# Inclusiveness Matters: A Large-Scale Analysis of User Feedback

Nowshin Nawar Arony<sup>§</sup>, Ze Shi Li<sup>§</sup>, Bowen Xu, Daniela Damian

**Abstract**—In an era of rapidly expanding software usage, catering to the diverse needs of users from various backgrounds has become a critical challenge. Inclusiveness, representing a core human value, is frequently overlooked during software development, leading to user dissatisfaction. Users often engage in discourse on online platforms where they indicate their concerns. In this study, we leverage user feedback from three popular online sources, Reddit, Google Play Store, and Twitter, for 50 of the most popular apps in the world to reveal the inclusiveness-related concerns from end users. Using a Socio-Technical Grounded Theory approach, we analyzed 23,107 posts across the three sources and identified 1,211 inclusiveness related posts. We organize our empirical results in a taxonomy for inclusiveness comprising 6 major categories: Fairness, Technology, Privacy, Demography, Usability, and Other Human Values. To explore automated support to identifying inclusiveness-related posts, we experimented with five state-of-the-art pre-trained large language models (LLMs) and found that these models' effectiveness is high and yet varied depending on the data source. GPT-2 performed best on Reddit, BERT on the Google Play Store, and BART on Twitter. Our study provides an in-depth view of inclusiveness-related user feedback from most popular apps and online sources. We provide implications and recommendations that can be used to bridge the gap between user expectations and software so that software developers can resonate with the varied and evolving needs of the wide spectrum of users.

Index Terms-inclusion, diversity, user feedback, human aspects, deep learning

### 1 INTRODUCTION

As software usage continues to grow worldwide, an increasingly diverse user base is engaging with the applications. The diverse group includes individuals from various genders, regions, cultures, socio-economic backgrounds, political beliefs, people with physical and cognitive abilities, values, and educational backgrounds, among many others. However, software is often built for the "average user" [1] and fails to adhere to the diverse user needs. For instance, Twitter (currently known as X), a widely used social networking app with over 390 million global users [2], released an image cropping algorithm that automatically cropped images. It focused on important parts, such as faces and text, to optimize space on the main feed and allow multiple pictures in a single tweet. However, users soon identified that the algorithm could only detect white faces and cropped out faces of black people [3]. The topic soon became trending as thousands of users joined the discussion. Similarly, numerous other incidents have emerged from online user feedback [4], highlighting the lack of inclusiveness in software.

In fact, the feedback provided by users on online platforms (e.g. app reviews) has grown significantly in amount and significance to software organizations. Software companies are not only able to identify areas of product improvement based on such feedback but also to learn about the inclusiveness aspects of software. In this space, Crowd Requirement Engineering (CrowdRE) has become a popular area of study for identifying product relevant infor-

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mation from large volumes of user feedback in various online platforms such as app stores, social media, and forums. A growing body of research in "end user human aspects" has attempted to address and understand aspects like gender and accessibility using CrowdRE sources such as App reviews [5], [6]. Khalajzadeh *et al.* [7] studied user feedback from Google Play Store and developer discussion from GitHub to understand the human aspects related conversations from 12 open source apps. The authors found inclusiveness related discussions from both sources (31 from Google Play Store and 31 from Github). While insightful, open-source applications represent only a portion of the many applications used in our society and, therefore, can result in limited user feedback and, more importantly, a lack of representation of diverse opinions.

Therefore, there is a need for a more extensive exploration of the inclusiveness category from a larger, therefore more diverse, user base. The analysis may reveal variations in inclusiveness concerns depending on the type of software, insights which can help companies focus on their users' specific needs. Furthermore, with the increasing number of user feedback platforms (e.g., social media), diverse users may prefer using different mediums due to different levels of engagement with particular online platforms [8]. Thus, exploring a variety of sources of feedback can reveal more insights about inclusiveness. Finally, the growing amount of user feedback, while useful, represents a significant manual effort for software organizations, making the automation in identifying inclusiveness-related user concerns worth the effort to reduce the manual overload of analysis. Our study aims to fill this gap through a largescale analysis of user feedback for 50 of the most popular apps with millions of users, from Google Play Store, Reddit,

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and Twitter.

Guided by the following research questions, we employed a Socio-technical grounded theory (STGT) approach [9] to analyze the user feedback we collected from these multiple sources and software apps.

- **RQ1** What are the different types of inclusiveness related user feedback found on online sources?
- **RQ2** How does inclusiveness related user feedback differ for different types of apps?
- **RQ3** How does inclusiveness related user feedback differ across different sources of feedback?
- **RQ4** How effective are pre-trained large language models in automatically identifying inclusiveness related user feedback?

We collected over 10 million posts and examined the inclusiveness related user feedback both through qualitative analysis and by experimenting with large language models to automatically identify inclusiveness related user feedback. Our study provides the following contributions:

- We propose a two-layer taxonomy of inclusiveness based on user feedback from 50 of the most popular apps in a variety of types of software. Comprising of categories of inclusiveness concerns such as *fairness, technology, privacy, demography, usability* and *other human values,* the taxonomy advances our preliminary, limited understanding of user inclusiveness-related concerns developed in previous research from only open source projects;
- Insights into the different inclusiveness concerns in different application types and feedback sources.
- A manually annotated dataset of inclusiveness-related user feedback that can facilitate future research and practice.
- Insights and empirical results from using large language models to automatically identify inclusiveness related user feedback from multiple sources and which companies and practitioners can leverage to address the inclusiveness concerns of their end users.

#### 2 MOTIVATION

Inclusive software is about designing with everyone in mind and considering the full range of human diversity [10]. Traditionally, software requirements are gathered and incorporated into the software with a more technical focus, often leading to a lack of consideration for diverse user needs. As a result, many users are unable to access particular features or, in some cases, are excluded from using the entire software. App reviews, Reddit posts or tweets offer users a space to express their opinions regarding the software. These sources serve as a rich source of information that can be useful in identifying problems that exclude users from the software.

Figure 1 presents an example from Google Play Store where the user feels excluded from using dark mode on Android and removing the AI bot as they are not a paid subscriber, indicating technical and socio-economic restrictions. Similarly, the Reddit post in Figure 3 and tweet in Figure 2 demonstrates how Facebook disabled the user's account without any explanation and left no further options to appeal. In the Facebook examples, the users experience exclusion from the software as they are unable to access their accounts entirely. Overlooking such issues can eventually lead to the exclusion of a significant number of users from leveraging the full potential of the software. To further illustrate, consider an instance where an app does not support multiple languages. In such cases, it excludes users who do not understand the provided language. Many such issues can be identified from online user feedback that companies should take into account to ensure a more inclusive user experience.

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1. The Al is incredibly predatory, misleading, and annoying. It is forced upon you and cannot be removed, and is pinned at the top of the app. To remove it you need to pay, this is moronic. 2. Dark Mode for iOS has been available for several years. <u>Dark Mode for Android has only recently been</u> released, and it is a paid subscription. 3. Trying to turn off notifications prompts up several pop-ups begging you to turn them on again every time you open the app.

Fig. 1. App review for Snapchat from Google Play Store. Underlined text indicates inclusiveness concern.

7 r/facebook - Posted by u/stevemm70 3 hours ago
Facebook account permanently disabled
Disabled/hacked
I woke up this morning to a number of emails from Facebook, including notifications of password changes, a new email added to my account, and a removal of my actual email. When I started looking into it, I found that my account is now permanently disabled. My assumption is that the person took over my account and then started posting stuff that was against the rules. Facebook says the decision to permanently disable the account cannot be appealed. I've had this account since 2008. It has content about my kids and family members who are no longer with us. I also managed my business page and another for a podcast I host. To say I'm furious is an understatement. I've sent a note to the Facebook support email, but I don't expect to receive a response. I can't believe this happened, and frankly I have no idea HOW it happened.

Fig. 2. Reddit Post from Facebook subreddit. Underlined text indicates inclusiveness concern.

UserName @UserHandle · Aug 14 ···· My friend account was compromised by hackers. I am unable to access it. I request your immediate assistance in unlocking my account. Also, I can't recover my account when I submit my document. @facebook @FacebookGaming @MetaNewsroom @Meta @MetaforDevs #facebookhacked #accounthack

Fig. 3. Tweet from Facebook user. Underlined text indicates inclusiveness concern.

Inclusiveness related issues differ from conventional bug reports and feature requests, as they centre around the user experience rather than only technical aspects. Often, these issues stem from a lack of awareness, and the 3 examples show that there is a need to address inclusiveness related concerns. As illustrated in the examples, online sources carry insights into the various inclusiveness problems encountered by the diverse users of the software. Gaining more knowledge about inclusiveness issues can help raise awareness and design more inclusive software. Therefore, an in depth understanding of the inclusiveness related issues faced by diverse users is needed.

#### **3 RELATED WORK**

In this section, we describe the existing literature on inclusive software and user feedback.

#### 3.1 Inclusive Software

The term inclusive software is related to the notion of "universal access" which implies software that is accessible and usable by everyone [1]. The underlying philosophy behind designing an inclusive product is to ensure that the product can be used by as many different users as possible rather than excluding anyone [11]. A study by Savidis and Stephanidis [1] highlights the significance of providing the necessary tools to support inclusive software design and development. They indicate that an important aspect of inclusive software development is identifying user requirements that emerge from interaction with the software.

Conventionally, software is developed with a focus on the average user, and requirements for the software are developed with this perspective. Recent studies, however, highlight the need for more inclusive software. For example, although software is primarily intended to be neutral, software interfaces often contain stereotypical visual components that negatively impact many users' sense of belonging [12]. Burnett *et al.* [13] revealed that problem-solving software is developed with a perception that users will adopt the features through tinkering. However, statistically, these features are preferred by men than by women, making the software less inclusive for women.

There are some prior works toward building more inclusive software, particularly focusing on gender inclusion. Nunes et al. [14] proposed a conceptual model for genderinclusive requirements that involves creating a genderinclusive requirements document. The document supports practitioners in integrating the model into the requirement elicitation process. Upon evaluation of the model, they found 83.9% positive response in terms of the usefulness of the model [15]. The GenderMag (Gender Inclusiveness Magnifier) method developed by Burnett et al. [13] uses personas encapsulating five facets of gender differences to analyze gender inclusivity in software. An empirical investigation of GenderMag identified biases in an industrial software and helped derive design changes that improved the inclusiveness of the software [16]. Guizani et al., in their study, proposed a Why/Where/Fix approach to find and fix inclusivity bugs in an Open Source Software project. They reported their approach reduced inclusivity bugs by 90%.

While the studies focus on addressing gender-related concerns, the concept of inclusion extends beyond gender. Recent studies have indicated that to make software more inclusive, software companies need to better understand human aspects such as age, emotions, personality, human values, gender, ethnicity, and culture [17], [18]. There are various ways to understand the different human aspects of diverse users. For example, co-design or participatory design techniques where users are invited to participate and provide feedback during the design process [19]. However, as software grows and becomes more prevalent around the world, it becomes difficult for companies to conduct such design sessions. In such cases, CrowdRE (Crowd Requirement Engineering) [20] techniques can be leveraged. In our study, we complement current research and use the CrowdRE method of exploring inclusion from an end-user perspective in comparison to prior studies that focused on understanding inclusion from a developer or designer

perspective.

#### 3.2 User Feedback

Prior literature has shown that user feedback is beneficial for continuous improvement of software quality [21]. User feedback from the online platforms, i.e., from the "Crowd" [22], has been studied to identify a variety of user needs. One common type of user feedback found in app reviews [23], Twitter (now referred to as X) [24], and Reddit [25] are feature requests and bug reports.

More recently, Fazzi et al. [26] analyzed 2,611 app reviews from 57 COVID-19 apps and found nine categories of human aspect related discussions that impact software usage. The authors implied that these human aspects are not always taken into consideration and should be addressed during development. Another study on 1,500 top free Android apps more focused on accessibility issues revealed that the majority of these apps contain significant problems that prevent individuals with disabilities from using the apps [6]. The study demonstrated that various sub-categories of human aspects are identifiable from user feedback, which can raise awareness amongst developers and companies, enabling them to incorporate these insights during development. Similarly, Shahin et al. [5] conducted an analysis of gender related discussions on app reviews and found six major categories: AppFeatures, Appearance, Content, Company Policy and Censorship, Advertisement, and Community. In addition, they automated the identification of gender and non-gender related discussions and acquired an F1-score of 90.77%. Li et al. [4] obtained 4.5 million posts from Reddit and found 9 significant topics related to privacy concerns. Likewise, Olson et al. [27] examined 586 subreddit communities and identified discussions on ethical concerns from end users regarding social platforms. These studies provide empirical evidence that Reddit is a valuable source for gathering and understanding user concerns.

Khalajzadeh *et al.* [7] examined (manually) 1,200 app reviews and 1,200 GitHub issue comments for 12 open source projects and characterised human-centric issues into three major categories: App Usage, Inclusiveness, and User Reaction. They present the categories in the form of a taxonomy for human-centric issues and employ machine learning and deep learning models to automatically classify humancentric issues. 31 inclusiveness related posts were identified from the user feedback in Google Play reviews. While insightful, they represent only a starting point – the open source apps lack the full diversity of software end users and, therefore, are insufficient to build a deeper understanding of diverse end user concerns related to inclusion.

To address the gap, we conduct an analysis of inclusiveness from an end-user perspective and analyze end-user feedback for 50 of the most popular software applications in the world, using three popular sources such as Reddit, Google Play Store, and Twitter. We do not consider GitHub as a source in this study because it primarily represents the developer's perspective rather than that of the end users. Lastly, in contrast to prior work employing an iterative, open coding analysis method, we employ a socio-technical grounded theory [9] approach in our study.

#### 4 METHODOLOGY

In our study we collected user feedback from three popular platforms and employ Socio-Technical Grounded Theory (STGT) [9] method. In particular, we adhere to the STGT data analysis method that includes open coding, constant comparison, and basic memoing. We then proposed a model that can automatically classify inclusiveness related user feedback.

#### 4.1 Data Collection

We collected data from three popular online sources of user feedback: Reddit, Google Play Store, and Twitter. We chose the three sources as prior studies have successfully found software relevant information, such as bugs and features from these channels [23], [24], [25]. Reddit is popular for having a high character limit that allows users to engage in elaborate discussions. A single Reddit post has the room to provide extensive details about a particular issue that otherwise is not available in comparable feedback sources. Google Play Store offers app users to leave reviews about any app, which is useful for software organizations to elicit concerns regarding any particular app. In contrast, Twitter is well known as one of the most popular social media platforms, which supports short form textual user discourse about any particular topic. Twitter has been shown to provide requirement relevant information for organizations to analyze [28].

To compile our data, we collect a list of 50 of the most popular apps from Google Play Store that must have reviews between Jan 1, 2022, and Dec 31, 2022. These apps have a provenance from various domains and are actively installed by a diverse group of users from across the world. This list is used to scrape the data for Reddit and Twitter as well, thereby giving us a unified range of apps. For Reddit, we use a publicly available dataset [29] and obtain over 382K Reddit posts. Next, we collect 9 million app reviews from Google Play using the library Google Play Scraper <sup>1</sup>. Lastly, we use the snscrape library <sup>2</sup> to scrape 841,788 discussions from Twitter.

Once we collect all the data, we filter the original data by removing any empty posts. Additionally, we filter out any post that has less than three words as we believe that posts that cannot satisfy this criterion most likely do not provide meaningful information. We are left with over 3.7 million app reviews, 824 thousand tweets, and 359 thousand Reddit posts.

#### 4.2 Qualitative Analysis

To analyze the data, we used methods from Socio-Technical Grounded theory (STGT) [9]. STGT is a modern Grounded theory approach well suited for research in Software Engineering (SE); it enables a more focused study through a lean (i.e., lightweight) literature review and the utilization of new data collection methods, such as data mining techniques from online sources. STGT can be applied in either its full form, which produces novel theories, or in a more limited manner, utilizing the basic data analysis techniques to establish important categories or initial hypotheses. Due to the exploratory nature of our study, we opted for the second option to analyze online user feedback. Our goal was to develop an understanding of inclusiveness related to user feedback from the end user perspective.

The STGT basic analysis steps consist of open coding, constant comparison, and basic memoing. For the open coding, we first performed random sampling to obtain a large amount of data from all 50 apps and within each of the three sources. We used a random sampling technique with a 99% confidence level and a 2% margin of error, which resulted in 4,113 samples from Reddit, 4,156 from Google Play Store, and 4,140 from Twitter.

To guide our coding technique, in line with the STGT, we conducted a lightweight literature review in preparation for the study to identify the existing understanding of inclusiveness in software engineering (as outlined in the Related Work section). We refer to the definition of inclusiveness from Khalajzadeh et. al [7] and establish the term as "any user concern related to the inclusion, exclusion or discrimination toward a specific individual or group of users while using the software." Based on this definition, two members of the research team analyzed the randomly selected data and assigned a binary inclusiveness or non-inclusiveness label to each post. When a post was given an inclusiveness label, we further included a code based on the characteristics of the feedback. For example, the quote "Worse customer service. Don't any respect for people. Several times Amazon canceled my order without reason. I tried to wake them up about costumer rights, but they prefer to ignore rather than understand the concept. Amazon thinks there is no any consequences for them because this corporation already grows up and don't need to care about us. I really disappointed and sure they will fall in the end" was first labelled as inclusiveness-related. Additionally, the code service was assigned to it as the user expressed frustration about feeling excluded as they do not receive customer support. Table 1 illustrates examples of the labelling process.

Any time a new code emerged for the inclusivenessrelated user concerns, the two human annotators met and discussed the implications of the new code. We used constant comparison method to compare the derived codes across all three user feedback sources and to uncover the underlying patterns and relations between the codes. Our analysis yielded 18 codes under inclusiveness, and which we further grouped into 6 categories. We employed the basic memoing technique to document the reflections on the emerging codes and categories. A significant part of STGT, memoing is encapsulates the researchers' thoughts, enabling a systematic development of categories from the initial codes.

Another important aspect of STGT is theoretical saturation, which means "when data collection does not generate new or significantly add to existing concepts, categories or insights, the study has reached theoretical saturation" [9]. Therefore, the two human annotators continued the labelling process until no new categories emerged and code definitions became stable (i.e.saturation). During this process, our initial random sample became insufficient to reach saturation, and we further randomly sampled additional posts from all three sources and analyzed them until we reached saturation for each category of our analysis. We

<sup>1.</sup> https://github.com/JoMingyu/google-play-scraper

<sup>2.</sup> https://github.com/JustAnotherArchivist/snscrape

TABLE 1 Example Open Coding of Raw Quotes and relationship to the Taxonomy of Inclusiveness

Raw Quote indicating an inclusiveness-related concern	Code (sub category)	Category	
Worse customer service. Don't any respect for people. Several times Amazon canceled my order without reason. I tried to wake them up about costumer rights, but they prefer to ignore rather than understand the concept. Amazon thinks there is no any consequences for them because this corporation already grows up and don't need to care about us. I really disappointed and sure they will fall in the end.	Service	Fairness	
Problem with subscribing to discord nitro, Help? I used to be a nitro subscriber and I had to upload my billing address, it wont recognize my location even though I've tried everything, I wish it would say something like address invalid or incorrect postal code would help a lot	Location	Demography	
This app is horrible. You can't do or say anything that you wanna do or say. If you want to be censored and controlled, then this is the app for you. They want everybody to think the same & what's the fun in that? There is no diversity & no respect, just overbearing control & censorship.	Freedom	Other human values	

stopped labelling when we observed no additional insights emerging from the last 200 posts that we coded from Reddit and Google Play Store. For Twitter, due to the presence of irrelevant discussions in the data, saturation was reached after we coded 500 additional posts.

In total, we labelled 4,647 discussions from Reddit, 4,949 from Google Play Store, and 13,511 from Twitter.

We present categories from our analysis in the form of a two-layer *taxonomy of inclusiveness*, with these six categories forming the primary layer and the 18 codes distributed within each category as a sub-category. The labelled data and memoing can be found in the replication package [30]. In Section 5, we describe the *taxonomy of inclusiveness* with detailed examples.

#### 4.3 Automated Analysis

To analyze the effectiveness of automatically identifying inclusiveness related user feedback, we experimented with a number of classifiers that can automatically classify inclusiveness and non-inclusiveness from the user feedback dataset. Recall in Section 4.2 we collated a large human annotated set of user feedback. This labelled set served as a ground truth for us to train a classifier.

We studied five widely recognized pre-trained large language models (LLMs) that have demonstrated effectiveness in text classification. The five models are: GPT-2 (Generative Pre-trained Transformer 2) [31], BERT (Bidirectional Encoder Representations from Transformers) [32], RoBERTa (Robustly Optimized BERT Approach) [33], XLM-RoBERTa (Cross-lingual Language Model - Robustly Optimized BERT Approach) [34], and BART (Bidirectional and Auto-Regressive Transformers) [35]. Previous work classifying requirements relevant information from text has achieved satisfactory results using these five models [36]. Therefore, we opt for the same set of LLMs.

From the labelled dataset obtained through STGT, we prepared a balanced set of training data, as an imbalanced dataset can lead machine learning models to prioritize the major categories and diminish the minor categories [37]. We report the performance of the classifiers and use 4 widely used evaluation metrics: precision, recall, accuracy, and F1-score.

In the sections that follow, we present the empirical results of our study.

#### 5 A TAXONOMY OF INCLUSIVENESS

To answer our first research question What are the different types of inclusiveness related user feedback found on online sources?, our in-depth analysis of 4,647 discussions from Reddit, 4,949 from App reviews, and 13,511 from Twitter identified a total of 1,211 inclusivess-related posts: 712 from Reddit, 377 from Google Play Store, and 116 from Twitter. Using STGT we derived 6 categories and associated sub-categories of inclusiveness from the three sources, and integrated them into a taxonomy of inclusiveness from end user feedback, as illustrated in Figure 4. In this section, we describe each category with examples from our analysis, indicating in brackets the percentage from each source (while R refers to Reddit and A to app reviews from Google play store, X symbolizes results from Twitter). We note that the reason behind the smaller number of inclusiveness related user feedback from Twitter is due to the presence of posts that are either ads or pertain to some social or political topic rather than the app itself.

#### 5.1 Fairness

The fairness category covers any user feedback where a user describes unfair behaviour or treatment during app usage. It is the most common category and accounts for almost a third of all inclusiveness concerns (R: 29.5%, A: 33.42%, X: 15.6%). Specifically, fairness includes instances where users encounter unfair behaviour from the software, such as bans/restrictions that they cannot resolve or unwanted recommendations. We found that fairness usually concerns three sub-categories: *Terms/Conditions, Recommendation,* and *Services*.

5.1.0.1 *Terms/Conditions*: We observe users frequently complain about unjustified banning or restriction of their accounts. These bans are often a result of the terms and conditions enforced by the software organizations.

(**Reddit**) - "I got banned on YouTube because of malware on my [laptop] and they uploaded scam videos on my account and

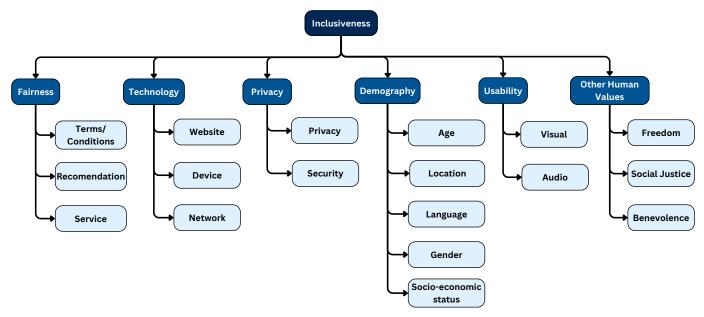


Fig. 4. Taxonomy for Inclusiveness related user feedback from an analysis of Reddit, Google Play and Twitter

I got terminated. Ive got rid of the malware and I requested an appeal now they wont give me my account back." (Youtube) X (Twitter) - "... I am limited still unable to follow. Shadowed or

*limited since 2015. #twitter" (Twitter)* (Play Store) - "I didn't get a account [warning] they just permanently banned me without giving me a warning and it's not my fault kids kept saying "You're 7 8 10" and they don't get banned wow and I want my account back I lost 1k followers and it's not my fault so 1 star for now I try to download my data and make a new account that won't work" (TikTok)

These quotes from the three sources exemplify similar types of issues: perception that the software apps are not *fairly* treating end users and that there is little transparency for what transpired. In the YouTube example, the user feels that it is unjustified for terminating their account for a malware that they did not cause. In the Twitter example, the user describes a limited/shadow banned user experience, and in the Tiktok example, the user describes an account banning without any kind of warning. The commonality between the behaviour of the apps is that account restrictions do not seem impartial. It seems in these scenarios that the apps also suffer from a lack of additional support for users to appeal their case.

(Reddit) - "Facebook disabled both me and my wife's accounts for infringing someone else's intellectual property rights. We never done anything wrong. We admin and manage several groups on Facebook in which members post goods etc. When Facebook send any notifications we go and check and if necessary we remove and ban those members on those specific groups." (Facebook)

X (Twitter) - "… I like how I have been signed out and forced to change my password to something else. … I'd hate to have to cancel my subscription over a forced password changed." (Hulu) ♥ (Reddit) - "So i reported the bots that mass spammed people and the fake link posing as the real account, and what does facebook do? Nothing, refused my report and said it didn't go against community guidelines. It's really weird a huge site like Facebook let scams go untouched, and with the system in place you cannot actually ask them directly or explain the situation." (Facebook) In these examples, we see further examples of users complaining about the perceived lack of fairness in their user experience. Account restrictions and limitations often stem from company policies and are carried out by automated decision-making algorithms, frequently in the form of bots. Software organizations often employ these bots to automatically resolve potential account issues and flag infringing accounts. However, it appears from the perspective of users, many feel that there exists algorithmic bias.

5.1.0.2 *Recommendation*: We uncovered several users expressing frustration with the automated recommendations in the apps. We found this occurring frequently as software apps use machine learning to recommend services or content to users. Users start complaining when they feel that these machine learning systems fail to consider their preferences, which occurs when an app unexpectedly and continuously suggests content that the user does not want to see. When this happens and is not rectified by the app developer, it may cause the user to feel that the app is unfairly treating the user. The recommendations may pertain to content that users did not subscribe to or have marked as unwanted. In addition, they may be subjected to unwanted ads, leading to a feeling of exclusion and causing them to leave the app entirely.

(*Play Store*) - "Worst recommendations on the app. I am spending so much time to see videos on the Fb. I have noticed facebook recommends me the videos that i don't want to see... Every time i am blocking the video page but still it recommends." (Facebook)

(**Reddit**) - "... recently my [Timeline] is full of random reels and post from people I dont follow. Does anyone know how fix this in settings? Its very annoying and usually leads me to closing the app after about 5 minutes." (Instagram)

(Play Store) - "... this app forces you to see [specific news channel] content. You partner with these trash news sites but not enough good ones to round it out. Please stop pushing these machine generated news sites so hard on those who actively don't

#### want it." (Robinhood)

( $\because$ ) (**Twitter**) - "... Im about to delete all other platforms because of the amount of adds. Also, dont really care for meta. Hope to be more active here :) #twitter" (**Twitter**)

**X** (Twitter) - "I just want to say [redacted] #HULU for throwing ads into the middle of a documentary you released about 9/11! Immediately canceling my subscription. Unbelievable and so god damn heartless" (Hulu)

5.1.0.3 *Service*: The service sub-category comprises any inclusiveness feedback related to customer support issues with an app. Although many software apps are straightforward to use and require little manual intervention from app developers in everyday usage, occasional situations become awry, and users interact with customer service or support. Essentially, to foster an inclusive user experience, users should have access to reliable customer service that can help fix user problems when they occur. However, we observe a number of complaints from users about how they receive unfair treatment from app developer representatives who cannot or do not want to resolve conflicts. This impacts user's ability to continue using the app. In particularly challenging circumstances, users find it difficult to contact customer support to report their problems.

(...) (Play Store) - "Venmo just does not seem to work. I have called customer service and they were useless. They have no idea how their product works. I can no longer make purchases and this is made everything difficult. After this experience I would actually recommend people just start deleting this app. It kind of sad because it was useful until the latest update now I can even connect my account. If I could give zero start I would." (Venmo)

(Reddit) - "My personal account got hacked and disable but my business account linked to it still on. I cannot access both. I filled a claim on 10-14 and still nothing! It says due to the few reviewers it may take longer. The thing is my account will be permanently disabled in 8 days if nothing is done. I am thinking about buying an Oculus Quest to try to contact their customer service... Had anyone done this with success? Please post some hope here." (Facebook)

In the Venmo example, the user experienced a lack of customer service that renders their account, and by extension, the Venmo app, useless for the user. The inability to resolve the user's problem creates a sense of exclusion from Venmo's intended functionality. In the Facebook example, the user faces the potential that their account is permanently disabled. The severe lack of customer support is so dire that the user mentioned that they are considering spending money to buy an additional Facebook product so that they may have access to other customer service.

(Reddit) - "I attempted to use my Coinbase Card in a supermarket and it was declined. Upon checking my Coinbase account I receive an error message saying: "You are currently blocked. Sorry, account temporarily disabled. Please contact support" The problem is, support have never answered my support case. I used their telephone support, which said to email them... I have never used Coinbase for any nefarious purposes and have no idea whatsoever of the reason why they would lock my account. ..." (Coinbase)

(Play Store) - "Facing a worse scenario and Your Customer service is unacceptable and very weird! My facebook account has been locked and I'm not able to login regarding that I have mailed you through this gmail but not responded yet. Kindly Reply to my query asap." (Facebook)

**X** (Twitter) - "Making me wait for 15 mins and then connecting call after that disconnecting saying network issue. After they call back and asks for otp which I didn't receive ND again disconnects" (Amazon)

For the user blocked from using Coinbase, they tried phoning and emailing, which all failed to connect with any customer service. Similarly, in the other two examples, users tried emailing and calling but was not successful. These examples demonstrate how users perceive a lack of fair customer service from app developers regarding their problems. More importantly, these examples show a lack of inclusiveness from app developers to restore services back to users currently unable to use their respective apps.

#### 5.2 Technology

This category refers to concerns regarding users experiencing exclusion from a software or feature, due to certain technology restrictions enforced by the developer. It is the second most prevalent category out of the 6 (R: 23.7%, A: 20.69%, X: 32.8%). These limitations arise when developers insist on users having access to particular *website*, *device*, or *network*. Inadvertently, developers may exclude users by specifying certain devices or mandating third-party account access, which may not be applicable to all users. Therefore, user feedback pertaining to the integration of any technological aspect, assuming that users have access to the technology when they do not, falls within this category.

5.2.0.1 *Device*: Users often face the obstacle when features for an app no longer work on a particular device.

(Reddit) - "hey, so I use the discord browser on my tablet to manage multiple accounts, but today I just seem to get a blank grey screen, and visiting their website there's no longer any way to login or access to web browser. Is anything else having this issue? It's really obnoxious, because I'm even visiting through the desktop website, and the formatting on their web browser has been working fine up until now - it's like they've gone out of their way to check my browser and specifically disable a totally functional feature" (Discord)

(*Play Store*) - "Videos stutter and play so choppy on my galaxy s22 ultra. This has gone on since I bought this phone. Please fix this app so videos will play smoothly on this phone. Other people with this phone have had the same complaints. PLEASE FIX!!!" (Amazon Prime Video)

**X** (Twitter) - "How is @hulu not supported on the @Samsung-Mobile Galaxy s22 Ultra?" (Hulu)

From these examples, we see that the lack of support for apps or features in various devices is a recurring problem echoed by users across all three Reddit, Twitter, and app reviews. The impact of inclusiveness related to technology is often quite significant as it is the difference between whether a user can even use an app or not. As seen in the example from Twitter about Hulu on Samsung Galaxy S22 Ultra, the app is not even supported on the particular device.

5.2.0.2 *Network*: In addition to devices, we also observe instances of users retelling issues surrounding their network signal.

(:::) (Play Store) - "the app never works with my wifi. I have to Initiate the app via cellular data, load the show I want to

# *watch, and THEN initiate my wifi connection. I do not have slow internet.*" (Hulu)

We also find users discussing problems that manifest after software updates. Organizations frequently update their software or opt to discontinue the product on devices or networks without providing any prior information to users. This generates frustration and a feeling of exclusion from the software amongst users.

**X** (Twitter) - "... @Microsoft is suddenly refusing mails from my servers, auto-responding "part of [..] network is on our block list (S3150)". Their postmasters, though, just literally told me the 3rd time, that they "were unable to identify anything on our side". Frustrating." (Microsoft Outlook)

(Reddit) - "I have an iPhone SE (2020), and I'm on a "pay as you go" phone plan. When I text with Whatsapp, it uses wifi to send my messages without any problems. However, when I make a voice/video phone call, my Whatsapp will use my "pay you as go" minutes instead of wifi. What is the problem? How do I prevent Whatsapp from using my "pay as you go" minutes when making voice/video phone calls with Whatsapp? I never had this problem when using Whatsapp on an Android phone." (Whatsapp)

We see in these examples the difficulty that users experience when the service provided by the apps suddenly changes without warning. In the complaint from Reddit about Whatsapp, it seems that Whatsapp is only causing this additional surcharge after the users switch their phone from Android to iPhone.

5.2.0.3 *Website*: Similarly, we observe users facing restrictions on the basis of single sign-on or app partnerships. Some apps require users to sign up to another website or app first before granting access. In one example, a user is refused the ability to change the email for their account despite them no longer having access to the email. We also observe instances of users not being able to link information that otherwise works in other platforms.

(Play Store) - "It would be wonderful if I could change the email address so I could use my account that already use my phone number so now I'm just ..... cuz I no longer have access to that email NEED TO CHANGE MY EMAIL ADDRESS OR REMOVE MY PHONE NUMBER SO I CAN CREATE MY ACCOUNT" (Afterpay)

(*Play Store*) - "Cant even link to my bank account. I used Plaid on another app and no issues. Just venmo having issues." (Venmo)

(...) (Play Store) - "Ease of using this app is the biggest joke of the millennium. A person gets a new device and tries to get back in to their account and Facebook and it's associated sites won't permit you to log in. Sends you to a security question where their computers make you select statements you made from 3 months ago. Then it determines that it can't identify its you and blocks you from using the site. Hopefully someone else will develop a better version of Facebook so everyone can delete this obsolete app." (Facebook)

#### 5.3 Privacy

This category relates to any user feedback about *privacy* and *security* concerns such as system permissions, personal data access and compromises (R: 11.8%, A: 16.2%, X: 10.7%). Personal data access covers a large breadth of areas and includes personal information like banking information, social

security number, geographical location, and others. Personal data refers to situations where users are limited from using any software due to the exploitation of their accounts in the app. A hacked account is a common example of this exploitation. Additional user feedback involves concerns about the security of their personal data.

5.3.0.1 *Privacy*: We find numerous examples of users complaining about apps requesting users to give up their privacy.

(Reddit) - "I have been thinking about starting my own depop shop... and at first I thought I was supposed to have a business paypal. In the middle of setting up my account I heard that you needed a personal account instead of a business account. So I went back to my business account and tried to close it, but its making me fill out my ssn and all this stuff about my business when I dont even have one in the first place. I just dont know what to do because I really dont want to put in my ssn." (Paypal)

(...) (Play Store) - "To use this app must turn on GPS (location)" (Facebook)

These user feedback share a common theme. Users frequently cannot use an app or their features without first providing *additional* data. In the case of PayPal, the user seeks to close their account, but they are unable to do so without providing their social security number, which they do not even have. Moreover, in the Facebook example, the user cannot use the app without first turning on GPS and granting the app to the user's location. In either situation, the user cannot complete their desired task without giving up more of their personal data as they face the prospect of being excluded from the software. From what we can see from the feedback, the apps have not successfully convinced the users that providing additional personal data is warranted for the circumstances.

We also observe privacy concerns regarding the terms of service and privacy policies that apps prescribe. In the following example, a user is frustrated that signing up for BeReal means agreeing to a policy for user data that gives unlimited rights to BeReal. The app developer would be able to do whatever they want with user data once uploaded. As described earlier in the section, this is a clear example of an inclusiveness concern as users feel excluded from using an app without, in this particular case, giving *unlimited* rights to their data.

**X** (Twitter) - "@BeReal\_App this is crazy. I wouldn't care if you'd just store those BeReals at your servers, but giving you rights to do anything you want with them? No, thanks. I'm deleting the app." (BeReal)

5.3.0.2 *Security*: Similarly, hacking and security incidents frequently put users in a challenging situation where they cannot access an app or have a reduced sense of customer trust.

(Reddit) - "...You can't just lure people in, give them a reason to lock their money, then you come up with something that you think 'sustainable' in the long run, while people seeing their investment is bleeding. ... Just like Robinhood doing to their customers, see what they got? Their customers are abandoning the platform. You should treat us with respect. Don't ever try to be 'RobbingHood' in crypto. ... With regards to the way you make recent decisions and how centralised the chain is, there is no way in hell I would put my money into CRO again ..." (Crypto.com) (*Play Store)* - "Without my permission I'm getting OTP from the what's app like it showing your what's being registered in new device I don't know who was using my number...it's affect the customer trust" (Whatsapp)

(**Play Store)** - "Many IT Team hacks my whatsapp contact And I can only block them in WhatsApp, why strict action is not taken against them, why there is no option to write anything against them in the report. (FROUD LOTTERY SCAM, LOAN RECOVERY AGENT HARRASMENT SOFTWARE) LIKE ETC," (Whatsapp)

(**Play Store**) - "now today it suddenly shows me that someone other owner changed my account password how's that even possible I shared my id with my friend nd she said it's fine I am very tensed about this please solve this problem as soon as possible" (Instagram)

In all of these instances, users are reporting about perceived fraudulent activity surrounding their account or exploitation of their account. Since access to one's personal account is a basic requirement for any app, software app developers should take precautions if account security issues are a recurring concern. The other concern from users is the perceived inaction or lack of options for users to report fraudulent activities.

#### 5.4 Demography

Demography amalgamates concerns about user feeling excluded due to their demographic factor including *age, gender, language, location,* and *socio-economic status* (R: 12.6%, A: 13.1%, X: 13.9%).

5.4.0.1 *Age*: One common sub-category of demography inclusiveness feedback concerns users griping about age-related policy violations.

(Reddit) - "I hate Twitter so much man Ok so my Twitter got deactivated cause I made it wheN I was 10. I changed my DOB and it suddenly locked me out. This was on Sept 7 and now Im tryna log in and i cant get my account back? Its not recognizing it. Whats going on? How do I get it back? I got 8 years of stuff in there" (Twitter)

Software organizations must follow the law, and many jurisdictions have stringent laws regarding child protection. In the Twitter example, it seems that the user is concerned because they are locked out of their account, which has close to a decade of content. The user is of age now, but it seems that there is limited guidance for supporting the user to unlock their account. We find that age inclusive problems are closely related to the service category. When users have a problem, they tend to try to contact support, but we find users complaining that support is unresponsive or negligent. In the example below, a user attempts to contact TikTok to resolve their age dispute, and they never heard back from the app, nor did their age verification get approved.

(Play Store) - "... I had submitted a claim to get my age verification done after not being able to have the option to add my birthday even though I did it when signed up. Reported it. Team followed up. I then did as they asked. I submitted a second claim and got no response. They ghosted me. It's absolutely ridiculous I followed instructions only to never hear back. Can't view age restricted videos but im over 18. I have now told everyone to avoid this app." (Tiktok) 5.4.0.2 *Location*: Another common sub-category is location, which encapsulates any user feedback about exclusion from using an app based on a user's location. Specifically, location may refer to a user's country, city, province, state, or anything to do with the geographic coordinates.

(...) (Play Store) - "Why ain't Reels available for everyone in every country and Instagram music? It sucks not being able to hear the sounds some [people] post just because IG music isn't available in my region." (Instagram)

(**Reddit**) - "My account got locked and it asked me to verify my phone and email but my country code isn't even an option how am I supposed to verify? Country code is South Africa (+27) (**Twitter**)

(**Reddit**) - "I am aware that paypal supposedly has a minimum amount you can withdraw (around a dollar) but in new zealand you cant withdraw any amount of money. Any amount of money i try to withdraw (tried 20\$) will say "does not meet the minimum amount required to withdraw". I now have money sitting there forever, and need to do some other sales but cant if i cant withdraw the money. On top of this, paypal (that ive been able to see) only does support via phone, on numbers that you cannot call from new zealand. So i essentially have no contact for support, and hence why im asking for help here." (Paypal)

In these examples, users complain about a variety of problems that all relate to exclusion from using the apps properly due to restrictions based on their location. For Instagram, the user feels excluded from the app as music is not available in every country, and the user's country is not on the list of exempt countries. Similarly, a user of Paypal in New Zealand laments that they cannot withdraw money due to location restrictions. In addition to this, Paypal also cannot request support either as Paypal does not provide a local phone number for people in New Zealand.

(reddit) - "Hello! I am trying to open an Etsy shop, but when I try to set up my shop security, by the authenticator app, I just can't... Every code I entered was a correct one, but Etsy said they weren't valid. Now I have too many failed attempts and do not know how to proceed... The other methods do not work for my country... Any tips? Has anybody dealt with this before? Thank you..." (Etsy)

(Play Store) - "I can't close my account after sending funds across the ocean because it's up to a random person in another country to have the knowledge to accept them once sent because of a redundant verification system." (Paypal)

We observe similar location problems when it comes to account opening or closing. An Etsy user complains that they cannot open an Etsy shop because they cannot use codes from the authenticator app, but this was their last opportunity after exhausting all other available attempts to open the account.

(**Reddit**) - "Trying to buy with N26 card from France Used to buy without any problem, now I get this: "We currently do not support the bank cards issued in your country, but we are working on making this a possibility as soon as we can." Did they ban Germany from Binance? What's happening?" (Binance)

We also see location issues that occur from sudden shifts in geographic restrictions. A feature that used to work for users is modified and no longer works for users from a country or state.

**X** (Twitter) - "Pluto TV as Xumo on Firestick needs a VPN in UK" (Pluto TV)

(Reddit) - "Search feature is difficult, many items are not found in intuitive categories, searches bring up 1000 "related" or "suggested" items and you must search thru pages of listings sometimes to find the item you are looking for. When you choose an item and add it to your cart, the app will not allow you to change the delivery method that was chosen by default when you opened the app. The app does not save my location and the "use my location" feature does not work. My default is always Sacramento CA? " (Walmart)

5.4.0.3 *Language*: Closely related to location, we find an assortment of user feedback about language issues. Users often complain about a perceived lack of inclusiveness, where their choice of language is not supported by an app. (Play Store) - "one star because instagram doesn't have Albanian language" (Instagram)

(**Play Store**) - "Usually good, but the change in notification is annoying and confusing, a lot of creators are harassed and receive strikes when they are being harassed, the language configuration is not able to detect the language in content and often send me content in languages I signaled as not interested. ..." (**TikTok**)

We observe from these examples that criticism is directed at the choice of languages in the app and that their choice of content is excluded from the app. End users cannot use an app if their preferred language of choice is not supported by the app developers.

5.4.0.4 *Gender*: We also find user feedback about gender inclusiveness, albeit to a limited extent. In the following example,

(**Play Store**) - "This is such a useful app and it has everything, literally. It has clothes of every style and it's just overall a great app with also things for your house. Everything about this app is great, the only thing I would say could be improved is that the app is based around women and mainly women and maybe could have more advertising for men." (SHEIN)

5.4.0.5 *Socio-economic Status*: Another common problem we find plaguing users is the limitation caused by a user's socio-economic status and payment preference. A number of users explain the issues related to apps being too expensive for them to continue using. We find, in this scenario, that economic status impacts a user's access to the app. When a user is unable or not willing to pay for premium subscription services, the user experiences a sense of exclusion despite their fondness for the app.

(*p*) (**Play Store**) - "Premium features are too expensive. Video/audio calls are very poor when one end has a slow device or poor connection." (**Telegram**)

(Play Store) - "This is a very good place to watch anything you want!! But the price is pretty expensive.....I would really love to keep watching my precious anime on here but I can't keep up with the payments" (Hulu)

#### 5.5 Usability

This category focuses on *visual* and *sound* aspects of accessibility and preference for user interface design. In particular, usability covers any user feedback regarding concerns about software usability (R: 15.3%, A: 8.0%, X: 11.5%).

5.5.0.1 *Visual*: Visual usability concerns are more widespread than audio. There are numerous incidents of users feeling some sort of visual inhibition that prevents them from a painless experience.

**(Reddit)** - "Cant use the app cause the screen is too small to reach [the] button at the bottom wtf who Programms something like that?" (TikTok)

(windows) and it's horrible. Font size is tiny and no way to change? Messages are centered and not left-justified like before. Unable to quick reply - now have to click a menu first, and select "reply"? Put this back the way it was or off to SIgnal et, al. I go" (Whatsapp)

In all of these examples, users reporting their problems experience difficulty using the app due to the visual usability, either due to small font or design that may not consider the user's device. It is representative of a lack of inclusiveness related to user interface design. To offset these issues, app developers would need to consider designing a user interface that considers these diverse user needs. We see from the Whatsapp example that the font size in the user interface is small for the user, but they do not have an option to modify it. The Tiktok example illustrates a problem when the screen is too small, and the app does not consider this problem. To support diverse users with different visual requirements, organizations should consider implementing various visual options.

(Reddit) - "Is it me or has Instagram WEB changed their adblocker policy? I use instagram Web occasionally and without my ublock origin being disabled the main features/buttons are not able to be clicked and not visible either. It couldn't have been more than a few weeks since I could use Instagram with adblocker ON and fully functionally. Now I am getting Ads every other scroll and it's unbearable for an autist like me... I can't tolerate the format and frequency of those ads so I'm going to have to stop using it if no solution can be found" (Instagram)

5.5.0.2 *Audio*: In addition to visuals, we find audio related usability inclusiveness user feedback. As suggested by the sub-category name, audio concerns user feedback where user describes sound issues.

(**Reddit**) - "Discord makes every mic I use super Quiet I've tried basically everything in terms of my discord and my windows settings trying to make my mic sound louder, but nothing works. My friends can barely hear me when I'm on 200%. I've had this issue for a while and it's really frustrating. ..." (Discord)

(*Play Store*) - "Voice call not always audible enough." (*Whatsapp*)

We find instances of users lamenting the lack of audio quality in the usage of the apps. The basic function of communication apps is defeated when users cannot make basic voice calls, and the microphone audio fails to work.

#### 5.6 Other Human Values

We found various posts that indicated the violation of different basic human values and resulted in the user feeling excluded from the software. This category was the least common out of the 6 (R: 7.0%, A: 8.75%, X: 15.6%). Basic human values refer to "principles that guide social life and are modes of conduct that a person likes or chooses among different situations" [38]. To better structure and present such related user feedback, we draw upon Shalom H. Schwartz's [39] theory of basic human values. The theory amalgamates 58 values grouped into 10 categories. In our dataset, we identified user concerns related to 3 values

*freedom, social justice,* and *benevolence*. We identified users expressing exclusion from the app when they perceive a violation of these human values.

5.6.0.1 *Freedom*: This sub-category particularly advocates for "freedom of thought or speech," often tied to ideals of equality. We found users describing their feelings of exclusion from freely providing their thoughts or interjecting their voices. Many users express frustration about being restricted from voicing their opinion in any given app.

(Play Store) - "They ban users for political views. Not acceptable!" (Cash App)

(Play Store) - "It restricted our account when We say true words and we say true words about human rights because if we say about some places or people that don care about human rights when we say our account restricted" (Facebook)

**X** (**Twitter**) - "You officially lost a customer you are a big time loser facebook learn to respect freedom of speech!" (**Instagram**)

**(Reddit)** - "I got banned from Tik Tok because I posted a picture of Turkish Homelander, literal censorship" (**TikTok**)

(**Play Store)** - "I remember when Facebook was fun, not it's not any longer. It was a place to connect with family and friends. A place to talk and share thoughts and ideas but since it started to censor speech it's no longer a place to be." (Facebook)

All these examples suggest that users with specific opinions may feel marginalized or excluded from these platforms as their ability to freely express themselves is being restricted.

5.6.0.2 *Social Justice*: We found many user complaints regarding social justice, leading users to experience a sense of exclusion within the app. Social justice refers to a commitment to ensure that all members of society, irrespective of their race, religion, gender, or other characteristics, have equal access to opportunities and resources, in this context, equal access to the app and all the features. However, our results indicate a different scenario.

(*Play Store*) - "This app is based on Islamophobia. We cannot post openly about Islam. If we do, they give restrictions on our accounts much needed to improve" (*Facebook*)

(**Play Store**) - "They support racism and conspire in front of the Arabs. ..." (Facebook)

(Play Store) - "Completely biased platform always support muslims and Christians. Always hindu phobic" (Instagram)

5.6.0.3 *Benevolence*: This sub-category pertains to users feeling excluded due to their concern about the well-being of people they interact with on a regular basis, i.e., family and friends [39] We particularly found instances where users believe the software lacks child-friendly content and lacks features that could improve the overall family experience.

(Reddit) - "My young kids love watching YouTube. But I'm really uncomfortable letting them have unfettered access to the full YouTube content. There is a lot of disturbing content and the algorithms are known for luring people into extreme content. I have Roku TVs and the YouTube for Kids app is unavailable. ..." (Youtube)

(Play Store) - "... The recent video released of Disney internal meets proves they dont have the best interest of children in mind. When you decide to make wholesome content again and stop pushing sexuality on children is when we will spend money with you again. From now on our home will be Disney free. ..." (Disney+) (Reddit) - "Trying to add grandma to my daughter's kid messanger and keep getting an error please try again later message when I try to approve her and nothing has fixed it. ... We live far away from my parents so this is really the only way my mom gets to see her and the fact that it's not working only for her is very frustrating..." (Facebook)

RQ1: We find six major categories of inclusiveness, ranked in order of prevalence: *fairness, technology, demography, privacy, usability, other human values,* and which we present in the form of a taxonomy of inclusiveness.

Fairness - Technology - Privacy - Demography - Usability - Other Human Values

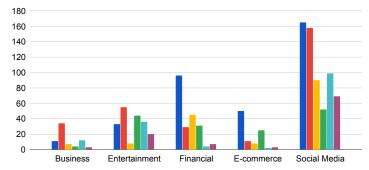


Fig. 5. App Category Distribution

## 6 INCLUSIVENESS CONCERNS IN DIFFERENT TYPES OF APPS

To answer our second research question, *How does inclusiveness related user feedback differ for different types of apps?*, we analyzed the distribution of the six major categories in our taxonomy across the fifty apps in our dataset, which consisted of five types of software: business, entertainment, financial, e-commerce, and social media (with ten apps in each type of software). Table 2 illustrates the total number of inclusiveness related user feedback in the five types of apps from across the three sources. We found that 633 out of 1,211 of the inclusiveness related user feedback emerged from *social media* apps. This is followed by *financial* apps (212) and *entertainment* apps (196). Whereas *e-commerce* (99) and *business* (71) software contain the least number of inclusiveness posts.

The distribution of the inclusiveness categories is shown in Figure 5.*Fairness*-related concerns represent the most frequently discussed (355 out of 1,211) category and is more prominent for *social media, financial,* and *e-commerce* apps. On the contrary, *technology* is the more dominant category in *business* and *entertainment* software and a close second for *social media* apps.

*Social media* consists of a significant number of user feedback from the 6 categories, particularly for *fairness*, *technology*, *and usability*. These three from *social media* surpass even the most popular categories for the other app types. However, we note that the other three categories, *privacy*, *demography*, and *other human values*, are still more frequently occurring than in the other apps.

TABLE 2 Total number of inclusiveness related user feedback in the 5 types of Apps from Reddit, Google Play Store, and Twitter

Арр Туре	Source	Technology	Privacy	Fairness	Demography	Other Human Values	Usability	Total
	Reddit	20	3	4	3	2	5	37
Business	Play Store	6	3	7	1	0	2	19
	Twitter	8	1	0	0	1	5	15
	Total	34	7	11	4	3	12	71
	Reddit	34	6	18	22	14	25	119
Entertainment	Play Store	13	1	12	9	3	5	43
	Twitter	8	1	3	13	3	6	34
	Total	55	8	33	44	20	36	196
	Reddit	17	35	65	26	4	3	150
Financial	Play Store	9	8	30	5	3	1	56
	Twitter	3	2	1	0	0	0	6
	Total	29	45	96	31	7	4	212
	Reddit	5	5	20	15	1	1	47
E-commerce	Play Store	4	1	22	9	1	1	38
	Twitter	2	2	8	1	1	0	14
	Total	11	8	50	25	3	2	99
	Reddit	93	35	103	24	29	75	359
Social Media	Play Store	46	48	55	25	26	21	221
	Twitter	19	7	7	3	14	3	53
	Total	158	90	165	52	69	99	633
	Reddit	169	84	210	90	50	109	712
Total	Play Store	78	61	126	49	33	30	377
	Twitter	40	13	19	17	19	14	122
	Total for all	287 (24%)	158 (13%)	355 (29%)	156 (13%)	102 (8%)	153 (13%)	1211

We also observed varying levels of popularity for each category depending on the type of app. For example, 45 out of 121 inclusiveness concerns for *financial* apps are about *privacy*, which is to be expected as *financial* apps obtain confidential information from users, and it is their responsibility to adequately safeguard this data. Similarly, we find *demography* to be a popular category for *entertainment* type of software. *Demography* being popular in this context appears reasonable, given that location, language, and socioeconomic status may impact the content provided or suggested in *entertainment* apps. For *business* apps, we found *technology* as the most popular. Since productivity is critical for *business* apps, technological restrictions that prevent users from completing their tasks and work would definitely be a high area of concern.

RQ2: Fairness is most prominent for social media, financial and e-commerce apps, whereas technology is most common for business and entertainment apps.

# 7 INCLUSIVENESS ACROSS DIFFERENT SOURCES OF USER FEEDBACK

To answer our third research question, *How does inclusiveness related user feedback differ across different sources of feedback?*, we analyzed the distribution of the categories in our taxonomy across the three sources. As shown in Table 2, *Reddit* has a far greater number of inclusiveness user feedback in comparison to the other two sources. After all, *Reddit* has by far the largest character limit among the sources and is a platform for users to engage in long form discussion. Therefore, users often share a breadth of details,

including inclusiveness problems. Particularly, we found the inclusiveness feedback materializing in the *fairness* and *usability* categories, where users are likely to give detailed descriptions of their unfair or poor usability experience.

In contrast, we observe slightly different popular categories for *Play Store*. We discovered that *privacy* is a more prominent category for *Play Store*, which makes sense as users who encounter *privacy* or *security* issues in an app can directly voice their reviews to warn other potential app users. For *Twitter*, the popular categories differ slightly, and *technology* is by far the common category. Since *Twitter* is most often a platform for users to contact support or voice real time feedback, users will discuss device or network *technology* problems when they occur.

RQ3: Reddit contains more inclusiveness feedback in comparison to Twitter and Google Play Store. Fairness is most common for Reddit and Play Store, but technology is most common for Twitter.

# 8 AUTOMATED IDENTIFICATION OF INCLUSIVE-NESS USER FEEDBACK

In answering our fourth research question, *How effective are pre-trained large language models in automatically identifying inclusiveness related user feedback?*, we assessed the effectiveness of the five LLMs, as detailed in Section 4.3 through evaluating the same dataset. We fine-tuned the pre-trained models on each of the sources and measured the performance in terms of precision, recall, F1-score, and accuracy. The performance results of the five models for each source are outlined in Table 3. We found that the overall evaluation results are best for Twitter user feedback. All the evaluation metrics are above 0.85 for Twitter for all five different classifiers. Among the five classifiers, we find BART to have the best results in terms of F1-score, achieving a value of 0.930. One possible reason for the better performance on Twitter may be that Twitter data has a lot of unrelated discussion (e.g. ads), making it relatively easier for the classifier to differentiate between inclusiveness and non-inclusiveness. Since there are many Twitter posts that consist of completely random dialogue or topics obviously unrelated to inclusiveness, this may help the models to classify the user feedback.

We observe that the classification results for app reviews are not as good as Twitter's (i.e., roughly 8-12% lower). For Play Store, the best performing classifier is BERT, with an F1-score of 0.849. There are many user feedback reviews that report bugs concerning the apps, but not all of these bug reports are about inclusiveness. This may be a reason for the increased difficulty for the classifiers to identify inclusiveness in app reviews.

Finally, we observed the classifiers exhibiting a comparatively lower performance on Reddit in comparison to the other feedback sources. The best performing classifier for Reddit data is GPT-2, whereas the overall performance for classifiers for Reddit is roughly 8-14% lower than Twitter. The most likely reason why performance on Reddit is lower is that user feedback from Reddit is often complex and detailed in nature, which may contain an assortment of topic discussions. Identifying the inclusiveness aspect in a Reddit post is less clear cut than in a Twitter post or app review.

TABLE 3 Results of Different Deep Learning Models on Classifying between Inclusiveness and Non-Inclusiveness.

Source	Model	Precision	Recall	F1-Score	Acc.
Reddit	GPT-2	0.903	0.812	0.838	<b>0.813</b>
	BERT	0.895	<b>0.813</b>	0.837	0.803
	RoBERTa	0.899	0.785	0.802	0.772
	XLM-RoBERTa	0.887	0.768	0.802	0.772
	BART	<b>0.904</b>	0.769	0.805	0.776
Google Play Store	GPT-2 BERT RoBERTa XLM-RoBERTa BART	0.934 0.930 <b>0.940</b> 0.926 0.928	0.775 <b>0.806</b> 0.739 0.801 0.767	0.828 <b>0.849</b> 0.802 0.845 0.822	0.778 <b>0.811</b> 0.737 0.798 0.766
Twitter	GPT-2	0.992	0.851	0.911	0.851
	BERT	0.992	0.853	0.913	0.852
	RoBERTa	0.992	0.863	0.919	0.861
	XLM-RoBERTa	0.991	0.850	0.911	0.851
	BART	0.992	<b>0.884</b>	<b>0.930</b>	<b>0.881</b>

RQ4: GPT-2 achieves the best results for Reddit, BERT achieves the best results for app reviews, and BART gets the best results for Twitter in identifying inclusiveness-related user feedback.

#### 9 DISCUSSION

In this study, we propose a taxonomy of inclusiveness related user feedback based on an in-depth analysis of user feedback on fifty popular software apps using methods from socio-technical grounded theory [9]. Our approach involved labelling over 23 thousand user feedback posts across three popular sources of user feedback: Reddit, Google Play Store, and Twitter. The analysis resulted in identifying 1,211 user feedback related to inclusiveness. Having developed a labelled set, we also conducted an empirical investigation on a set of popular pre-trained large language models to classify user feedback from the three sources into inclusiveness or not. We achieved an F1-scores of 0.838. 0.849 and 0.938 for Reddit, Google Play Store, and Twitter, respectively. The promising scores indicate that the models are effective in

#### 9.1 Comparison with Related Work

identifying the inclusiveness-related user feedback.

Previous work on human aspects provided a preliminary introduction to inclusiveness based on their analysis from GitHub and Google Play Store [7] from both the developer and user perspectives. However, our study focused specifically on inclusiveness from the end user perspective. Furthermore, the prior work focused on open source software, which may not reflect the entirety of end users or software apps. Only a fraction of users use open-source software, and even fewer provide user feedback. The prior research reported only 31 posts from Google Play Store related to inclusiveness, whereas our work identified a higher amount (1,211), indicating a greater representation of inclusiveness. Additionally, the vast majority of apps, especially the popular ones, are not open source, ranging from social media, entertainment, and business apps. Thus, an understanding of inclusiveness issues from a larger user base was required. In our study, we focused on popular for-profit apps used by millions of users across the world to obtain a more diverse representation of users.

In the work by Khalajzadeh *et al.* [7], the authors included 5 sub-categories under inclusiveness: *compatibility, location, language, accessibility, and others.* In our study, we identified the presence of these sub-categories. However, we categorize them under different higher level categories for better restructuring.

The *compatibility* category, for instance, aligns closely with our technology category. Their category is primarily about the compatibility across different devices and platforms, considering socio-economic factors. Whereas we focus on concerns related to users encountering restrictions set by developers. We include socio-economic concerns under *demography* in our taxonomy as the feedback is more in line with dimensions of demographics. Regarding the *location* and language sub-categories, we choose to reclassify them within the demography category in this study. This was done as the two categories were not as dominant in our dataset compared to the previous work. Hence, amalgamating them into the *demography* category helped to achieve more clarity and better structure. Furthermore, we encountered only a small amount of user feedback explicitly emphasizing accessibility. Whereas we observed a broader distribution of posts focusing on visual and audio usability. Therefore, any accessibility posts were subsequently placed under the two types of **usability**, ensuring a more structured distribution of the user feedback related to accessibility concerns.

# 9.2 Algorithmic Bias in software apps: A Barrier to Inclusiveness

Our manual analysis allowed us to uncover various inclusiveness issues that users face while using the software. One of the key problems that emerged throughout the analysis was algorithmic bias. With the rapid evolution of AI, companies are increasingly inclined towards integrating algorithms in their decision making process. As such, many features are automated and often exhibit biases towards certain users [40]. Algorithmic bias predominately originates from underrepresented data and biased methods [41]. These biases create both a perceived and real non-inclusive experience for users.

In Section 5, when we discussed the *fairness* category, we described how the automated decision-making process leads to the exclusion of users from software or specific features in a software. For example, Facebook heavily relies on their algorithms for content review process. AI decides if a content is allowed on their platform based on Community Standards [42]. Our analysis revealed many users complaining about being banned from the platform due to policy violations without warning nor prior notification. In these cases, users have no idea what action even triggered the ban or account restriction. Despite the company asserting that users can seek a repeal if they believe their content aligns with the community standards, our observations in our fairness category reveals a contrasting reality.

(Reddit) - "I wanted to get started with Facebook ads and was really motivated about it. Only to find out that somehow my account on Meta Business was disabled, I tried to appeal but it somehow got rejected. I ended up purchasing another domain in order to create another account but during the creation of the facebook account (even though all the information was different compared to my main account), it instantly got disabled and told me to appeal. I feel like the situation is going to repeat itself. I've tried hard to find some support, but after hours of searching I didn't find anything." (Facebook)

Our *fairness* category has numerous similar examples where users experience a lack of support and must rely on automated algorithms to make further decisions. Similar to this example, many software organizations incorporate AI to make decisions and that creates more frustration and a feeling of exclusion amongst the users. We find similar patterns manifesting in other inclusiveness categories as well, such as *other human values*, where users report frustrations from apps enforcing their beliefs on users. In an ideal scenario, recommender systems would learn from user preferences and tailor them. However, we observe opposite instances where users receive engagements and recommendations that deviate from what they actually anticipate or prefer.

In recent years, there have been numerous instances of biased AI systems that have come to light. Famous incidents exposing biased AI systems include the COMPAS recidivism algorithm [43], which had a significantly greater likelihood of incorrectly judging black defendants in comparison to white defendants, whereby black defendants were more likely flagged as high risk. Recently, Meta, formerly known as Facebook, agreed to a settlement after it was revealed they implemented features in its advertising to exclude specific groups of people [44].

Stemming from these examples, the study of reducing bias in machine learning systems is actually a large subject area [45]. Several studies explore reducing bias in AI systems, particularly for those that conduct automated decision making [46], [47]. These studies attempt to research how to minimize algorithmic bias from a data collection, model training and testing level. However, as our study indicates, organizations should avoid completely relying on AI for decision making, whether it is adhering to community standards or generating recommendations.

#### 9.3 Culture: A Factor impacting Inclusiveness

An interesting observation emerging from our analysis indicates the potential underlying influence of culture on the inclusiveness related user feedback. Culture is defined as the "collective programming of the mind which leads to a common way of doing things by a group of people in a larger society" [48]. The taxonomy proposed in our study illustrates how a lack of inclusiveness can impact a user's experience using a software. The apps we analyzed have millions of users from different cultural backgrounds. However, app developers may not be aware of all the different cultural aspects, expectations, norms, and experiences. This may lead to the development of software that fails to meet the users' expectations, resulting in a lack of inclusiveness.

To discuss the potential influence of culture, we draw on Hofstede's Cultural Dimensions Theory [48] and consider, for example, the concepts of *individualism* and *collectivism*. Technology typically demonstrates the characteristics of the culture in which it is developed in [49]. However, depending on the user and their cultural background (i.e., individualistic or collectivistic), they may expect different functionalities. When software fails to adhere to different cultural expectations, users feel frustrated and consider leaving the app. The frustrations may be attributed to complicated or biased features, lack of available technology, and even technological literacy.

From our taxonomy categories like *privacy*, *demography*, and *other human values*, we see representative quotes that indicate a potential impact of ethnic culture and user preferences. This is a fruitful direction for future research as the cultural impact on system usage and end user preferences is largely unexplored. A study on culture and user feedback reported that aspects like length of the review, sentiment, ratings and amount of useful feedback provided by users on app reviews can indicate the user's cultural background in terms of Uncertainty Avoidance and individualism/collectivism [50]. However, these aspects focus more on the characteristics of the feedback and lack an analysis of the actual content, which may help to understand the challenges users encounter due to cultural differences.

In our study, for instance, we found a user wishing the app would allow access to his wife, which exemplifies a collectivist point of view. (Play Store) - "I like the app but you need to change your policy I would like to add access for my wife." (Robinhood) Similarly, in the benevolence subcategory under other human values, we found users expressing a desire to include family members in their software. The inability to do so results in a sense of exclusion.

A study conducted in rural India reported that often, only one male member of the family owns a mobile phone, and other members can only use it when the male member is around [51]. Another telling example is from an ethnographic study of ATM introduction in India where it is highlighted that people often shared their bank account cards with friends and family [52]. When first introduced to the ATM, they approached the learning process as a group and showed less concern about sharing sensitive information. This suggests a collectivist cultural perspective where concern for privacy is not as prominent as in an individualistic culture. Thus, depending on the cultural background, users may prefer software features that accommodate their situation. Failing to consider these cultural nuances can generate a sense of exclusion among users and influence them to stop using the app entirely. Therefore, for a software to be more inclusive, it is important that users' cultural context is understood.

#### 9.4 Implications for Practitioners

For practitioners, our empirical study shows the importance of considering user feedback for inclusiveness, as well as provides a practical approach to identifying inclusiveness related user feedback for their software. We detail a number of implications for practitioners here:

- The taxonomy of inclusiveness can be used to categorize user feedback so that the issues are easy to identify and resolve. Developers are predominantly male, technically skilled, and affluent, therefore significantly different from the diverse end-users they serve. Awareness of the inclusiveness issues will allow them to learn and consider the diverse user needs and develop more inclusive software.
- 2) The increasing use of AI-enabled systems is resulting in a lack of inclusiveness which requires more attention. Even though automated AI-enabled systems are useful, they lack a sense of inclusiveness, and the issue is becoming a serious concern because generative AI techniques are deployed aggressively now. Our study highlights these inclusiveness issues that practitioners should recognize and consider during development.
- 3) Companies can prioritize the specific inclusiveness concerns based on our findings for each type of app. Many software companies are often resource constrained and lack the resources to address every single user need. Our study results brings categories identified from five types of software: business, entertainment, financial, shopping, and social media. We indicate which categories are more prevalent in each type of software that the companies can leverage accordingly.
- 4) The automated approach proposed in this study provides potential solutions in the form of automated flagging (i.e. a plugin) on source platforms to address the limitations of the current manual approach in identifying inclusiveness related user feedback. Online platforms like Reddit, Google Play Store, and Twitter generate a large number of user reviews, posing a challenge for companies to manually identify the issues. A plugin tool that automatically flags inclusiveness issues could enable companies to easily detect the inclusiveness related feedback from the

respective pages on Reddit, Twitter, and Google Play Store.

#### 9.5 Implications for Researchers

Our findings carry several implications for future work:

- More research should be conducted with practitioners to understand how they address the inclusiveness user feedback, particularly how organizations manage inclusiveness requirements.
- Researchers should focus more attention on studying additional sources of user feedback. These additional sources may help refine the categories and subcategories in our taxonomy.
- 3) Our study presents a large number of manually labelled inclusiveness related user feedback. Future researchers can leverage this data to conduct studies on improving the automated classification approach and automated identification of the categories of inclusiveness.
- 4) We found that inclusiveness concerns are often the result of human value violations. A number of issues are related to Schwartz's theory [39]. Future research can further explore if there is a prevalence of other categories from the theory.
- 5) In addition, we suggest that culture may potentially influence end-users' perception of inclusiveness. Therefore, we believe that studying the cultural context from the end user perspective is valuable as it may help make software more inclusive.

#### 9.6 Threats to Validity

We describe several threats and mitigation strategies in our study using the total quality framework of Roller [53].

*Credibility* indicates "the completeness and accuracy associated with data gathering" [53]. This study may have the threat of sampling bias because we collected user feedback from 50 apps from the sources of feedback. However, we selected a diverse group of apps, and the feedback sources are also common platforms that users often use to discuss concerns. Our study also used standard web scraping libraries to collect the data. Additionally, we try limiting bias by creating a randomly sampled batch of user feedback to conduct manual annotation. We did not seek to give more weight to any particular app or source of feedback.

Analyzability refers to "completeness and accuracy related to the processing and verification of data" [53]. We analyze the data with two co-authors who follow a social technical grounded theory approach [9], where open coding, constant comparison, and memoing were used to analyze the feedback for inclusiveness. Furthermore, the co-authors were in constant dialogue during the coding process to ensure consistency and remove bias. Since this study leverages user feedback from three popular sources (i.e., Reddit, Twitter, and Google Play) and different apps, we were able to triangulate our analysis with the different sources.

*Transparency* is the "completeness of the final documents and the degree to which the research can be fully evaluated and its transferability" [53]. We provide extensive and rich descriptions of our methodology, as well as detailed quotes to support our taxonomy. The entirety of our data is provided in our replication package, including our manually labelled dataset [30].

Usefulness specifies the "ability to do something of value with the research outcomes" [53]. Our study aims to shed more insight into the role of inclusiveness in user feedback. More importantly, our study aims to advance the state of knowledge of inclusiveness by providing a taxonomy for the different types of inclusiviness related discussions. In particular, our study encompasses a significant number of user feedback and includes more empirical insights for organizations. We acknowledge that our results may not hold for every software app, but we believe organizations can benefit from the inclusiveness categories as they try to consider the concerns from diverse end users.

# **10** CONCLUSION

Our study follows a socio-technical grounded theory approach to gain a deeper understanding of inclusiveness related user feedback from end users. Across manual analysis of over 23K user feedback posts from Reddit, Twitter, and Google Play Store regarding 50 popular for profit apps, we build a taxonomy of inclusiveness. Our taxonomy has six main categories, including fairness, technology, privacy, demography, usability, and other human values. The classifier that we train on our data shows that we can automatically identify inclusiveness related feedback among general user feedback. Our results indicate to practitioners that these online sources contain a rich trove of inclusiveness feedback that organizations should consider to build more inclusive software products for diverse end users. We also present our labelled dataset that researchers can use to refine tooling to better support practitioners.

#### REFERENCES

- A. Savidis and C. Stephanidis, "Inclusive development: Software engineering requirements for universally accessible interactions," *Interacting with Computers*, vol. 18, no. 1, pp. 71–116, 2006.
- [2] J. Shepherd, "23 essential twitter statistics you need to know in 2023," https://thesocialshepherd.com/blog/twitterstatistics#: :text=TwitterMay 2023.
- [3] T. Gaurdian, "Twitter apologises for 'racist' image-cropping algorithm," https://www.theguardian.com/technology/2020/sep/21/twitterapologises-for-racist-image-cropping-algorithm, 2020.
- [4] Z. S. Li, M. Sihag, N. N. Arony, J. B. Junior, T. Phan, N. Ernst, and D. Damian, "Narratives: the unforeseen influencer of privacy concerns," in 2022 IEEE 30th International Requirements Engineering Conference (RE). IEEE, 2022, pp. 127–139.
  [5] M. Shahin, M. Zahedi, H. Khalajzadeh, and A. R. Nasab, "A
- [5] M. Shahin, M. Zahedi, H. Khalajzadeh, and A. R. Nasab, "A study of gender discussions in mobile apps," *arXiv preprint arXiv*:2303.09808, 2023.
- [6] A. Alshayban, I. Ahmed, and S. Malek, "Accessibility issues in android apps: state of affairs, sentiments, and ways forward," in *Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering*, 2020, pp. 1323–1334.
- [7] H. Khalajzadeh, M. Shahin, H. O. Obie, P. Agrawal, and J. Grundy, "Supporting developers in addressing human-centric issues in mobile apps," *IEEE Transactions on Software Engineering*, 2022.
- [8] J. Tizard, T. Rietz, X. Liu, and K. Blincoe, "Voice of the users: an extended study of software feedback engagement," *Requirements Engineering*, vol. 27, no. 3, pp. 293–315, 2022.
- [9] R. Hoda, "Socio-technical grounded theory for software engineering," *IEEE Transactions on Software Engineering*, vol. 48, no. 10, pp. 3808–3832, 2021.

- [10] K. B. M. , "Designing inclusive software in Windows - Windows apps," https://learn.microsoft.com/enus/windows/apps/design/accessibility/designing-inclusivesoftware, may 13 2022.
- [11] M. Pattison and A. W. Stedmon, "Inclusive design and human factors: Designing mobile phones for older users." *PsychNology J.*, vol. 4, no. 3, pp. 267–284, 2006.
- [12] D. Metaxa-Kakavouli, K. Wang, J. A. Landay, and J. Hancock, "Gender-inclusive design: Sense of belonging and bias in web interfaces," in *Proceedings of the 2018 CHI Conference on human factors in computing systems*, 2018, pp. 1–6.
- [13] M. Burnett, S. Stumpf, J. Macbeth, S. Makri, L. Beckwith, I. Kwan, A. Peters, and W. Jernigan, "Gendermag: A method for evaluating software's gender inclusiveness," *Interacting with Computers*, vol. 28, no. 6, pp. 760–787, 2016.
- [14] I. Nunes, A. Moreira, and J. Araujo, "Conceptual modeling of gender-inclusive requirements," in *International Conference on Conceptual Modeling*. Springer, 2021, pp. 395–409.
- [15] —, "Gire: Gender-inclusive requirements engineering," Data & Knowledge Engineering, vol. 143, p. 102108, 2023.
- [16] M. Vorvoreanu, L. Zhang, Y.-H. Huang, C. Hilderbrand, Z. Steine-Hanson, and M. Burnett, "From gender biases to gender-inclusive design: An empirical investigation," in *Proceedings of the 2019 CHI Conference on human factors in computing systems*, 2019, pp. 1–14.
- [17] J. C. Grundy, "Impact of end user human aspects on software engineering." in ENASE, 2021, pp. 9–20.
- [18] J. Grundy, I. Mueller, A. Madugalla, H. Khalajzadeh, H. O. Obie, J. McIntosh, and T. Kanij, "Addressing the influence of end user human aspects on software engineering," in *International Conference on Evaluation of Novel Approaches to Software Engineering*. Springer, 2021, pp. 241–264.
- [19] S. Donetto, P. Pierri, V. Tsianakas, and G. Robert, "Experiencebased co-design and healthcare improvement: realizing participatory design in the public sector," *The Design Journal*, vol. 18, no. 2, pp. 227–248, 2015.
- [20] E. C. Groen, J. Doerr, and S. Adam, "Towards crowd-based requirements engineering a research preview," in *Requirements Engineering: Foundation for Software Quality: 21st International Working Conference, REFSQ 2015, Essen, Germany, March 23-26, 2015. Proceedings 21.* Springer, 2015, pp. 247–253.
- [21] D. Pagano and B. Bruegge, "User involvement in software evolution practice: A case study," in 2013 35th International Conference on Software Engineering (ICSE). IEEE, 2013, pp. 953–962.
- [22] E. C. Groen, N. Seyff, R. Ali, F. Dalpiaz, J. Doerr, E. Guzman, M. Hosseini, J. Marco, M. Oriol, A. Perini *et al.*, "The crowd in requirements engineering: The landscape and challenges," *IEEE software*, vol. 34, no. 2, pp. 44–52, 2017.
  [23] W. Maalej and H. Nabil, "Bug report, feature request, or simply
- [23] W. Maalej and H. Nabil, "Bug report, feature request, or simply praise? on automatically classifying app reviews," in 2015 IEEE 23rd international requirements engineering conference (RE). IEEE, 2015, pp. 116–125.
- [24] G. Williams and A. Mahmoud, "Mining twitter feeds for software user requirements," in 2017 IEEE 25th International Requirements Engineering Conference (RE). IEEE, 2017, pp. 1–10.
- [25] T. Iqbal, M. Khan, K. Taveter, and N. Seyff, "Mining reddit as a new source for software requirements," in 2021 IEEE 29th International Requirements Engineering Conference (RE). IEEE, 2021, pp. 128–138.
- [26] M. Fazzini, H. Khalajzadeh, O. Haggag, Z. Li, H. Obie, C. Arora, W. Hussain, and J. Grundy, "Characterizing human aspects in reviews of covid-19 apps," in *Proceedings of the 9th IEEE/ACM International Conference on Mobile Software Engineering and Systems*, 2022, pp. 38–49.
- [27] L. Olson, E. Guzmán, and F. Kunneman, "Along the margins: Marginalized communities' ethical concerns about social platforms," arXiv preprint arXiv:2304.08882, 2023.
- [28] E. Guzman, M. Ibrahim, and M. Glinz, "A little bird told me: Mining tweets for requirements and software evolution," in 2017 IEEE 25th International Requirements Engineering Conference (RE). IEEE, 2017, pp. 11–20.
- [29] Watchful1, "Subreddit comments/submissions 2005-06 to 2022-12." [Online]. Available: https: //www.reddit.com/r/pushshift/comments/11ef9if/separate\_ dump\_files\_for\_the\_top\_20k\_subreddits/
- [30] N. N. Arony, Z. S. Li, B. Xu, and D. Damian, "Inclusiveness Matters: A Large-Scale Analysis of User Feedback," Oct. 2023. [Online]. Available: https://doi.org/10.5281/zenodo.10050673

- [31] A. Radford, J. W. Kim, T. Xu, G. Brockman, C. McLeavey, and I. Sutskever, "Robust speech recognition via large-scale weak supervision," in *International Conference on Machine Learning*. PMLR, 2023, pp. 28 492–28 518.
- [32] J. Devlin, M.-W. Chang, K. Lee, and K. Toutanova, "Bert: Pretraining of deep bidirectional transformers for language understanding," arXiv preprint arXiv:1810.04805, 2018.
- [33] Y. Liu, M. Ott, N. Goyal, J. Du, M. Joshi, D. Chen, O. Levy, M. Lewis, L. Zettlemoyer, and V. Stoyanov, "Roberta: A robustly optimized bert pretraining approach," arXiv preprint arXiv:1907.11692, 2019.
- [34] A. Conneau, K. Khandelwal, N. Goyal, V. Chaudhary, G. Wenzek, F. Guzmán, E. Grave, M. Ott, L. Zettlemoyer, and V. Stoyanov, "Unsupervised cross-lingual representation learning at scale," arXiv preprint arXiv:1911.02116, 2019.
- [35] M. Lewis, Y. Liu, N. Goyal, M. Ghazvininejad, A. Mohamed, O. Levy, V. Stoyanov, and L. Zettlemoyer, "Bart: Denoising sequence-to-sequence pre-training for natural language generation, translation, and comprehension," *arXiv preprint arXiv:*1910.13461, 2019.
- [36] M. Sihag, Z. S. Li, A. Dash, N. N. Arony, K. Devathasan, N. Ernst, A. B. Albu, and D. Damian, "A data-driven approach for finding requirements relevant feedback from tiktok and youtube," in 2023 *IEEE 31st International Requirements Engineering Conference (RE)*. IEEE, 2023, pp. 111–122.
- [37] R. Akbani, S. Kwek, and N. Japkowicz, "Applying support vector machines to imbalanced datasets," in *Machine Learning: ECML* 2004: 15th European Conference on Machine Learning, Pisa, Italy, September 20-24, 2004. Proceedings 15. Springer, 2004, pp. 39–50.
- [38] S. Parashar, S. Dhar, and U. Dhar, "Perception of values: a study of future professionals," *Journal of Human Values*, vol. 10, no. 2, pp. 143–152, 2004.
- [39] S. H. Schwartz, "Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries," in *Advances in experimental social psychology*. Elsevier, 1992, vol. 25, pp. 1–65.
- [40] Y. Brun and A. Meliou, "Software fairness," in Proceedings of the 2018 26th ACM joint meeting on european software engineering conference and symposium on the foundations of software engineering, 2018, pp. 754–759.
- [41] S. Akter, G. McCarthy, S. Sajib, K. Michael, Y. K. Dwivedi, J. D'Ambra, and K. N. Shen, "Algorithmic bias in data-driven innovation in the age of ai," p. 102387, 2021.
- [42] "How does Facebook use artificial intelligence to moderate content? | Facebook Help Center." [Online]. Available: https: //www.facebook.com/help/1584908458516247
- [43] J. Larson, S. Mattu, L. Kirchner, and J. Angwin, "How We Analyzed the COMPAS Recidivism Algorithm." [Online]. Available: https://www.propublica.org/article/ how-we-analyzed-the-compas-recidivism-algorithm
- [44] A. Tobin and A. Kofman, "Facebook Finally Agrees to Eliminate Tool That Enabled Discriminatory Advertising," Jun. 2022. [Online]. Available: https://www.propublica.org/article/ facebook-doj-advertising-discrimination-settlement
- [45] J. Chakraborty, S. Majumder, and T. Menzies, "Bias in machine learning software: Why? how? what to do?" in *Proceedings of the* 29th ACM Joint Meeting on European Software Engineering Conference and Symposium on the Foundations of Software Engineering, 2021, pp. 429–440.
- [46] S. Krishnan, J. Patel, M. J. Franklin, and K. Goldberg, "A methodology for learning, analyzing, and mitigating social influence bias in recommender systems," in *Proceedings of the 8th ACM Conference* on Recommender systems, 2014, pp. 137–144.
- [47] V. Tsintzou, E. Pitoura, and P. Tsaparas, "Bias disparity in recommendation systems," arXiv preprint arXiv:1811.01461, 2018.
- [48] G. Hofstede, "Cultures and organizations: Software of the mind (london and new york, mcgraw hill)," House, RJ, Hanges, PJ, Javidan, M., Dorfman, PW, & Gupta, V.(Eds. 2004), Airaksinen, pp. 1–25, 1991.
- [49] N. Al-Huwail, S. Al-Sharhan, and A. Al-Hunaiyyan, "Learning design for a successful blended e-learning environment: Cultural dimensions," *INFOCOMP Journal of Computer Science*, vol. 6, no. 4, pp. 60–69, 2007.
- [50] R. A.-L. Fischer, R. Walczuch, and E. Guzman, "Does culture matter? impact of individualism and uncertainty avoidance on app reviews," in 2021 IEEE/ACM 43rd International Conference on

Software Engineering: Software Engineering in Society (ICSE-SEIS). IEEE, 2021, pp. 67–76.
[51] D. Potnis, "Culture's consequences: Economic barriers to owning

- [51] D. Potnis, "Culture's consequences: Economic barriers to owning mobile phones experienced by women in india," *Telematics and Informatics*, vol. 33, no. 2, pp. 356–369, 2016.
- [52] A. De Angeli, U. Athavankar, A. Joshi, L. Coventry, and G. I. Johnson, "Introducing atms in india: a contextual inquiry," *Interacting with Computers*, vol. 16, no. 1, pp. 29–44, 2004.
- [53] M. R. Roller and P. J. Lavrakas, Applied qualitative research design: A total quality framework approach, ser. Applied qualitative research design: A total quality framework approach. New York, NY, US: The Guilford Press, 2015, pages: xviii, 398.