Pots of Gold at the End of the Rainbow: What is Success for Open Source Contributors?

Bianca Trinkenreich, Mariam Guizani, Igor Wiese, Tayana Conte, Marco Gerosa, Anita Sarma, Igor Steinmacher

Abstract—Success in Open Source Software (OSS) is often perceived as an exclusively code-centric endeavor. This perception can exclude a variety of individuals with a diverse set of skills and backgrounds, in turn helping exacerbate the current diversity & inclusion imbalance in OSS. Because one's perspective of success can affect one's personal, professional, and life choices, to support a diverse class of individuals we must first understand how OSS contributors understand success. Thus far, research has used a uni-dimensional, code-centric lens to define success. In this paper, we challenge this status quo to reveal OSS contributors' multifaceted definitions of success. We do so through interviews with 27 OSS contributors whose communities recognize them as successful, and a follow-up open survey with 193 OSS contributors. Our study provides nuanced definitions of success perceptions in OSS, which might help devise strategies to attract and retain a diverse set of contributors, helping them attain their unique "pot of gold at the end of the rainbow".

Index Terms—open source software, success, career, qualitative analysis

1 Introduction

Success in Open Source Software (OSS) encompasses much more than code contributions. However, there is a prevailing misperception that programming skills determine success in OSS [1]. This perception is apparent in how projects highlight programming-related metrics on their sites (e.g., number of lines of code, number of commits) and in how they determine advancement in roles (e.g., what it takes to become a core member/maintainer or gain commit access)—all code-centric concepts [2, 3]. Academic research has also, perhaps inadvertently, added to this misperception, as past studies have largely been code-focused. For instance, numerous papers recognize the "onion model" as *the* mechanism through which contributors join, grow, and receive *commit access* to the code repository [4, 5, 6].

OSS contributors, however, are a heterogeneous group, with differing talents, skills, career goals, and motivations [7, 8, 9, 10]. Some perform a variety of non-code related activities (e.g., advocacy, technical writing, translation, project management) [1, 11] and follow a different pathway than the acclaimed "onion model" [12, 13, 1]. Given that OSS communities involve many more players than simply their "code warriors", success must be recognized as entailing more than just the quantity of code one produces.

How people define success impacts the choices they make in their personal and professional lives and how they evaluate others. Definitions of success can affect educational choices, decisions about where to work, project involvement, career attainment, life satisfaction, and so on [14]. Thus far, the OSS literature has largely investigated the immediate motivation to join and continue in OSS [7, 8, 9, 10], overlooking contributors' perceptions of success. Perceptions of success represent long-term goals and an imagined career future [15, 16], which influences commitment [17] and human behavior [15, 16]. Therefore, it is important to comprehensively understand the multitude of factors that underlie what success means to an individual in OSS. Without such an understanding, how can OSS communities support the many diverse individuals whose future goals and pathways do not fit the typical onion model career mold?

In this study, we tackle the fundamental research question: *What does it mean to be successful in OSS?*

To answer this question, we interviewed 27 OSS contributors who are recognized as successful figures in their communities. We qualitatively analyzed the interviews using the "success model" proposed by Dries et al. [18]. We then triangulated our results with data from a survey of 193 OSS contributors.

Our results indicate that OSS contributors define success in multi-faceted and nuanced ways. Success includes both objective measures (e.g., monetary compensations, amounts of contribution) as well as subjective ones (e.g., recognition in the community, satisfaction). In the words of von Krogh [9]: "*Occasionally, humans also make elaborate detours, strive for bigger things in life, and undertake long voyages to find the gold at the end of the rainbow*." Thus, it is time that we reflect on what we consider success in OSS, and how we can help make OSS more diverse by finding different ways to support individuals with various backgrounds and who have distinct definitions of success.

In this paper, we introduce the definition of career success and the theoretical success model we use in Section 2, followed by our research method and results in Sections 3 and 4, respectively. Sections 5 & 6 discuss the implications of our results, followed by related work, limitations, and conclusions in Sections 7, 8, and Section 9.

- *Bianca Trinkenreich and Marco Gerosa are with the Northern Arizona University, USA.*
- *Mariam Guizani and Anita Sarma are with School of Electrical Engineering and Computer Science of the Oregon State University, USA.*
- *Igor Wiese and Igor Steinmacher are with the Department of Computer Science, Federal University of Technology – Paraná (UTFPR), Brazil.*
- *Tayana Conte is with the Institute of Computing (IComp) of the Federal University of Amazonas (UFAM), Manaus, AM, Brazil.*

2 Defining Success

Success can be defined as "the accomplishment of desirable work-related outcomes at any point in a person's work experiences over time" [19] and is a dynamic concept [20]. Existing literature shows that career success can be characterized from different perspectives, such as: job, interpersonal, financial stability, and life success [21]; balance, relationships, recognition, and material success [14]; psychological, and social success [22]; and extrinsic and intrinsic success [23].

Dries et al. [18] organized existing literature enhanced with additional data collection into a comprehensive multidimensional theoretical model that describes how people perceive career success (Figure 1). Their model has been used in multiple contexts, such as the success of women in Science and Technology [24], the effects of cultural values on career success [25], and the reasons behind turnover between employees who are repatriates [26]. We use this model to organize our findings since it provides a comprehensive view of success, consolidates previous literature, is not tied to a specific type of organization, and generalizes to different contexts, fitting well to the heterogeneity of OSS and the boundaryless career path that OSS contributors follow.

Dries et al. [18]'s model comprises two dimensions, further classified into four quadrants and ten regions. The first dimension is *Affect* × *Achievement*. *Affect* represents the subjective feelings and perceptions that cause people to weigh their success as high or low. *Achievement* represents the objective side: the factual accomplishments through which people measure their success.

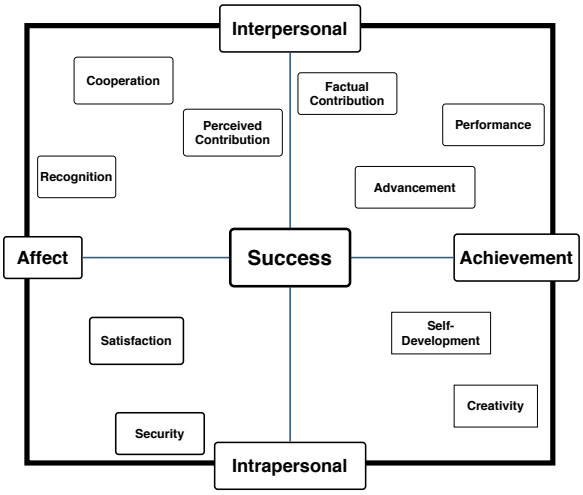

Fig. 1. The multidimensional model of success [18]

The second dimension is *Interpersonal* × *Intrapersonal*. *Interpersonal* involves one's relationships and interactions with the outside world. *Intrapersonal* indicates one's "self": their internal world. The combination of these two dimensions (Affect × Achievement and Interpersonal × Intrapersonal) generates four quadrants: (Quad1) Interpersonal × Affect; (Quad2) Interpersonal × Achievement; (Quad3) Intrapersonal × Achievement; (Quad4) Intrapersonal × Affect. The multidimensional nature of this model shows how success can have several different—yet complementary—meanings that may serve people with different goals.

Akkermans and Kubasch [27] explain that careers have been changing over the past few decades, evolving into more complex and unpredictable endeavors that require empirical studies in different domains to understand success. We use the above model to analyze the definition of success in OSS.

3 Research Design

This section presents the design of our study, which included interviews and a survey [1], as depicted in Figure 2.

3.1 Interviews: Building the OSS Success Model

Due to the complexity of the phenomenon under study, we started with in-depth interviews to understand how OSS contributors perceive success.

3.1.1 Interview Planning

For the interviews, we aimed to recruit recognized OSS contributors to understand successful OSS career stories. We started by recruiting invited speakers of the Open Source Software Conference (OSCON-2019), a well-recognized open source conference focused on practitioners. These speakers were invited to give talks in the main lineup of the conference, suggesting they are successful in OSS.

Before OSCON started, we emailed and sent direct messages via Twitter to all speakers whose contact information was publicly available (15). We also approached some of them during the event. During the event, we conducted 11 face-to-face interviews. In addition, we used a snowball approach to recruit more interviewees. At the end of each interview we asked them to introduce us to other qualified participants for the study. We conducted 4 additional interviews from this snowball approach. A majority of our interviewees were women, possibly because they cared about our goal. This initial imbalance was counterbalanced in the subsequent interviews (see Table 2).

After this first cycle of interviews and analysis, we recruited 12 additional participants. We invited maintainers of mature OSS projects who could share their perspectives of contributing to OSS. In both phases of interviews (at OSCON and post event), we used a snowball approach: at the end of each interview, we asked interviewees to introduce us to other qualified participants for the study, aiming to reach other speakers and successful project maintainers. Our goal was to interview experienced contributors working at least 5 years in well-known and mature OSS projects. We compensated interviewees with a 25-dollar gift card.

Before interviewing participants, we conducted five pilot interviews with a professor and four PhD students who were experienced in OSS. The goal was to solicit feedback on the script and ensure that the interview would fit in a 40- to 60-minute time slot. We analyzed the pilot interview responses to ensure that we answered our research question with an adequate level of detail.

We conducted semi-structured interviews [28]. We used a script as we present in Table 1 to guide the different areas of inquiry, while also listening for unanticipated information during the flow of the conversation. The interviews revolved around the central question: *"How would you define being successful in Open Source?"* We approached this topic

1. The research protocol was approved by the Oregon State University institutional review board (IRB).

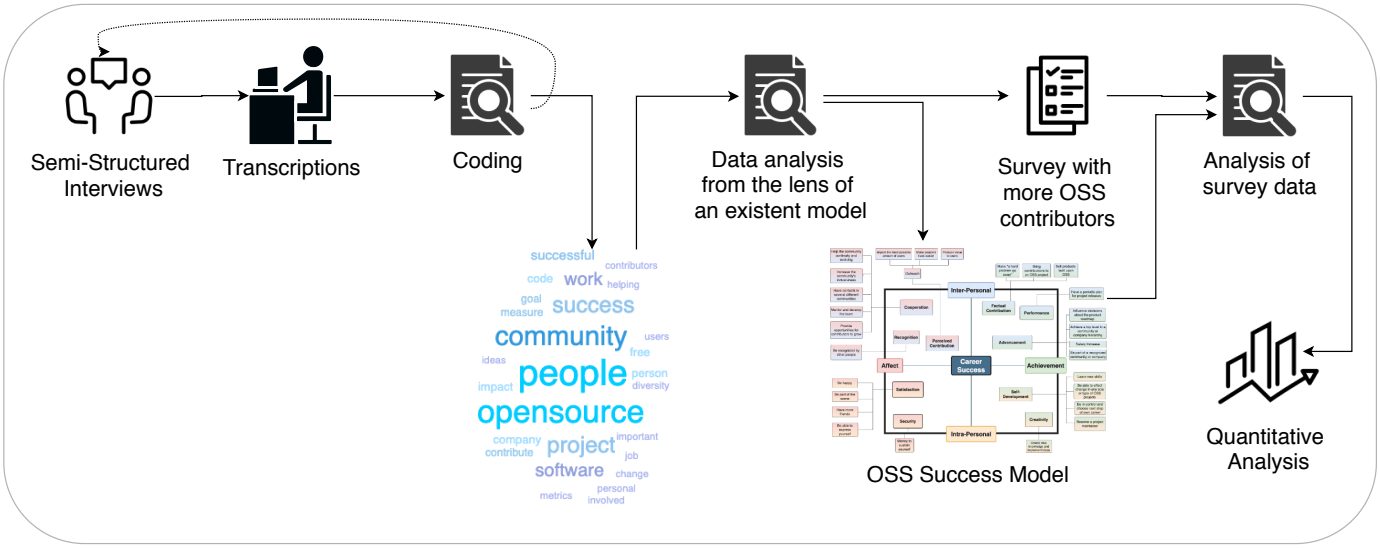

Fig. 2. The research method, which included face-to-face interviews at the OSCON'19 event and later with OSS maintainers through video conferencing, as well as a large-scale survey. We conducted qualitative analysis to build the OSS Success Model and qualitative and quantitative analysis to triangulate the definition of success we found from the interviews' data

TABLE 1
Interview Script and Survey Questions (excluding demographic questions)

Interview Script
I-1. Can you please tell me all the story of your career? All your professional journey, from the beginning of your career until where you are today
I-2. How would you define yourself as being a successful OSS contributor?
I-3. Is there any kind of success that you didn't achieve yet? What do you plan to achieve in the future?
I-4. Please think about a person you consider successful in OSS. Why do you think this person is successful?
I-5. Now the opposite. Please think about a person you consider not successful in OSS. Why do you think this person is not successful?
Survey Questions
S-1. Do you consider yourself a successful OSS contributor? (Yes/No/I don't Know)
S-2. How would you define a successful person in OSS? (Open Question)

after establishing rapport with the interviewee, asking about their career story and contributions.

We interviewed participants until we could not find any new concept related to our research question for five consecutive interviews. Our final sample comprised 27 participants. Table 2 presents their demographics.

3.1.2 Data Collection

Five researchers participated in conducting the interviews, where there were at least two researchers per interview. The researchers have at least six years' experience in qualitative studies. The interviews were face-to-face during OSCON and over video conference calls afterward. Interviews lasted between 40 and 60 minutes. With participant consent, we recorded all interviews. The first author of this paper transcribed the interviews using OTTER.AI[2] and listened to each recording, adjusting the corresponding transcriptions, mainly regarding technical terms and project names.

Our sample comprises paid and volunteer contributors across 20 different OSS projects (e.g., Kubernetes, Drupal, R, Noosfero, Fedora, Debian, GitLab), which vary in terms of number of contributors (30 to 3,000 contributors), product domains (including infrastructure and user-application projects), and types (backed by foundations, communities, and companies). Table 2 presents the demographics of our sample. Because of the terms of consent, we cannot link each participant to their project.

3.1.3 Data Analysis

The data analysis was performed in two stages. In the first stage we analyzed the interview data collected at OSCON 2019 and in the second stage we analyzed the data from the additional interviews.

We qualitatively analyzed the transcripts of the interviews by inductively applying open coding in groups, wherein we identified the definition of success that each participant provided. We built post-formed codes as the analysis progressed and associated them with respective parts of the transcribed text, so as to code the success definitions according to the participants' perspectives, who were identified as P1 to P27.

The outcome was a set of higher-level categories as cataloged in our codebook [3].

To organize our categories according to Dries et al.'s model [18] (see Section 2), three of the authors conducted multiple card sorting sessions together [29], arranging the codes according to the regions of the model. After the initial sorting, the group met once a week for four weeks to discuss and validate the results with the other authors. The process of categorizing the codes into the regions of Dries

2. https://otter.ai

3. https://figshare.com/s/39491da83e398612dffa

TABLE 2
Demographics for the Interview Participants

Participant ID	Gender	Years in OSS	Main Type of Contribution	Recruitment	Interview Mode
P1	Woman	6	OSS Advocate	OSCON Speaker	In-person
P2	Woman	5	OSS Coder	Mature project	Video-conference
P3	Woman	13	OSS Treasurer	OSCON Speaker	In-person
P4	Man	9	OSS System Admin	OSCON Speaker	In-person
P5	Prefer not to say	7	OSS Coder	OSCON Speaker	In-person
P6	Man	5	OSS Coder	OSCON Speaker	In-person
P7	Man	12	OSS Coder	OSCON Speaker	In-person
P8	Woman	30	OSS Strategist	OSCON Speaker	In-person
P9	Man	13	OSS Advocate	OSCON Speaker	In-person
P10	Woman	20	OSS Advocate	OSCON Speaker	In-person
P11	Woman	20	OSS Writer	Snowballing	Video-conference
P12	Woman	20	OSS Advocate and Writer	OSCON Speaker	In-person
P13	Woman	7	OSS Advocate	Mature project	Video-conference
P14	Woman	20	OSS License Manager	Mature project	Video-conference
P15	Woman	15	OSS Advocate	OSCON Speaker	In-person
P16	Woman	10	OSS Advocate	Snowballing	Video conference
P17	Woman	5	OSS Project Manager	Snowballing	Video conference
P18	Man	8	OSS Coder	Mature project	Video-conference
P19	Man	8	OSS Coder	Mature project	Video-conference
P20	Man	5	OSS Coder	Mature project	Video-conference
P21	Man	15	OSS Coder	Mature project	Video-conference
P22	Man	10	OSS Advocate	Mature project	Video-conference
P23	Man	7	OSS Coder	Snowballing	Video-conference
P24	Man	20	OSS Coder	Mature project	Video-conference
P25	Man	23	OSS Coder	Mature project	Video-conference
P26	Prefer not to say	10	OSS Project Manager	Mature project	Videoconference
P27	Woman	10	OSS Coder	Mature project	Video-conference

et al.'s model [18] was conducted using continuous comparison [30] and negotiated agreement [31] (as a group). In the negotiated agreement process, the researchers discussed the rationale they used to categorize each code until they reached consensus [31].

3.2 Survey: Data Triangulation

Next, we conducted an online survey to triangulate the interview results by gathering data from a different perspective [32] and a larger sample.

3.2.1 Survey Planning

In the survey, we asked two key questions about participants' perceptions of success (see Table 1), and additional demographic-related questions, including the relationship with OSS (paid/unpaid), types of contributions, gender identity, country of residences, and age. The target population included any person who contributes to OSS.

We advertised the survey on social media and community blogs (e.g., Linkedin, Twitter, Facebook, Reddit, Hackernews, CHAOSS blog, and others). To reach a broader audience, we paid to promote our posts on Twitter, Facebook, and Reddit. We also sent direct messages to OSS contributors and discussion lists. We offered the participants a chance to enter a raffle for US$100 to increase the response rate. To enter the raffle, they needed to opt-in and provide an email address at the end of the survey.

3.2.2 Data Collection

The survey was available between June 4^{th} and July 3^{rd}, 2020. We received 217 non-blank responses. We filtered our data to consider only valid responses. We analyzed the attention check answers, time to complete the questionnaire, equal/similar e-mail addresses, and inappropriate answers to the open questions (e.g., "I am the POTUS," "I don't wanna answer"), resulting 193 valid responses.

We asked participants their three main types of contributions and classified participants as "coder" if they selected "code developer" or "code reviewer" as one of the three main types of contributions. We classified as non-coders those who selected only a subset of these options: translation, documentation, mentorship, user support, community building, bug triaging, event presentations, advocacy and evangelism, creative work and design, and project management. We present the demographics of the survey participants in Table 3.

TABLE 3
Demographics for the Survey Respondents

Type of Contribution	#	%
Coder	163	84.46%
Non-Coder	30	15.54%

Gender	#	%
Men	165	85.49%
Women	16	8.29%
Non-Binary	2	1.04%
Did not answer	10	5.18%

Financial Relation	#	%
Paid	36	18.65%
Unpaid	137	70.98%
Partially Paid	16	8.29%
Did not answer	4	2.07%

Country of Residence	#	%
Germany	89	46.11%
USA	59	30.57%
Netherlands	12	6.22%
Brazil	9	4.66%
Others	23	11.92%
Did not answer	1	0.52%

Age	#	%
24 or less	30	15.54%
25-34	60	31.09%
35-44	59	30.57%
45-54	27	13.99%
55 or more	10	5.18%
Did not answer	7	3.63%

Do you consider yourself a successful OSS contributor?	#	%
Yes	72	37.31%^
No	80	41.45%
I'm not sure	41	21.24%

3.2.3 Data Analysis

We used the categories from the interviews, classified into the regions of Dries et al.'s model [18], as the starting point of the qualitative analysis of the survey questions. We diligently analyzed the answers to identify any new perceptions of success that did not previously emerge from the interviews, but all survey answers could be mapped to the existing categories. We also used descriptive statistics to

summarize the survey responses, their association with each other (success constructs), and the demographics data [33].

See supplemental material[4] for additional details, including sample answers to the demographics and open question survey questions and the qualitative analysis codes.

4 RESULTS

Here, we present our participants' definitions of success.

4.1 Understanding Success in OSS

Our analysis of the interviews (see Section 3.1.3) revealed 26 categories that explain how our participants defined success. We organized these categories using the multidimensional model of success proposed by Dries et al. [18] (see Section 2), as can be seen in Figure 3. The 26 categories covered all ten regions of the model. Table 4 presents the number of participants (interviews and survey) whose responses fit in each region. The survey analysis did not provide any new definitions of success. In the following, we present our findings organized by quadrant.

4.1.1 Quad1: Interpersonal × Affect

The first quadrant in Dries et al.'s model [18] is defined by two dimensions: (1) Interpersonal, which represents an individual's relationships with the outside world; and (2) Affect, which represents internal feelings and perceptions that characterize success. This quadrant contains three distinct regions of meaning: Cooperation, Perceived Contribution, and Recognition.

COOPERATION (Figure 3.I(a)) is defined as working with others (peers, superiors, subordinates, clients, etc.). The collaborative nature of OSS relates to this region as OSS contributors work together, support their community, and help their peers. In our analysis, we identified five categories, which we explain next.

Success included building social capital, i.e., *"having contacts in several communities"* as it allows identifying sources of help quickly when necessary (P8, P17, P21). It also includes being able to contribute to *"community sustainability"*, so it can be "as great as it can possibly be" (P3) and "more diverse and more inclusive" (P13). "Bringing people together" (P8) to *increase the community's inclusivity* was also repeatedly mentioned as a factor of success. Participants often mentioned individual success as part of the community's success: "having a healthy community is probably the most important thing" (P4) and "the sign of a healthy open source project is where everybody feels like their voice is heard and their opinion matters" (P7).

The cooperation aspect of OSS was also highlighted when participants defined their success as the ability to support others' success by *"providing opportunities for contributors to grow"* (P7) and "become more present and productive" (P15) by "giving everybody the opportunity [to climb] the contributor ladder" (P7).

Participants also cited success as being a *mentor* who is "friendly, didactic, and receptive to increase contributions" (P2 and P20), "who [neither] burn themselves out, [nor act as] the hero in the situation" (P15). An OSS mentor plays a crucial role in collaborative communities and influences the degree to which a newcomer relates to an OSS community and identifies with it [11]. Indeed, our participants mentioned that newcomers need to "feel they are heard" (P3), and that successful mentors *develop the team* by "let[ting] people participate" (P4) and "being open to new ideas, whether that could be coding, helping to figure out what the roadmap is, identifying features, identifying bugs, kind of all those things coming together" (P4).

PERCEIVED CONTRIBUTION (Figure-3.I(b)), according to Dries et al. [18], equates with serving society. In the context of OSS, our participants mentioned perceived contribution from the perspective of *outreach*—i.e., "impact on people in the world" (P11). Participants considered themselves as successful when the product they contribute to has "high adoption"(P9), "produce[s] value for the people" (P17), and makes people's lives easier" (P5).

RECOGNITION (Figure-3.I(c))—or being adequately rewarded and appreciated for one's efforts or talents [18]—was also mentioned by our participants. P13, for example, defined success as *"being recognized by the community and the project's stakeholders."* P1 considered recognition as awareness that "the maintainer of these projects know that they can come to [participate] as a subject matter expert" (P1).

4.1.2 Quad2: Interpersonal × Achievement

As per Dries et al. [18], this quadrant includes accomplishments external to the actor's self across three regions: Advancement, Performance, and Factual Contribution.

ADVANCEMENT (Figure-3.II(a)) is defined as progressing and growing in terms of level and experience. In the OSS context, this relates to *influencing decisions* about the product, being [part of] an *"influential community that is well recognized, a community that you say the name and people know what is"* (P21), *receiving job offers*, "writing [one's] own ticket" in one's career (P12), receiving a *salary increase*, or *achieving a top-level position*. "Money" in some cases represented growth (e.g., "salary going up" (P16)), which differs from some other cases in which money represented a way of earning a living from OSS, which we classify as SECURITY.

The PERFORMANCE (Figure 3.I(b)) region is defined as attaining verifiable results and meeting set goals [18]. In our context, this translated to having a *plan for project releases* "depending on what the goals of the project are, such as working on a new release every six months" (P4). Project planning activities demonstrated the relation of the actor to the external world (interpersonal dimension), as explained by P4: "if [one is] not making [the release], [they are] letting a lot of people down".

FACTUAL CONTRIBUTION (Figure-3.II(c)) is about individual contributions to the collective [18]. An indication of success in this region includes *bringing contributions to an OSS project*, by "getting a change that you wrote accepted" (P12), including "a code change, a documentation change... [or otherwise] getting something you made merged" (P12). Besides code contributions, interviewees mentioned implementing ideas or any type of revisions or contributions to the project, as well as "actively reviewing and looking at what people are suggesting" (P2). Contributions can also represent something tangible, such as achieving financial gains when "selling the platform" (P6) or when having a "ventured organization" (P6).

4. https://figshare.com/s/39491da83e398612dffa

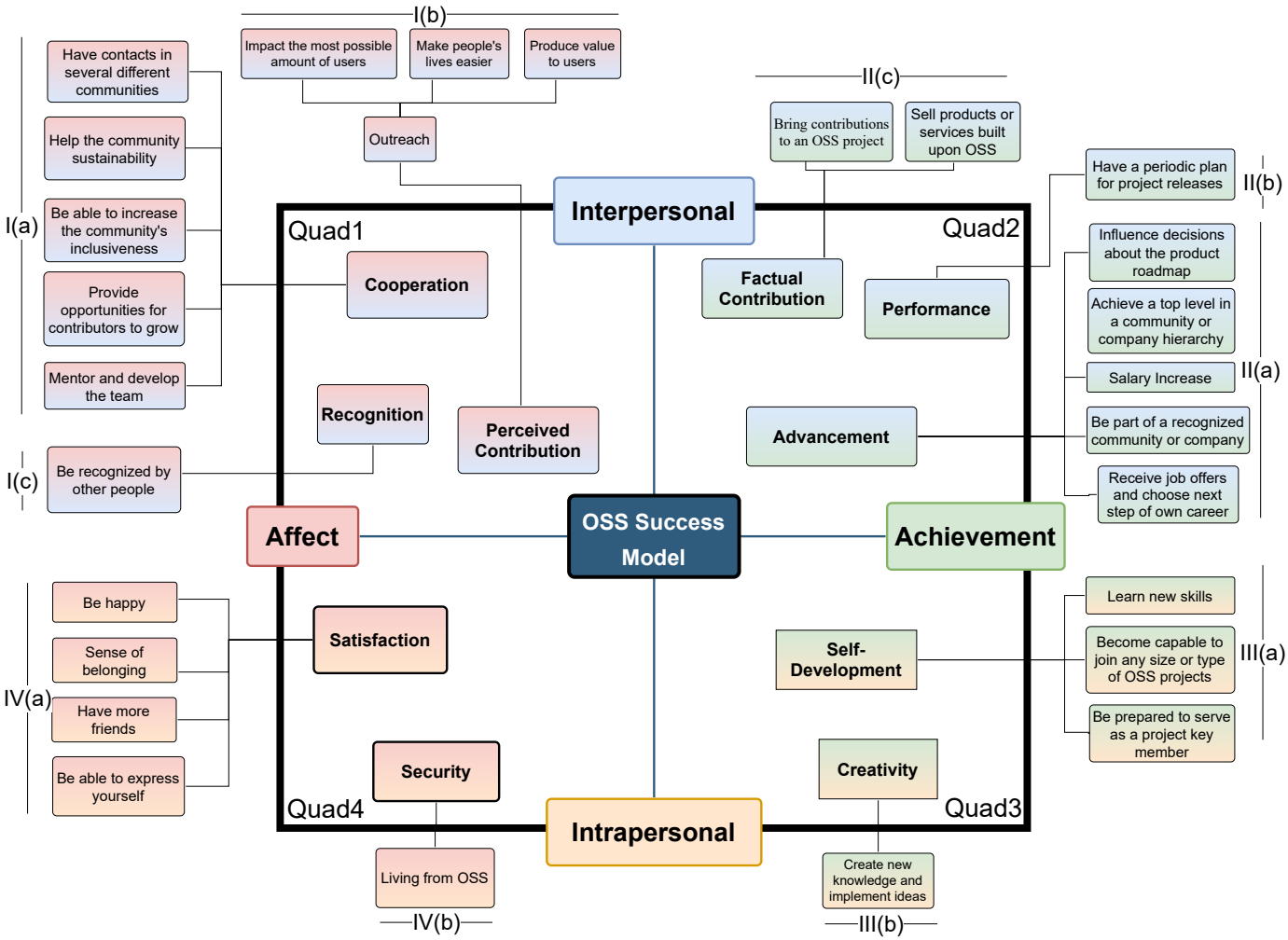

Fig. 3. OSS Success Model. We mapped our participants' definitions (shown outside the bold square) to Dries et al.'s model [18], which organize success in four quadrants.

4.1.3 *Quad3: Intrapersonal × Achievement*

Dries et al. [18] describe this quadrant as including real accomplishments of the actor's "self". It contains two distinct regions of meaning: Self-Development and Creativity.

SELF-DEVELOPMENT (Figure-3.III(a)) is defined as realizing one's potential through self-management of challenges and learning experiences [18]. This has been a classic motivation for contributing to OSS [8, 7, 34]. However, success definitions mentioned by the interviewees go beyond *"learning new skills"* (P16). They also include the path to receive a promotion, as stated by P20: "I reviewed other people's code to improve my review skills to become a maintainer," and *be prepared to serve as a key project member* by "being a mature reviewer and contributor" (P2) *"capable of effecting change in an open source project, from the small to the large"* (P7).

CREATIVITY (Figure-3.III(b)) is about making something innovative and extraordinary [18]. We found this to mean the freedom to *"create new knowledge"* (P3), but also as *"propagating ideas"* (P3). Creativity is relevant to the OSS context as individuals from innovative communities have greater opportunities to express themselves and experience a sense of accomplishment [34].

4.1.4 *Quad4: Intrapersonal × Affect*

The Intrapersonal × Affect quadrant includes feelings and perceptions that characterize the career of an actor's "self" [18], which contains two regions: Satisfaction and Security.

SATISFACTION (Figure-3.IV(a)) is about achieving happiness and personal satisfaction, either in the family or in the work domain [18]. Participants mentioned satisfaction as *"being happy"* (P1, P16, P26), which also included *"being able to express yourself"* (P10). They talked about their *sense of belonging* and "need for emotional inclusion" (P16), the importance of "participating in the world that is being created" (P10), and having *"a ton of friends* and people [who they] would hang out with or chat with, about non technical stuff" (P5).

SECURITY (Figure-3.IV(b)) means meeting one's financial or employment needs [18]. Participants characterized success as the ability to *make a living from OSS*— to "receive money as an OSS developer" (P24) and "prioritize what [financially] sustains you" (P19).

> Success is a multifaceted and complex concept, including both objective metrics and subjective perceptions of accomplishments.

TABLE 4
Success meanings from the interviews and the survey classified per Dries et al.'s model [18]

	Region	Participants' IDs (Interviews)	# Interviews (total: 27)	# Survey (total: 193)
Participants who mentioned at least one Region in Inter-personal			26	162 (84%)
Quad1	Cooperation	P2, P3, P4, P5, P7, P8, P13, P15, P17, P20, P21	11	15 (8%)
	Perceived Contribution	P5, P6, P9, P11, P17, P18, P21, P22, P25	9	57 (30%)
	Recognition	P1, P9, P13, P22, P23, P25, P27	7	29 (12%)
Participants who mentioned at least one Region in Q1			**19**	**93 (48%)**
Quad2	Advancement	P1, P10, P12, P16, P20, P21, P22, P23, P24	9	8 (4%)
	Performance	P4	1	0 (0%)
	Factual Contribution	P2, P6, P12, P14, P18, P19, P20, P21	8	74 (38%)
Participants who mentioned at least one Region in Q2			**15**	**81** (42%)
Participants who mentioned at least one Region in Intra-personal			11	49 (25%)
Quad3	Self-Development	P7, P16, P18, P19, P20, P21, P24	7	19 (8%)
	Creativity	P10	1	2 (1%)
Participants who mentioned at least one Region in Q3			**8**	**21** (11%)
Quad4	Satisfaction	P1, P5, P10, P16, P21, P26	6	14 (7%)
	Security	P19, P24	2	17 (7%)
Participants who mentioned at least one Region in Q4			**7**	**30 (16%)**

Quad1: Interpersonal x Affect; **Quad2**: Interpersonal x Achievement; **Quad3**: Intrapersonal x Achievement; **Quad4**: Intrapersonal x Affect
The total per quadrant is not the sum of the regions since the participants often provided an answer that was categorized into **more than one region**.

4.2 Survey analysis

As explained in Section 3.2, we conducted a survey to triangulate the definitions of success we identified from the interviews, expanding our population and exploring whether we could find any new definitions of success. We qualitatively analyzed the 193 answers to our survey open question. Similar to interviews, the participants often provided multiple definitions, which could be categorized into more than one region from Dries' model [18]. However, no new category emerged from the survey analysis.

In this section, we look deeper into the survey results to understand the prevailing definitions of success among our respondents and across different demographics. When presenting the results, we use supplementary and corroborative counting of the survey responses to triangulate the qualitative analysis of the definitions of success [35].

The dimensions of success. The majority of respondents defined success in terms of a relationship with the external world (Interpersonal) rather than the actor's self (Intrapersonal), accounting for 84% vs. 25% of respondents. For the Interpersonal dimension, respondents identified success across both ends of the Affect and Achievement spectrum—25% were related to the Affect dimension and 49% were related to Achievement. When considering definitions related to the Intrapersonal dimension, none of the regions were mentioned by more than 10% of the respondents. This preponderance of definitions related to the Interpersonal side could be due to the collaborative nature of peer-production sites such as OSS, where contributing to a common good and being recognized for it have been cited as key motivation factors [9, 36, 8, 7, 37].

In fact, FACTUAL (38%) and PERCEIVED CONTRIBUTION (30%) were the most mentioned regions, followed by RECOGNITION (12%). None of the other regions across all quadrants had more than 10% of responses. These responses reflect that, in OSS, while contributions matter, the way that others (community, peers, society) value the contributions is also an important indicator of success.

Respondents who identified FACTUAL CONTRIBUTION as a definition of success emphasized that the number, size, and frequency of contributions can be objective concepts to quantify a significant contribution to the community. They defined success as *"finding a way to sustainably contribute"* (S25), or being *"someone who is able to regularly contribute"* (S11) and *"spending time on the project often"* (S68). A successful contributor is one who provides *"a wide spectrum of contributions"* (S6). Moreover, respondents identified various types of contributions for contributors in different project-centric or community-centric roles [1], as mentioned by S2: *"Successful contributors add or change major features, and organize the community"*.

Those who considered PERCEIVED CONTRIBUTION as success emphasized the importance of their contribution, such as publishing and maintaining software that is used by and useful to a lot of people. According to S136, the perceived value of their contribution could be measured by *"how many people have used the OSS code and how much value has it created"*. Some of these definitions of success in OSS included: *"someone who publishes and maintains software that is useful for a lot of people or for the user community"* (S3) and *"when the software solves and helps real world problems"* (S169).

Finally, our respondents reflected many different perceptions of success related to RECOGNITION in their community; which included *"having a high number of stars on the own repository in GitHub"* (S58 and S109), *"receiving donations"* (S21), and *"being invited for conference invites/talks"* (S16).

Demographics and the meaning of success As recent literature has shown, the OSS community is becoming more diverse in terms of the gender of contributors, types of contributions, and financial rewards [11, 1]. We took a deeper look into these demographic subgroups with respect to their definitions of success. Understanding how different demographics perceive success can help us create mechanisms to better support diverse contributors and improve the state of diversity in OSS. Figure 4 illustrates the definition of success for each demographic subgroup. The percentages in the figure reflect the number of participants who mentioned any meaning under each quadrant per subgroup. For example, 80 participants who identified themselves as code contributions reported at least one meaning of success categorized in Quad1. Therefore, given there were 163 code contributors, 49.1% of the code contributors in our sample associated success with Cooperation, Perceived Contribu-

tion, or Recognition (Quad1).

From the 193 survey respondents, 165 identified as men, 16 as women, and 2 as non-binary. The gender distribution of our respondents matches that of those reported in other OSS studies ([38, 39, 40]). We dropped from this analysis the 10 respondents who did not disclose their gender. Comparing the distributions of definitions reported by men and women, we could not find statistically significant differences between the two groups either in terms of quadrants or regions. As illustrated in Figure 4, both men and women more frequently mentioned success definitions classified in the Interpersonal quadrants (Quad1/Quad2) than those in Intrapersonal (Quad3/Quad4).

Our survey included answers from 163 *coders* and 30 *non-coders*, i.e., those who work only on non-code related activities (e.g., advocacy, license management, technical writing). We could not find statistically significant differences between the distribution of answers from the two subgroups. We could also not find statistically significant differences when sub-grouping based on compensation (paid vs. unpaid). The statistical test results including the p-values of these comparisons are in the supplementary material.

> The Interpersonal dimension plays a dominant role in the definition of success, in which factual and perceived contributions are the most referenced, followed by recognition. Contributors across different demographic groups—gender, contribution type (code vs non-code), and compensation (paid vs. non-paid)—report similar perceptions of success.

5 Discussion

5.1 Success is multifaceted and hard to measure

Success in OSS is a complex concept with multiple dimensions. Our participants reported different definitions for success, encompassing all the regions of the Dries et al. model [18]. Even a single person's understanding can span multiple dimensions. Therefore, the dominant view of successful OSS contributors as code "hackers" [34] is inadequate, even from the point of view of coders. Success in OSS is a nuanced, multifaceted concept that goes well beyond becoming a core member or a maintainer.

This variety of perspectives makes it challenging to measure success. Even common terms, such as "contribution," can be understood differently. While some people consider a high number of contributions or the frequency of contributions as a measure of success, others relate success to the impact of their contribution—or how it is perceived by the users or the society. Current literature, tools, and project infrastructures unfortunately tend to focus on measuring code-centric contributions (e.g., [37, 41, 6]). However, there are subjective perspectives of success closer to the *Affect* dimension that also need to be measured. For example, how does one measure contributions for those who mentor or work on community building (Quad1)? The benefits of these types of contributions are intangible and by their nature difficult to measure. In fact, our results show even tangible products, such as money, can represent multiple meanings of success: for instance, Security when related to making a living from OSS, and Advancement, when related to growth (salary increase). Therefore, it is important that researchers and practitioners take a more nuanced approach in developing ways to evaluate success, considering the multitude of profiles and activities that are part of OSS. There is no "one size fits all" measure of success.

5.2 Coders & non-coders look for the same pot of gold

While coders and non-coders may contribute differently to OSS, they perceive success in similar ways. Our analyses (Figure 4) show that both coders and non-coders often mentioned definitions that relate to the *Interpersonal* dimension.

Coders and non-coders perform different roles and have different career pathways in OSS [11, 1]. These pathways may include not only code-centric, but also community-centric activities, including advocacy, community building, mentorship, and technical writing. These activities are important for projects' sustainability and growth, but are currently not well-recognized.

Therefore, showing that there are multiple ways to achieve success is important, regardless of their roles. To do so, current strategies and metrics to support contributors need to be adapted to consider the multitude of success definitions to include activities not directly related to code. For example, coders gain recognition from having their names in a "credits" file or badges in their profiles, but non-coders are commonly overlooked because their activities are harder to quantify [42]. Identifying ways of showing Recognition for non-coders is important future work.

5.3 Subjective definitions of success is prevalent

In our study, both men and women mentioned success definitions related to the *Affect* and *Achievement* dimensions, and at similar rates. Contrary to research in other domains [14, 43, 44] that found that men relate success to tangible and objective outcomes, the men in our study often provided subjective meanings of success.

We hypothesize that the nature of OSS defines how people see success in this context. OSS is an open collaboration community [45], in which collective work is central to the success of projects. Additionally, altruism, reciprocity (giving back), and maintaining high-quality social bonds are common motivations to contribute to OSS [9, 36]. These motivations relate to working together to create better software and for the greater good. Individuals who are attracted to an open-collaboration community may attribute a high value to these dimensions.

6 Implications of Results

There are several ways our results can inspire communities and researchers to engage OSS contributors.

6.1 Recommendation for Communities

Open source offers different "pots of gold" for different types of contributors. OSS contributors are diverse, have different motivations to join OSS and have different definitions of success. Our results highlight these differences. Being aware of the diverse success definitions can allow a diverse set of developers to be inspired to join OSS and find others who value similar aspects of success.

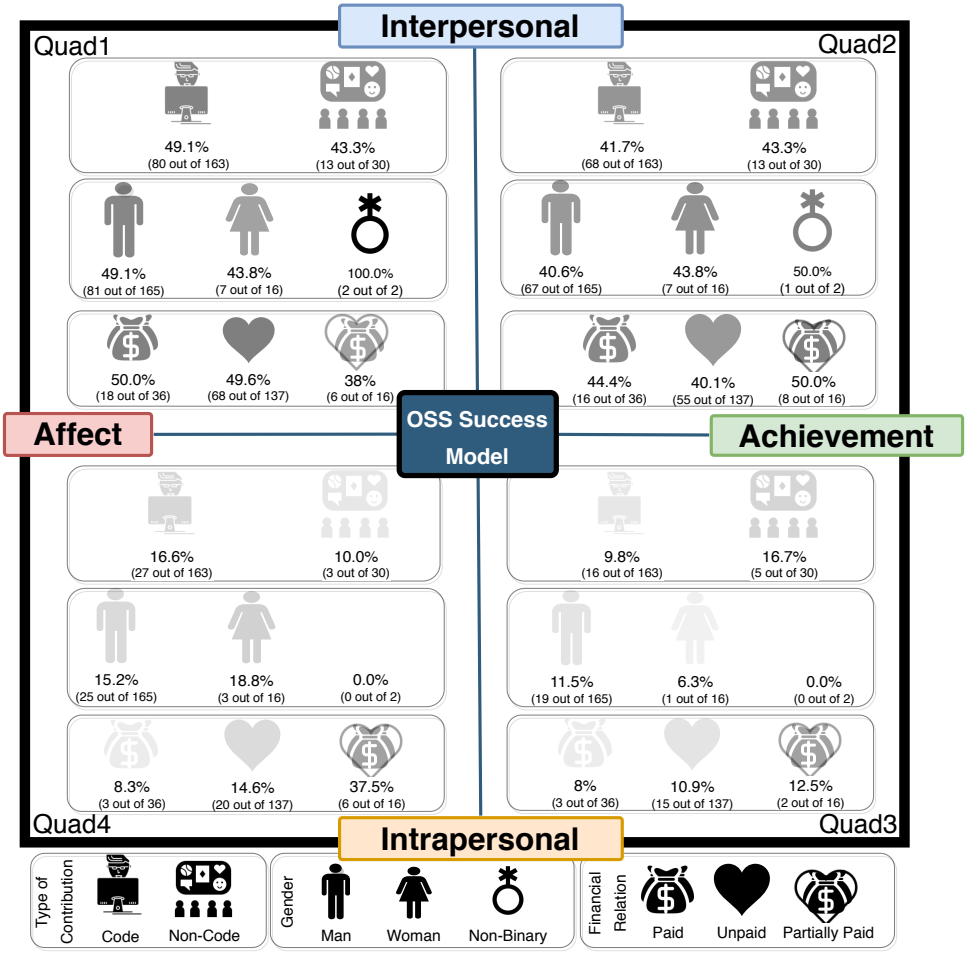

Fig. 4. Subgroup analysis of the meanings of success. The opacity of the icons represents the percentage of each group for the quadrant. Darker means a higher and lighter a lower percentage. Some respondents provided answers about success that accounted for more than one quadrant.

Our results can make OSS communities aware that individuals have diverse backgrounds and perceptions of success and may need different engagement strategies. By recognizing that success is multifaceted, communities can leverage our (sub-)categories to support the growth of individuals who hold different success definitions. By understanding what contributors they seek, leaders can cultivate practices that highlight the success attributes in their projects to improve retention and turn over rates [46].

Communities, for example, can foster engagement of contributors who define success in terms of increasing their personal networks and **COOPERATION** [47, 48]. They can do so by organizing meetups to increase contributors' social capital (Fig. 3 I(a)). Communities can organize Hackathons [49] or participate in "Summer of Code" programs [50, 51, 52], which offer the contributors opportunities to help with "outreach" (**PERCEIVED CONTRIBUTION**) (Fig. 3 I(b)) and improve the sustainability of the project (Fig. 3 I(a)) by mentoring and onboarding new members.

Communities can employ different **RECOGNITION** programs to value different types of contributions [1] and engage those who perceive success as "being recognized"(Fig.3 I(c)). For example, in addition to traditional metrics such as code commits, communities can award contributors who participate by answering questions and discussing issues [53]. Recognizing different types of contributions can engage those who value **FACTUAL CONTRIBUTIONS** (Fig. 3 II (c)).

PERFORMANCE and merit-based badges [54] can be used to recognize contributions and community building [55, 56] (Fig. 3 II (b)). Communities should make explicit their criteria and rules for promotion [57], making contributors aware of what is expected in terms of skills and contributions to achieve their **ADVANCEMENT** goals (Fig. 3 II (a)).

Communities are encouraged to prepare manuals and iterative learning modules and provide skill-specific mentoring [58] to help with continuous learning and **SELF-DEVELOPMENT** (Fig. 3 III (a)) [59]. The training content should not only cover technical topics, but also how to improve other skills (e.g., communication, networking). Contributors who value **CREATIVITY** can be engaged via badges that highlight different skills (Fig. 3 III (b)) [55] or by building and sharing new knowledge for online training of new developers [60].

As sense of belonging is directly related to job **SATISFACTION** (Fig. 3 IV (a)) [61], communities can promote inclusivity events [62, 63], ultimately aiming to reduce contributors' loneliness and alienation, and providing social support for mental health. Communities can help contributors avoid burnout, which can negatively affect satisfaction, well-being, and happiness [64, 65], by further supporting key members [66]. Finally, to support and retain

contributors who wish to achieve financial SECURITY from OSS, communities can explicitly state their partnerships with companies, offer "bounties" as payment per issue solved [67], or join onboarding programs (such as Google Summer of Code) that compensate participants [50, 51, 52].

6.2 Implications for Researchers

The multitude and nuance of definitions of success can serve as input for different research directions. It is important to find ways to support the growth of people whose background is not related to software development. Their activities are harder to quantify, given that they usually do not leave traces on project repositories. This may pose challenges beyond proposing metrics and toward proposing changes in terms of how these activities are performed, logged, and weighted. This may have additional impact on topics like mining and creating virtual resumes for hiring purposes [68], recommending mentors [69], and providing paths to becoming central to the project [70, 5].

7 Related Work

Thus far, the literature has discussed how to make projects successful [71, 72, 73]. In this study, our goal is to understand success from the contributors' perspective. People's perceptions of themselves impact their behavior and choices to achieve desired goals [74, 75]. Motivations to join and to stay also influence how people behave. In the following, we discuss related work focused on motivation in OSS and on skills needed to be a successful software developer.

7.1 Motivation to be an OSS contributor

Motivation to be an OSS contributor has been extensively studied since the early 2000s [7, 76, 34, 8, 77, 37, 78, 79, 80]. Von Krogh et al. [9] surveyed the literature and aggregated the studies about motivation in OSS published until 2009. They identified that the reasons to join OSS can be summarized into 10 motivation categories, grouped as intrinsic, internalized-extrinsic, and extrinsic.

More recently, Gerosa et al. [36] identified that while career is an extrinsic motivation relevant to many contributors, intrinsic and internalized motivations explained most of the contributors' motivations. Wu et al. [81] investigated the relationship between motivation and retention, and found that altruism, learning, career, and own-use are the main motivators that influence the intention to continue in the project, which was confirmed by Gerosa et al. [36].

Success perceptions and motivation to contribute complement each other, but play different roles. When considering the comprehensive study from Von Krogh et al. [9], although there is an intersection between definitions of success and motivation factors (e.g., money, ideology, reputation), not all motivation factors map to success definitions (e.g.,"Own-use") and not all the success definitions map to motivation factors (e.g., "Have a plan for project releases (Performance)"). In our study, we aim to highlight that OSS offers a multitude of success perspectives that, together with the motivation to join and to stay, should be used to understand and support diverse contributors. Our results can be used in future work to investigate how OSS contributors with different motivations perceive success.

7.2 The skills of successful individuals

Past research have been dedicated to providing answers to the question of what attributes and skills make someone successful in their current profession, using the term "great" as a proxy for success. Li et al. [82] conducted a study to identify the characteristics that distinguish "great" software engineers. The authors found that the top five characteristics are writing good code, regulating behaviors to account for future value and costs, exercising informed decision-making, avoiding making colleagues' work harder, and constantly learning. Kalliamvakou et al. [83] investigated the attributes of a "great" manager. According to their study, some level of technical skill is necessary, but they are not as relevant as management skills to guide engineers to make decisions, to motivate them, and to mediate their presence in the organization. Dias et al. [84] presented a conceptual framework to explain how management, social, technical, and personality attributes are connected. They noted that a great maintainer needs both technical excellence and good communication. Through six interviews, Kimmelmann [46] investigated the technical, social, and personal competencies developers need according to their stage in OSS projects, and claims that these competences can support or hinder a successful career by regulating professional behavior.

Some research considers core developers as "elite contributors" [6] or code heroes [5], who receive commit rights based on trust [85]. Although code heroes are valuable for OSS projects [5], being a core developer is not the only way to be successful. According to Zhou and Mockus [70], newcomers become Long Term Contributors if they start with comments and demonstrate a highly community-oriented attitude. While the theoretical converging lens orients most OSS research efforts towards the project-centric and technical side of OSS project development, our study aims to unveil other perspectives of success beyond the traditional ways to measure success of OSS contributors.

8 Limitations

Internal validity. The characteristics of our sample may have influenced our results. A great part of our interviewees (11 out of 27) were speakers at an OSS conference and half (13 out of 27) of the interviewees identified as women, even though we did not push toward having an equal gender split. This diversity of profiles helped bring a more diverse perspective about the phenomenon. Our survey, which received almost 200 answers, corroborated our results. The distribution of our survey demographics is similar to the larger OSS population as reported elsewhere [86, 39, 38].

Construct validity. One threat to construct validity in this work relates to the question about success, which explicitly asks how the respondent defines a successful person in OSS. While the question refers to the individual's perspective, respondents could interpret the question differently and answer from the perspective of a typical contributor. This was not a problem for the interviews, since we would have been able to clarify the question if any the interviewees misinterpreted this question (none did). We believe this threat to be minimal in the survey based on our pilot studies. Moreover, individuals' perceptions about typical and prominent participants in the OSS ecosystem are also relevant in creating a broad understanding of success.

The theoretical model [18] used to categorize the definitions of success also may pose a threat. However, the model was able to capture the nuances of success in OSS, enabling the researchers to map the concepts to the regions proposed by the model.

Survival bias. Our results reflect the opinion of current contributors who joined OSS and made it past the initial contribution barriers [87]. Therefore, to promote diversity in OSS, we acknowledge that additional research is necessary to understand success from the perspective of those who do not make it past the initial barriers and those who are currently not attracted to OSS.

Recall bias. Moreover, as our survey question was open ended, our results could be impacted by either salience bias, where respondents focus on definitions that are prominent or emotionally striking and not necessarily all the factors that matter; or by memory bias, where participants answered questions based on what they can first recall and not necessarily what's most important to them.

Data Consistency. Consistency refers to ensuring that the results consistently follow from the data and there is no inference that cannot be supported after the data analysis [88]. The same group of researchers performed the qualitative analysis of interviews' transcripts and survey's responses. We had weekly meetings to discuss and adjust codes and categories until reaching agreement. In the meetings, we also checked the consistency of our interpretations, continually discussing our results based on definitions of Dries et al.'s model [18]. All analysis was thoroughly grounded in the data collected and exhaustively discussed amongst the whole team. The team includes researchers with extensive experience in qualitative methods.

Theoretical saturation. A potential limitation in qualitative studies regards reaching theoretical saturation. In this study, we interviewed 27 participants with different backgrounds and perceptions about the studied phenomenon. The participants are diverse in terms of gender, number of years involved with OSS, and highest achieved academic degree. We kept inviting participants until we could not find any new concept for five consecutive interviews. Moreover, we collected answers from 193 respondents about what it means to be a successful OSS contributor, and we could not find any new meanings. Therefore, although theoretical saturation cannot be claimed, we believe that we obtained a consistent and comprehensive account of the phenomenon.

9 Conclusion

In this paper, we studied how OSS contributors define success. OSS has considerably changed over the last 20 years, from a generation of code-oriented volunteers to an ecosystem in which industry consortia push OSS projects forward with a significant amount of professional and paid contributors [89]. Our results show that OSS contributors have a broader perspective on success than the narrow focus on code-related activities—which is better supported by current tools and practices.

Our study of 27 interviews with well-recognized OSS contributors and a follow-up survey of 193 OSS contributors reveals a multi-faceted definition of success. We found 26 categories of definitions through our interviews and framed them through the theoretical lens of an existing success model [18]. Our analysis shows that success includes objective and subjective accomplishments. Even tangibles such as "money" can have different meanings to different people (e.g., a way to advance in career or a way to secure a living).

In conclusion, we hope our work in revealing the nuanced definitions of success that OSS contributors have can help us find out how to support diverse individuals with diverse backgrounds. Let us work together to support the different contribution pathways to help individuals reach that elusive pot of gold at the end of the rainbow.

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Bianca Trinkenreich is a PhD student at the Northern Arizona University. She holds a Master of Science in Computer Science from the Federal University of the State of Rio de Janeiro (UNIRIO) and researches about Software Engineering, CSCW, Software and IT Service Quality. Recent projects include the career pathways and motivations of Open Source contributors.

Mariam Guizani is a PhD student in Computer Science at Oregon State University. Her research area is in Human-Computer Interaction and Software Engineering. More specifically her research focuses on improving diversity in open source. She holds a Master of Science in Computer Science from Oregon State University.

Igor Wiese is an Associate Professor in the Department of Computing at the Federal University of Technology – Parana, Brazil. He is interested in Mining Software Repositories, Human Aspects of Software Engineering, and related topics. Wiese holds a PhD degree in Computer Science from the University of São Paulo. More information is available at http://www.igorwiese.com.

Tayana Conte holds a PhD in Systems Engineering and Computer from the Federal University of Rio de Janeiro (UFRJ). She is an associate professor at the Institute of Computing (IComp) of Federal University of Amazonas, heading the Usability and Software Engineering (USES) lab. Her research interests include the intersection between Software Engineering and Human-Computer Interaction, Software Quality, Human-Centered Computing, and Empirical Software Engineering.

Marco Gerosa is an Associate Professor at the Northern Arizona University. He holds a PhD in Computer Science from the Pontifical Catholic University of Rio de Janeiro. He researches Software Engineering and CSCW. Recent projects include the development of strategies to support newcomers onboarding to open source communities and the design of chatbots for tourism. He published more than 200 papers and served on the program committee (PC) of important conferences, such as FSE, CSCW, SANER, and MSR.

Anita Sarma is an Associate Professor in the School of Electrical Engineering and Computer Science, at Oregon State University. She holds a PhD in Computer Science from the University of California, Irvine. Her research interests intersect software engineering and human computer interaction, focusing on understanding and supporting end users and software developers. She has over 100 papers in journals and conferences. Her work has been recognized by an NSF CAREER award and several best paper awards.

Igor Steinmacher is an Assistant Professor at the Federal University of Technology, Paraná. He received a PhD in computer science from the University of São Paulo. His topics of interest include human aspects of software engineering, behavior in open source software communities, mining software repositories, and software engineering education & training.