Debugging Hiring: What Went Right and What Went Wrong in the Technical Interview Process

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ABSTRACT

The typical hiring pipeline for software engineering occurs over several stages—from phone screening and technical on-site interviews, to offer and negotiation. When these hiring pipelines are "leaky," otherwise qualified candidates are lost at some stage of the pipeline. These leaky pipelines impact companies in several ways, including hindering a company's ability to recruit competitive candidates and build diverse software teams.

To understand where candidates become disengaged in the hiring pipeline—and what companies can do to prevent it—we conducted a qualitative study on over 10,000 reviews on 19 companies from Glassdoor, a website where candidates can leave reviews about their hiring process experiences. We identified several poor practices which prematurely sabotage the hiring process—for example, not adequately communicating hiring criteria, conducting interviews with inexperienced interviewers, and ghosting candidates. Our findings provide a set of guidelines to help companies improve their hiring pipeline practices—such as being deliberate about phrasing and language during initial contact with the candidate, providing candidates with constructive feedback after their interviews, and bringing salary transparency and long-term career discussions into offers and negotiations. Operationalizing these guidelines helps make the hiring pipeline more transparent, fair, and inclusive.

CCS CONCEPTS

• **Software and its engineering**; • **Social and professional topics** → **Computing industry**; **Employment issues**;

KEYWORDS

career, hiring practices, interview feedback, opinion mining, reviews, software engineering, technical interviews, whiteboard

ACM Reference Format:
Mahnaz Behroozi, Shivani Shirolkar, Titus Barik, and Chris Parnin. 2020. Debugging Hiring: What Went Right and What Went Wrong in the Technical Interview Process. In *Software Engineering in Society (ICSE-SEIS'20), May 23–29, 2020, Seoul, Republic of Korea.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3377815.3381372

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ICSE-SEIS'20, May 23–29, 2020, Seoul, Republic of Korea
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ACM ISBN 978-1-4503-7125-4/20/05…$15.00
https://doi.org/10.1145/3377815.3381372

1 INTRODUCTION

The hiring pipeline is a chronological process through which companies recruit and obtain employees: for software engineering candidates, this pipeline typically begins with a preliminary screening, conducted over the phone, or through online coding platforms. If candidates pass this initial round, they are invited to participate in one or more remote or on-site technical interviews that involve whiteboards or simple text editors. Soon after, one or more of these qualified candidates can expect to receive an offer.

In an ideal hiring pipeline, the process yields a positive outcome for all parties: the candidate is happy that they've found a position that aligns with their skills, interests, and values—and the company is confident that they've hired a person who will make high-impact contributions to their role. Even rejected candidates—having a good understanding of why they weren't a good fit for the role, and armed with constructive ideas about what they'd need to improve—leave with a positive interview experience, continue to have a favorable impression of the company, and are open to potential future opportunities.

Unfortunately, the hiring process can also be a "leaky pipeline," a phenomenon where otherwise qualified candidates are lost at some stage of the hiring pipeline. This impacts companies in several ways. First, finding qualified candidates is a substantial investment, and hidden costs from engineers in a company—spent on interviewing and evaluating candidates—quickly add up [13]. When a candidate withdraws at nearly any stage of the hiring pipeline, this is an expensive loss. Second, leaky pipelines have been found to disproportionately affect minorities and other underrepresented groups, across a variety of disciplines [12, 21, 23, 29, 42]. In addition to issues of ethics and meritocracy, there is increasing evidence that suggests that more diverse software engineering teams are also fundamentally more innovative and productive [10, 31, 39], giving these companies a competitive edge [5]. Third, negative experiences from candidates have residual effects for the company beyond that of the candidate—recent studies show, for example, that negative reviews about the hiring process of a company can demotivate more than 55% of job seekers from applying to that company [34].

To understand where candidates become disengaged in the hiring pipeline—and what companies can do to prevent it—we conducted an empirical investigation of reviews on Glassdoor,[1] a website where current and former employees anonymously review companies, and where candidates share their experiences with technical interviews. Since 2010, the growth of employee review sites, such as Glassdoor (founded in 2007), has led candidates to increasingly share their experiences about different companies' hiring processes [33].

[1] https://www.glassdoor.com

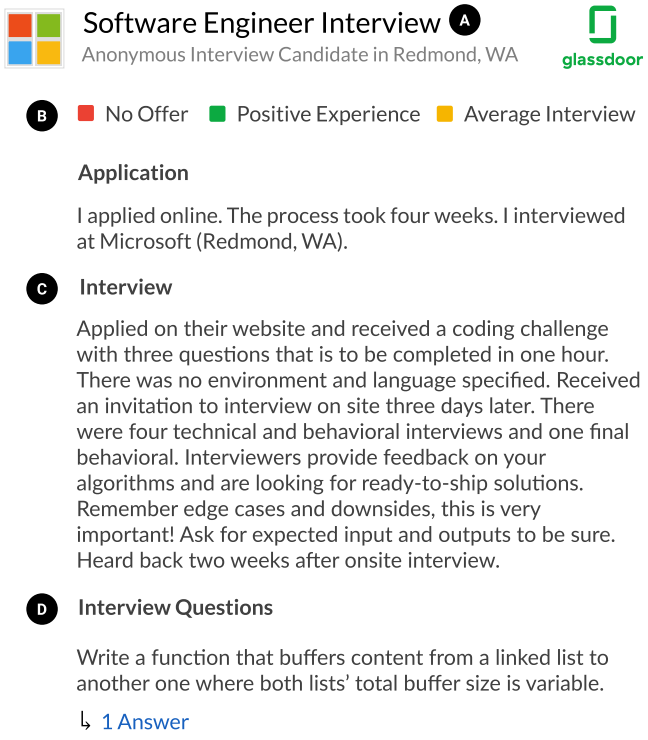

Figure 1: Software engineering candidates post their experiences about their technical interviews on Glassdoor. Although the candidate in this review ultimately did not receive an offer, they reported having a positive experience in their interview. Ⓐ Position title, Ⓑ offer status, self-reported experience, difficulty level of interview, Ⓒ interview description, Ⓓ interview questions.

From Glassdoor, we collected over 10,000 technical interview reviews on 19 companies. Through a qualitative analysis, we identified several leaks in the hiring pipeline that impact companies, such as: a lack of responsiveness to candidates' inquiries, disorganization in interview scheduling, a lack of transparency in the hiring criteria, inexperienced interviewers, and delays in the offer and negotiation stage. Our findings inform guidelines to make the hiring pipeline more transparent, fair, and inclusive—for example, from being deliberate about phrasing and language during initial contact with the candidate, providing candidates with constructive feedback after their interviews, and bringing salary transparency and long-term career discussions into offers and negotiations. The results of our study advocate for a company culture that fosters a meritocratic pipeline—one that benefits both candidates and companies alike.

2 METHODOLOGY

To understand how candidates become disengaged during the hiring process, we conducted a qualitative analysis on interview reviews posted to Glassdoor. Figure 1 depicts a Glassdoor review describing an interview experience at Microsoft.

Table 1: Breakdown of Companies' Technical Interview Reviews (Sorted in Decreasing Order Based on the Total Number of Reviews)

Company	Pos (%)	Neg (%)	Neu (%)	Total
Google	61	13	24	3186
Facebook	58	21	24	1320
Amazon	48	19	29	1294
Microsoft	61	11	25	1076
Accenture	74	10	16	720
IBM	64	11	23	529
Uber	46	33	21	300
Apple	50	29	19	287
Oracle	57	16	26	287
Twitter	43	32	23	235
Square	58	20	18	149
Adobe	76	10	12	144
Intuit	62	20	16	123
SAP	74	11	15	120
Ebay	41	28	28	116
VMWare	43	26	28	99
Symantec	61	14	17	96
HCL	54	18	29	80
Lyft	45	45	10	64

2.1 Data Collection

To conduct this study, we collected 10225 reviews about technical interviews for software engineering positions posted on Glassdoor.com (see Table 1). We limited our reviews to companies which appeared in the software category of Fortune 2000 and had at least 50 reviews on Glassdoor. This yielded a total of 19 companies. To collect the data, we developed a web scraper using Beautiful Soup. We selected positions tagged as "software engineering" and "software development engineering" roles. Reviews spanned from March 5, 2009 to June 25, 2019.

Our dataset can be found at: https://go.ncsu.edu/debugginghiring.

2.2 Data Filtering

We organized our collected data into positive and negative reviews based on tags provided with the review, such as '*Positive Experience*' or '*Negative Experience*'. We excluded reviews from further analysis if they did not provide a positive or negative tag. We also removed short, non-informative reviews, containing fewer than 35 words, such as "It was a terrible process." After filtering, 6747 reviews remained, including 5272 positive and 1475 negative reviews.

We then drew a statistically representative and stratified sample of reviews in our dataset. Because companies were not uniformly represented in the dataset, we determined a statistically representative sample size for each company. To do so, we used a proportionate stratified random sampling [20] by considering each company as a strata. We used a 95% confidence level and 5% margin of error to calculate the sample size of each strata. We repeated this process for positive and negative reviews separately, yielding a sample of 358 reviews from 5272 positive reviews and a sample of 305 reviews from 1475 negative reviews.

2.3 Analysis

We imported our sample into ATLAS.ti[2]—a qualitative data analysis tool—and performed two stages of qualitative analysis.

In the first stage of our qualitative analysis, we used descriptive coding, and assigned short codes and labels to capture and summarize the salience of the reviews [35]. To address reliability concerns for descriptive coding, we applied *negotiated agreement* [8]. Negotiated agreement has been applied as a means to address reliability in software engineering research [2, 19], and found to achieve "substantial agreement" [24] when independently verified [2]. Using this technique, the first two authors collaboratively coded 20 random reviews (10 negative and 10 positive) to clarify the definitions of the codes and understand and resolve disagreements. Then, the first two authors independently coded the remaining negative and positive reviews.

In the second stage, we performed a reflexive thematic analysis [7] to organize and cluster the codes. We first inductively clustered the codes across all reviews into themes, and then situated those themes within each stage of the hiring pipeline.

3 RESULTS

We present the experiences candidates encountered as they moved through each stage of a company's hiring pipeline. In each stage of the pipeline, we describe the resulting themes, and give examples of both negative experiences (*"what went wrong"*) and positive experiences (*"what went right"*) related to a theme (see Table 2).

3.1 Contact

The hiring process usually starts with first contact from a recruiter or a candidate reaching out to a company representative. Even in this early stage, problems can occur when key requirements about the position are not properly communicated or representatives from the company do not provide timely responses.

3.1.1 ***Paying attention to details.*** Glassdoor reviews reported several experiences where recruiters made critical mistakes in matching the candidate to a position; for example, ignoring willingness to relocate, requirements for work authorization, and skills required for the position.

Examples of what went wrong: "I specifically applied to Seattle, my resume said I'm located in Seattle, and my LinkedIn says I'm not interested in anywhere but Seattle," recalls N_{63} about a recruiter who wanted to bring them to San Francisco. Another candidate, N_{285}, details how a simple mistake in the beginning derailed the entire hiring process: "I had several phone calls with internal recruiters, in which I thoroughly described my visa status (I am on F-1 right now)." After proceeding with an on-site interview, the company still "chose not to go forward due to wrong visa reasons" after the immigration team was consulted. Similar experiences caused problems in the final stages of hiring: "I am in the offer stage but they're looking for an immediate start, which I already told them in the beginning that my notice period is three months and I cannot join immediately" (N_{11}). Such problems can make "the whole interview process a waste of time" (N_{285}).

[2]http://atlasti.com/

Examples of what went right: Candidates appreciated when companies had a streamlined process for collecting candidate preferences. "They gather info on your interests and ensure the role matches them, confirm your location preferences, work authorization, and visa requirements, and understand your decision timeline and desired start date," shares P_{185}.

3.1.2 ***Responsiveness.*** Responsiveness can keep candidates engaged during a potentially long and uncertain hiring process. Candidates expect recruiters to respond in a timely manner throughout the hiring process.

Examples of what went wrong: "Prompt feedback is essential. Expected better than this from such a reputed company" (N_{89}). Another candidate, N_3, had several offers in hand but found that communication had shutdown with the company: "both HRs and Management didn't inform or reply to my emails." N_{25} was particularly frustrated when the company did not provide any feedback after an interview: "they are just meant to disappoint candidates. I have gone through the programming interview for an hour with absolutely no feedback shared after the interview. I tried calling back the recruiter but just they don't respond. They are so unprofessional. I had to withdraw my application for such an unprofessional recruitment process." Once a candidate has disengaged, the effects can cascade to their peers, N_{25} continues: "will never recommend such horrible companies."

Examples of what went right: Candidates appreciate when recruiters make an effort to keep in touch throughout the process. As P_{125} says, "I got a prompt response from this point till the end…everyone was professional. Communication was prompt and fast!" P_{101} shares how their recruiter went the extra mile: "the recruiter was super engaging and extremely responsive. She even responded on Sunday night."

3.2 Preparation

After initial screening, companies need to schedule the interview and prepare the candidate for what to expect.

3.2.1 ***Interview scheduling.*** Interview scheduling is an important but often overlooked step in the hiring process [32]. Based on Glassdoor reviews, candidates were not always available to proceed with the interview. Poor handling of this step could influence future decisions to reapply when the time might be right.

Examples of what went wrong: "When I initially realized I was going to be interviewed for this position, I was enthused, and immediately began to prepare. However, this quickly waned as my interview was rescheduled three times, which as a candidate provides a terrible experience, especially as I am currently employed full-time," reports N_{29}. N_{32} recalls an even more extreme case: "probably the worst interview I ever had. They scheduled the interview for a day in which I was not available, after I sent them an availability table. I asked them to kindly reschedule and there was no reply till I got the call for the interview."

Examples of what went right: Candidates appreciated when companies provided multiple time slots or offered to accommodate special scheduling circumstances. P_{10} was pleasantly surprised when their recruiter agreed to tailor the timings of the interview, which was "very flexible. I had my technical interview on a Saturday and

Table 2: Summary of Themes Found from Studying the Hiring Pipeline

Pipeline stage	Summary of themes found	Example
Contact (Section 3.1)	Candidates reviewed their experiences on the initial phases (screening phases) in the hiring pipeline and their interaction with recruiters and hiring managers.	**What went wrong?** "I tried calling back the recruiter but they just do not respond…had to withdraw my application." (N_{25}) **What went right?** "I got prompt response from this point till the end…everyone was professional." (P_{125})
Preparation (Section 3.2)	Candidates expressed their opinions about interview scheduling and preparation. They also shared their opinions about hiring process organization.	**What went wrong?** "My interview was rescheduled three times, which as a candidate provides a terrible experience, especially as I am currently employed full-time." (N_{29}) **What went right?** "Very flexible…I asked the recruiter to schedule interviews during time that would not impact my activities. I was surprised when he proposed the first one on a Saturday morning." (P_{10})
Interviews (Section 3.3)	Candidates shared their experiences with technical interviews. They commented about interviewers' experience in conducting interviews, interviewers' involvement, and the relevancy and appropriateness of questions asked.	**What went wrong?** "The next interviewer was a very jaded engineer who clearly didn't want to be there. Unresponsive to questions. It was very awkward and put me off in a major way." (N_{86}) **What went right?** "Interviewer was smart and polite; asking 'logical' questions rather than trying to show off or stump-the-candidate sort of questions." (P_{118})
Hearing Back (Section 3.4)	Candidates commented about their experiences regarding feedback and status updates after each stage in the hiring process.	**What went wrong?** "I can deal with rejection. I cannot deal with poor processes, especially when followed by a generic rejection letter, and no opportunity for feedback." (N_{29}) **What went right?** "Overall the interview experience was pretty good and I got feedback in a decent amount of time." (P_{85})
Offer and Negotiation (Section 3.5)	Candidates shared their experiences in the last stages of the hiring process. They commented on companies' performance in promptness in extending an offer, team-matching, and their openness to salary negotiation.	**What went wrong?** "The team matching progress is extremely slow and the recruiter is reluctant to arrange it. Took around three months to finish everything, way too long. Declined the offer without hesitation." (N_{159}) **What went right?** "They were aware that I had a pending offer that I had to make a decision on, and were very good about moving the process along as quickly as possible." (P_{112})

the interview with a senior manager the next Friday, end of the day. Since I was in a critical phase of the project with deliverable, I asked the recruiter to schedule interviews during times that would not impact my activities. I was surprised when he proposed the first one on a Saturday morning."

3.2.2 ***Hiring criteria.*** Transparency throughout the hiring process, especially in hiring criteria, results in faster, more accurate hires and an improved employer brand in hiring [26, 41]. When companies are not clear on their hiring criteria, candidates perceived rejections as unfair and arbitrary.

Examples of what went wrong: Some companies offer preparation documents that emphasize the type of questions candidates can expect to be asked. N_{42} later found their interviewer did not adhere to it: "the document stressed that the most important thing was to prepare for algorithms and data structures and it stated clearly that no specific knowledge of databases was assumed. Well, guess what, half of the interviewers asked me about databases, so overall it did not go well…I spent several days preparing for the interview and took the time (and vacation) to go through the process. I think they should stick to what they write on their own documents." A lack of clear hiring criteria often results in candidates being uncertain how to prepare or what to expect after the interview process. In these cases, candidates feel that the process is "random, and is biased strongly toward failure" (N_{83}). Again, such experiences can lead to negative word-of-mouth to peers: "probably going to fail, regardless of performance" (N_{83}).

Examples of what went right: "They are incredibly upfront about what they want out of applicants" (P_{198}). Additionally, P_{174} found it helpful to get a run-down of the interview beforehand: "the recruiter who contacted me was very helpful. She described to me how the interview would be, what to expect, what not to expect, and what are the interviewers looking for pretty well without a single hint of any question. She did her job well."

3.3 Interviews

Candidates revealed several factors associated with the interview, such as helpful interactions with the interviewer and relevance of the interview questions to the position, that contributed to positive and negative outcomes.

3.3.1 ***Interviewers' involvement.*** Interviewers can act as shepherd through a long and stressful series of interviews, which can often last all day. Poor interactions can make this worse.

Examples of what went wrong: "The next interviewer was a very jaded engineer who clearly didn't want to be there. Unresponsive to questions. It was very awkward and put me off in a major way," recalls N_{86}. N_{104} noted the lack of direction offered by their interviewer: "when I had asked if I was going in the right direction, he said things along the lines of, whatever you think is right, which was not helpful at all." Many candidates also reported that their interviewers were distracted by something else instead of focusing on the interview: "one of the interviewers wasn't that nice and was quiet through most of the interview. While I wrote on the whiteboard and talked out loud, he was mostly on his laptop and barely responded" (N_{102}). Similarly, N_{178} found their "interviewer was just strange, and clearly was distracted." N_{178} continues, "any time I asked a question to clarify some part of the problem statement he grunted and glanced around the room wildly before stating that it was obvious. Once the hour was up, the interviewer stood up abruptly and said 'I have to go' and left the room. With no instructions as a candidate I had to run after the interviewer to catch him outside the building to ask what happens next. To which he shrugged and said 'go home or go find HR.' With no further information I decided that this wasn't a culture I was willing to work in."

Examples of what went right: Candidates feel more comfortable when interviewers occasionally nudge them in the right direction and provide hints. P_{45} recalls, "when I got stuck, the interviewer gave helpful tips to guide me in the right direction and I used it." Despite not receiving an offer, P_{309} appreciated their interaction with interviewers: "I was only able to get it to work with some debugging help from the interviewer, who was very nice and polite and helped me along the way. Even though I didn't pass the interview, I enjoyed the coding challenge and felt proud of what I was able to complete."

3.3.2 ***Interviewers' knowledge and experience.*** Knowledgeable and experienced interviewers conduct effective technical interviews. Unfortunately, Glassdoor reviews often described many instances where interviewers conducted interviews in an ambiguous and inflexible manner.

Examples of what went wrong: "Problem description was very vague and she never clearly mentioned what exactly she wanted and kept rushing me into coding it without properly understanding the question" (N_{217}). When asked to clarify questions, interviewers often did "a poor job of explaining the problem and, when asked specific questions, was unable to explain what [they were] really looking for" (N_{27}). Technical interview questions may have multiple solutions, yet several reviews described interviewers who rigidly expected a specific solution. N_{48} shares, "the interviewers sounded like robots, they had this script of how one should frame answers and if I did not frame it like they wanted, it's like they did not understand me." Knowledge of different programming languages hindered some interviews: "the last interviewer was unfamiliar with my requested coding language (python) and didn't understand lots of the built-in methods that were being used" (N_{135}). Beyond the technical questions, candidates hope for interviewers to give them an "indication of the culture of the company" (N_{38}). They also expect interviewers to be knowledgeable about the job description and prospective role. "I asked him some questions about the job role, but all I got was vague/cryptic answers," recalls N_{164}.

Examples of what went right: Candidates noted that skilled interviewers helped put them at ease and made them "feel comfortable" (P_{217}). P_{118} found their interviewer "smart and polite; asking 'logical' questions rather than trying to show off or stump the candidate sort of questions." Candidates expected interviewers to give a better idea about whether the candidate would potentially be a good "fit" at the company and what their expected responsibilities would be. As P_{334} explains, "the exact interview is quite fun, with interview questions being interleaved with chats about your work, their work and their short-term to mid-term focus. This gives you an idea of what you will get to work on and helps to have an informed decision. Again, many companies do not provide such information."

3.3.3 ***Interviewers' friendliness.*** Glassdoor reviewers reported several cases of rude or hostile interviewers.

Examples of what went wrong: "This particular interviewer made the entire session extremely stressful. I wasn't sure if this interviewer was trying to show off to a person who was shadowing the interview session. The entire session was very unhelpful, condescending, and interrogative," recalls N_{136}. "Interviewers were not very friendly. One was very abrupt. One behaved like a police officer who pulled me over," said N_{172}. N_{277} recalls a hiring manager "with a condescending tone and treated me like I was lying about everything. He acted like he did not believe me." N_{277} concludes, "I will never waste my time applying to this company again."

Examples of what went right: "Everyone was very friendly, positive, and respectful, so even though I was rejected, all-in-all a positive experience—as someone often involved in recruiting myself, I think we can all learn a lot from how it's done there" (P_{86}). P_{115} shares, "as far as the interviewers go, they were an amazing bunch. Even when I was bombing the system design module, the interviewer was very respectful, encouraging, and friendly. I walked away with a very positive experience."

3.3.4 ***Relevant and appropriate interview questions.*** Questions are tools to help interviewers find best-fit candidates for positions. Irrelevant and inappropriate questions can add to a frustrating interview experience.

Examples of what went wrong: N_{29} was frustrated when "questioned on skills that did not remotely align to the role for which

[they] applied." This often extended to mismatches in programming languages: "profile was of Java but asked C questions" (N_{205}). Candidates also described being given unrealistically hard questions which are not solvable within the interview's time limit. N_{21} shares their story about such a question: "I presented a solution and the interviewer said that it's not what he wants…then, in the next few minutes I noticed that the question is very hard. He admitted that the real solution is very very hard. Then he explained that the question is a more complex version of the knapsack problem." Candidates remain unclear if they are expected to solve such tasks in time or if they are just supposed to make their best attempt. N_{223} recalls another example of a long question: "the problem they give is three typed pages long (yes, not kidding, in standard 11pt type). It requires scaffolding an entire working application, reading in input from a file and writing out to another file, converting between strings and time objects, managing multiple queues, and has an algorithmic basis that would be at least a LeetCode medium (and maybe a hard). If you were to ignore all good programming practices, you might be able to squeak it out."

Examples of what went right: P_{328} found the interview question relevant for evaluating their skills: "I had to code an Android app in the interview, which was pretty cool and I think a good test of my engineering skills." Some interviewers provided a variety of questions that appealed to candidates in different ways. P_{174} appreciated that the company asked straightforward, but challenging questions: "they asked very smart, algorithms based questions. No tricky questions." Moreover, P_{315} appreciated that the company asked well-rounded and thoughtful questions, that included behavioral aspects: a "highly technical interview with good level of complexity. Coding tests, problem solving, in-depth technical interviews with a minimum of three technical rounds. It is very technology-oriented product-based company that hires very selective people with good technical and verbal skills and the interview process is genuinely talent-oriented."

3.3.5 ***Impression from on-site interviews.*** Impressions during interviews have a strong effect on candidates' decisions to join a particular company. Poor experiences related to a company's culture, its campus, and other aspects can change candidates' minds.

Examples of what went wrong: "I was supposed to be very impressed about them as a brand. I wanted so bad to fit in, but I realized that it just wasn't for me…I just didn't care anymore. I asked the interviewers what projects they worked on, and I got the same lack of passion I got from my lunch-mate" (N_{130}). Poor impressions can form when the interview process does not go smoothly. N_{31} describes a late interviewer: "it was 3 pm, the last interviewer was late, I was waiting for him, he came more than 20 minutes late (3:22pm), then he apologized, then he gave me a question. I was in the middle of the answer when he said, 'it's OK, I think we are out of time.' I felt kicked out (3:28pm)." Unenthusiastic interviewers can change a candidate's mind about a company: "unfortunately most of the interviewers were cold and gave a strong vibe they didn't want to be there or be constructive…it was not a good experience and left a bad impression on a company I previously thought highly of" (N_{220}).

Examples of what went right: P_{132} expressed the importance of punctuality: "the pace of the interviews was comfortable, there was free lunch, and everyone was on time." When company employees show that they genuinely enjoy working there and are passionate about their projects, candidates pick up on their job satisfaction, and hence, feel good about the company. P_{115} saw themselves fitting in at the company: "I walked away with a very positive experience. Everyone was excited to be working there, and I can see that it is a terrific place!"

3.4 Hearing Back

Ghosting refers to when someone suddenly stops reaching out or responding to messages. Candidates reported many instances of being ghosted by companies. Candidates did not know whether the company was not interested in them or if their application "fell through the cracks" [9].

3.4.1 ***Status update.*** Candidates often had difficulty tracking down the status of their application and whether there would be a next step, or not.

Examples of what went wrong: "Weeks passed without a response (it was already mid-April), so I emailed asking what the status of my application is. Was told I would have a response by April 29. It's now mid-May with no response," said N_{273}. "They don't have time to update status. Suggestion: go for a better opportunity," warns N_6.

Examples of what went right: P_{112} shares, "the recruiter did a great job of keeping me up-to-date about what was happening." Similarly, candidate P_{100} recounts how their recruiter was swift in moving along the process and updating them about future interviews: "after I was contacted by the recruiter, she arranged the first technical interview in less than a week. The second one was planned two days after and the onsite interview just two weeks after first contact."

3.4.2 ***Feedback.*** While companies are not legally required to provide (or not provide candidates) with feedback, candidates desire explanations for the reasons they were rejected [18].

Examples of what went wrong: Candidates expressed that they appreciate constructive feedback and they expect it from companies. N_{29} explains, "I can deal with rejection. I cannot deal with poor processes, especially when followed by a generic rejection letter, and no opportunity for feedback." Candidates perceived feedback as way for companies to signify appreciation of their time, and felt frustrated when they did not hear anything: "I spent three hours doing their HireVue exam so the least I expect is to at least get a follow-up email from the recruiter that they changed their mind or something instead of just ignoring me," said N_{208}. N_{35} also shares their experience with being ghosted, "after a month, I sent an e-mail requesting a feedback. They said that they will contact me in a couple of days, but they didn't. Overall, it was a waste of time." When no feedback is provided, candidates do not know how to improve: "I am not sure on what grounds they rejected me. Not sure what else they expect from an interviewee. I feel it's totally unfair and have a very bad opinion about the company" (N_{107}).

Examples of what went right: P_{85} appreciated prompt feedback: "I got feedback in a decent amount of time—overall interview experience was pretty good." Correspondingly, candidate P_{186} describes how the company provided a personal touch by sharing feedback on their implementation over a phone call: "three days later after

a phone interview recruiter called me and gave me full feedback (which was very positive)." Candidates remember and appreciate individuals in the company who get back to them regarding their work. P_{226} shares, "the reason that I hoped for the best is that at the end of the interview, he was the only person who gave me very honest feedback."

3.5 Offer and Negotiation

Team matching and negotiation are the final stages of the hiring process. If anything goes wrong in this stage, it could be a large waste of time and resources for companies and candidates alike.

Examples of what went wrong: When the process of team matching takes too long, candidates will start considering other offers they have. "The team matching progress is extremely slow and the recruiter is reluctant to arrange it. Took around three months to finish everything, way too long. Declined the offer without hesitation," says N_{159}. Non-negotiable companies also put themselves at the risk of losing candidates to rivals when it comes to candidates who have multiple offers. N_{46} recalls, "their offer was reasonable, but nothing extraordinary. I decided to sign with another top company for significantly better salary, perks, and location, but a bit less interesting project." Candidates warn their peers that companies which are resistant to negotiate try to "low-ball everyone unless [they] have a competing offer" (N_{159}).

Examples of what went right: "After the interviews the recruiter followed up promptly, with accurate estimates of when I would get updates. The hiring committee approved the application in a week, followed by the final offer a few days later" (P_{162}). Candidates appreciate when the company moves "the process along as quickly as possible," particularly when they have other pending offers that they have to make a decisions about (P_{112}).

4 LIMITATIONS

A limitation of using Glassdoor, like many online review sites, is that it is subject to a number of biases. These include under-reporting bias [6]—where candidates who have extreme experiences, either positive or negative, are more likely to post them—and the "hyperbole effect" [15], where candidates may tend to exaggerate or even misrepresent their actual experiences. To reduce this threat, we inspected multiple reviews, across multiple companies, and synthesized the commonalities between these reviews into themes. Nevertheless, we should be cautious about how we interpret any specific review.

Conducting qualitative research can introduce several types of threats related to confirmation bias, interpretative validity, and ecological generalizability [27]. We acknowledge that these threats exist to some degree within our study. To reduce these validity issues, the two authors who were responsible for qualitative analysis met frequently to discuss the reviews and themes. Future studies should corroborate or disconfirm our findings through triangulation, using other sources of interview experiences such as surveys, interviews, online forums, and hiring data from companies.

Although stratified sampling attempts to include diverse companies, this approach nevertheless results in overrepresenting interview experiences from larger companies that also have a proportionally larger number of reviews on Glassdoor—such as Google, Facebook, and Microsoft. Moreover, our findings may be influenced by the particular companies that we sampled. An interesting future study could consider interview experiences for hiring pipelines in different types of software organizations, such as startups, non-profits, and software engineering roles outside of the technology sector.

5 RELATED WORK

Although hiring processes are widely discussed in the literature, hiring processes specifically in software engineering are understudied. To the best of our knowledge, a few studies have been recently conducted on technical interviews but not on all stages of the hiring process. Behroozi et al. [4] conducted a qualitative study from developers' perspectives. Their aim was to reflect developers' concerns about technical interviews. They studied comments from Hacker News[3]—a venue for software practitioners—through the lens of small stories. Their study identified six concerns that makes technical interviews unpleasant for candidates. They also provided guidelines to mitigate these concerns. In contrast, our study in this paper does not focus on a specific aspect of the hiring pipeline—the technical interview—but instead takes a broader approach to shed light on successful and unsuccessful practices throughout the entire technical hiring pipeline.

Ford et al. [14] studied mismatches between candidates' expectations from technical interviews and interviewers' assessment criteria. In their study, hiring managers conducted mock interviews for University students, and asked the hiring managers to evaluate students' performance. Results from their study report what interviewers actually expect from technical interview candidates and how they are different from what candidates try to prepare for.

Behroozi et al. [3] conducted a preliminary study on cognitive load differences between public whiteboard interview settings and solving problem privately on paper. In their study, they used head-mounted eye-trackers and found that candidates keep shorter attention lengths and experience higher levels of cognitive load in the public whiteboard setting. They conclude that "programming is a cognitively intensive task that defies expectations of constant feedback that today's interview processes follow."

Findings from exploratory qualitative study conducted by Wyrich et al. [43] on 32 software engineering students show that students with better exam grades and more programming experience were more successful in coding challenges. Also, they report that happiness enhances software engineers' performance.

Our study, besides complementing this prior work, has common ideas with other qualitative studies conducted on online reviews in software engineering. Specifically, in this study we were inspired by work done by Washburn Jr et al. [40]. They studied 155 post-mortems published on Gamasutra, a gaming site. The goal of their study was to find out a set of best practices and drawbacks for game development. To uncover user complaints about iOS apps, Khalid et al. [22] conducted a qualitative study on low-rated user reviews and found 12 types of complaints. Their goal was to help developers better prioritize Quality Assurance resources by reporting the number and types of user-reported complaints. Vasa et al. [38] analyzed user reviews of mobile apps. Their results showed

[3] https://news.ycombinator.com/

that reviewers use longer and more detailed comments to describe their dissatisfaction, which highlights the usefulness of studying low-star reviews. In our study, we considered both positive and negative reviews. But we also admit that negative reviews were generally more detailed and helpful.

6 DISCUSSION

We discuss our results through five guidelines that help improve each of the stages in the typical hiring pipeline.

Guideline I—Recruit widely and tailor communications to your candidates. Companies must expand their recruiting practices beyond the traditional avenues of posting to the company's career site, broadcasting on social media, and submitting positions to University recruiting channels. To identify and attract these diverse candidates, companies should be visible in venues that acknowledge, promote, and bring together students and professionals from different backgrounds and experiences; such venues include Tapia, Grace Hopper Celebration, Latinx Tech Summit, and the National Society of Black Engineers Convention. They should additionally reach out to community colleges, historically black colleges and universities, and non-profit coding bootcamps.

Recruiting from such a diverse background means that generic communications with candidates are often insufficient: interactions should be tailored and roles should be matched such that these roles resonate with the candidates. As we found in Section 3.1.1, candidates can become quickly dissatisfied when available careers are radically misaligned with their own skills, values, and career objectives.

A study by Wynn and Correll [42] found that recruiting sessions in technology sometimes alienated women, because these sessions included gender-imbalanced presenter roles, geek culture references, overt use of gender stereotypes, and other gendered speech and actions that lessened womens' interest at the point of recruitment. Another study by Snyder [36] on hiring language from over 25,000 job descriptions found that phrases such as "whatever it takes," "all-star," and "high-performance culture" tended to attract a statistically higher proportion of applications from men, while phrases such as "building alliances," "lasting relationships," and "passion for learning" attracted a higher proportion of applications from women. In short, companies that want to attract diverse candidates must take the lead.

Guideline II—Help candidates prepare for your interviews. Although companies want to accurately assess candidates based on their actual skills, they can inadvertently favor those who happen to be more familiar with the technical interview structure or other skills that are orthogonal to the requirements of the position. For example, Larson [25] argues that writing algorithms on a whiteboard have almost nothing to do with modern software development, and that "it becomes difficult for the average interviewer to figure out who's good at developing software, and who's merely good at whiteboard interviewing." Fortunately, learning to code on the whiteboard is something candidates can prepare for—but only if they know that it's important to do so.

Even then, every company has different evaluation criteria for how they assess candidates: while some companies are more focused on the candidates' ability to communicate clearly about design choices and the trade-offs, other companies may focus more on raw problem-solving and coding abilities [14]. Candidates who aren't aware of the peculiarities of a company may spend substantial effort incorrectly preparing for their interviews (Section 3.2.2).

To address this inequity—and put all candidates on equal footing—companies should provide candidates with information about: the skills they should emphasize; the scope of the topics, such as specific algorithms or data structures that they are expected to know; references to relevant materials, such as books or tutorials; representative interview questions; and, if possible, sample interviews so that candidates can become "virtually" acquainted with the interview experience. For example, to make candidates feel comfortable throughout their interview process, Asana provides an engineering interview guide with information about the types of questions, what qualities they're looking for, and how to prepare [1]. Similarly, Jane Street interviews are relatively standardized: their guide explains the interview structure, enumerates the core computer science concepts that the candidate should know, and includes a walkthrough of an example phone interview [37].

Guideline III—Develop standards and train interviewers. Just because someone is a great software engineer doesn't mean that they're a great interviewer. As we found in Section 3.3, candidates report that they experience high variability between interviewers—not only in knowledge, experience, and attitude, but even in the types of interview questions different interviewers prefer to ask. Moreover, while software engineers like to believe that they judge candidates purely on their merits, neuroscience suggests that this isn't always the case [23]—unconscious biases, for example, are learned stereotypes that interviewers may unintentionally project on a candidate, influencing their evaluation of them [11]. Unconscious bias when interviewing candidates, if unchecked, impacts a company's ability to hire diverse, yet qualified candidates.

When companies develop standards and train interviewers, both of these issues can be addressed. For example, Google makes interviewing a part of every engineer's role, requiring them to attend training where they learn about Google's standards regarding desired attributes for candidates, the hiring process, and conducting legally-compliant interviews—so that candidates have a consistent experience, regardless of who they interview with. One way that Google trains interviewers is through shadowing experienced interviewers. This way, trainees have a consistent frame of reference for interview performance—this is called interview calibration, and helps to ensure that interviewer ratings are valid [17].

And at GitLab, interviewers receive training on recognizing different forms on unconscious bias—such as affinity bias, confirmation bias, and the halo effect—and learn about practical ways to reduce or avoid the impact of bias. For example, the GitLab handbook asks interviewers who recognize a positive or negative bias during the interview to excuse themselves and ask someone else to interview that candidate [16].

Guideline IV—Inform candidates of where they are in the interview process, and give constructive feedback to them.

Candidates should have a positive experience about the hiring process and feel that they have benefited from their interview experience, regardless of whether they ultimately receive an offer (Section 3.4.2).

One way to do that is to give candidates constructive and timely feedback [18]. First, companies should tell the candidate about where they performed well, and let them know about any interviewers who felt strongly about championing their hiring. Second, the candidate should be told about what specific areas or skills they would need to improve in order to make a stronger case for their hiring. This type of actionable feedback gives the candidate confidence that they can be successful and would be considered for other opportunities if they improve on these areas. Third, companies should provide candidates with a reason for their rejection—this can be slight performance differences between candidates, or even the result of internal changes within the company for the job role. Leaving a good impression on the candidate is important because they or one of their colleagues may want to apply in the future.

Guideline V—Negotiate not just the immediate the offer but invest in long-term career growth. Qualified candidates are likely to be in a competitive, multiple-offer situation. In the long term, giving candidates appropriate time to make an informed decision about joining the company benefits both the candidate and the company. When candidates make rush decisions about a non-negotiable, *exploding offer*, they may be forced to accept an offer which is not their ideal choice (Section 3.5) [30] . Although this benefits the company in the short term, it ultimately results in higher attrition once the engineer finds a more suitable position.

The offer can also go wrong when candidates feel slighted: either they feel that the salary is low-balled, or that they have been underleveled for the role based on their experience. Specifically, self-reported salary data is often available on sites such as Glassdoor or levels.fyi,[4] but these numbers can be out-of-date, incorrectly reported, or otherwise misleading because companies have different bonus structures and vesting schedules [28].

To mitigate against potentially incorrect information, companies can provide a reliable source of data by publishing their salary ranges. By providing this transparency, candidates can be reassured that they are receiving a fair offer relative to others within the same level. In addition, because different companies have different career ladders, it can be difficult for candidates to compare job responsibilities solely from job title. To address this concern, companies should publish their career guides, which outline the specific responsibilities for each level and the pathway for growth within the company.

7 CONCLUSION

The hiring pipeline for software engineering has become ubiquitous within the industry as means to recruit, evaluate, and onboard qualified candidates. We conducted a qualitative study using Glassdoor—a job review website—and analyzed reviews left by candidates to understand their experiences within the hiring pipeline. The findings in our study bring to attention how leaky hiring pipelines materialize—across all of the stages of the pipeline. Poor practices within each of these stages impact companies in several ways, ultimately hindering a company's ability to recruit competitive candidates and build diverse software teams. Our findings inform guidelines that if operationalized, stand to make the hiring pipeline more transparent, fair, and inclusive.

[4]https://levels.fyi

ACKNOWLEDGEMENTS

This material is based in part upon work supported by the National Science Foundation under grant number 1755762.

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