring managers to share their decision making process with the top leader of the team (e.g. VP) to ensure that an appropriately diverse pool of candidates was considered, and check that the final choice was not based on conscious or unconscious biases.
- Acknowledge and reward managers who grow diversity and their teams' inclusive culture.
- Give managers security to do due diligence when recruiting and hiring by committing to the promised resources. For example, clearly provide a timeframe in which an open role can be filled without being retracted.

## 7 LIMITATIONS

The reader should consider several limitations of the findings described in this paper. In terms of transferrability, we studied software engineering teams at one specific, large, US-based tech company, and results are more likely transfer to similar contexts than dissimilar contexts. For instance, our findings may not transfer well to small companies without a mature recruiting program or to open source projects where project members are part-time, unpaid volunteers. Transferrability is also limited in that we assumed that the teams we studied were diverse because of the *actions* taken by people, but it could be that these teams were diverse due to contextual factors, such as that the type of software being built was highly appealing to engineers from URGs. Another limitation is that participants may have told the interviewer what they thought the interviewer wanted to hear due to social desirability bias [39]. We also assumed that what people told us made their teams successfully diverse actually did so; rather, it may be that teams who are not diverse are also using the same inclusion practices, yet are still failing to build diverse teams. To address the limitation, follow-up research should correlate the usage of practices described in this paper (e.g. hiring manager self-empowerment and assigning stretch opportunities) with the amount of diversity on a variety of teams.

In terms of credibility, we studied limited facets of team diversity (race, ethnicity, and gender) and only broad, US-centric demographic categories (e.g. Asian or Black or African American). Diversity defined in terms of other demographic categorizations (e.g. race and ethnicity in Latin America [46]) and other facets (e.g.

socioeconomics [41] or disability [5]) may require different strategies than those described here. Likewise, credibility is limited by survivorship bias in that we did not interview former engineers who left the company or industry, possibly for reasons that cannot be combated even by an engineering team that practices all of the inclusion strategies described in this paper.

## 8 CONCLUSION

We studied what leads to diversity in the dimensions of race/ethnicity and gender on engineering teams by identifying highly diverse teams at Google. We conducted 20 interviews with managers and engineers from URGs on these teams to learn from their experiences of what worked in practice. We synthesized the data by applying thematic analysis and validated the results through member-checking. Our findings suggest that combining top-down and bottom-up approaches to D&I efforts can lead to improved diversity. We hope organizations will take action by establishing accountability measures for effective and impactful D&I practices. Additionally, we show how developing technical allyship allows people at different levels on engineering teams to play an active role and have long lasting influence on the technical opportunities and career growth for engineers from URGs. If extended beyond software engineering teams, the theme of technical allyship could inspire positive change toward improving diversity and inclusion in any technical environment, where people from URGs experience challenges due to their backgrounds. We hope this research inspires the research community to continue investigating ways to grow diversity and inclusive practices in tech, the workplace, and beyond. In doing so, our hope for the future is simple: teams like the ones we studied in this paper should not be exceptionally diverse but should be the norm.

## 9 DATA AVAILABILITY

To enable replication, we provide our interview guides in our appendix. To maintain participant confidentiality, we do not include interview transcripts.

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