LFX | Mentorship

THE LINUX FOUNDATION | Research

Mentorship in Open Source

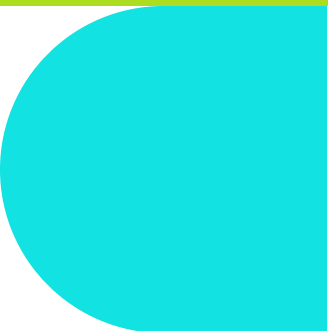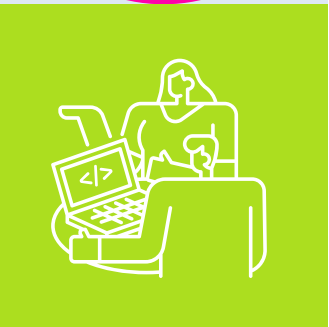Exploring the Intrinsic, Economic, and Career Value of Mentorship Programs

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Foreword

The ability to create software is a magical thing. Out of nothing, only an idea, one can construct one's own world as an object that performs some useful function, entertains, etc. Contributing to open source software provides the opportunity to take this to the next level, allowing the individual to contribute to something of interest to people worldwide. Nevertheless, different open source projects have different coding styles, standards of communication, preferred development tools, etc., and, to facilitate the development process, legitimately expect contributors to conform to a myriad of conventions that are not always written down. This is where mentorship comes in.

I have been involved in mentorship as a mentor for LFX, GSoC, and Outreachy and as a coordinator for the Linux kernel for Outreachy. Interns come to these programs with all different levels of coding skills and learn how they can contribute to software that today has become the foundation of all computing. The chance to work with a mentor provides the chance to explore ideas in a safe space, where the mentor can head off potential problems in algorithm design, coding style, and communication. In exchange, the mentor can ensure that the mentee is exposed to all of the information that the mentor would like a potential contributor to have. As the mentor and mentee in remote mentoring programs such as LFX and Outreachy often come from different countries and cultures, participating in such programs is also a wonderful way to learn more about the world.

Today, many of the mentees I have worked with have interesting jobs in the industry, while some have diverted to further studies. For some, the internship was one of many steps on the way to their current accomplishments, while for others, the internship represented a rupture in their career, from a position that they were not satisfied with to one that they found more rewarding. Some continue to do work related to the Linux kernel, others explore other directions, and some unexpectedly found their Linux kernel experience applicable in a different area. I am immensely proud of all of them. Mentorship is incredibly rewarding for the mentees, the mentors, and the organizations that benefit from the mentee's contributions. I would like to thank the various organizations that make these internship programs possible.

Julia Lawall
Senior Scientist, French National Research Institute for Digital Science and Technology (Inria-Paris)
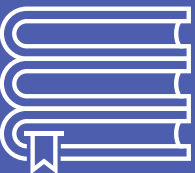
Infographic: LFX Mentorship program

Mentorship creates **opportunities for a healthy succession** of open source project contributions and leadership.

Mentorship encourages **greater equity and accessibility** for underrepresented groups to engage in open source projects.

87% of mentees are students, **86% already participate in open source,** and 88% are involved in IT broadly.
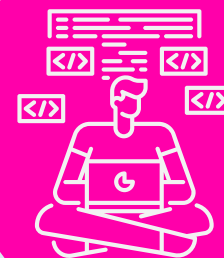
67% of mentees had **never been paid for their open source involvement** prior to beginning the mentorship.

Before completing the progam, 64% of mentees lacked some degree of confidence in their ability to engage in open source.

69% of mentees have seen their career advance because of mentorship, with 47% saying that the program helped them get a job.
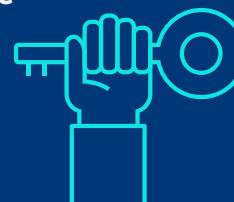
67% of employed mentees report an **increase in their income** after the program.
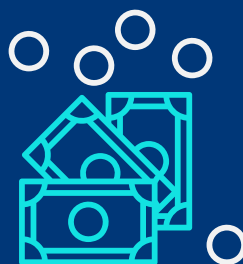
52% of the mentees who are now employed are **getting paid for their open source involvement.**

99% of former mentees recommend the program to others, and everyone involved says that the program was beneficial.
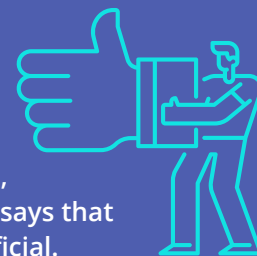
90% of mentees have increased confidence in their ability to contribute to open source compared to before they started the program.

85% of mentees are or are willing to continue contributing to the project they were involved in after mentorship.

One of the program's challenges is recruiting mentees with the essential skills for open source development.

About the LFX Mentorship program study

- Linux Foundation (LF) Mentorship helps build diverse communities of developers to address long-term project sustainability issues.

- LF Research assessed the effectiveness of the effort in addressing these issues and the career and economic benefits for mentees.

- The findings in this report are based on a survey of 100 graduates of the 2020 and 2021 LF Mentorship program.

Introduction: The problem that mentorship aims to solve

Why is it necessary to have open source and LF mentorship programs?

Open source communities face a two-fold problem: building diverse communities of developers and leadership succession. Mentorship programs help to solve the problem of ensuring robust succession and growth, where many new contributors become part of the community. Just as we require offspring as a human species to guarantee the health and continuation of our legacy and culture long after the current generation is a living memory, new entrants enable open source to breathe new life and continuity into our communities.

We invest in our communities as beneficiaries of our open source legacy by giving new developers access to knowledge and experience from more experienced participants. By helping new developers to begin, mentors can help ensure that the community continues to grow and thrive long after the founders of these projects cease their direct involvement.

Investing in our future by providing access to generational knowledge is not the only reason mentorship programs exist. We also wish to foster underrepresented groups—whether women, members of the LGBTQ+ community, people with disabilities, or non-native English speakers—to improve diversity within our communities. Shuah Khan, an open source fellow and Linux kernel maintainer, explains the grounding philosophy of the mentorship program, highlighting the importance of increasing diversity in open source communities, including the Linux kernel:

"The end goal was to have a healthy and sustainable kernel community with diverse viewpoints. Diverse communities are healthy and thriving. Having a different viewpoint in the development process keeps them healthy and relevant and serves the needs of people globally. So, improving diversity and opening up

"Open source software is the backbone of a lot of our world infrastructure in financial, healthcare, telecommunications, you name it—critical internet infrastructure. So, as a result, keeping these communities healthy for the long term is paramount to keeping this infrastructure working."

—SHUAH KHAN, OPEN SOURCE FELLOW
AND LINUX KERNEL MAINTAINER

the kernel community of people of different socioeconomic backgrounds was a huge component."

It's no secret that the open source community and surrounding culture are historically male-dominated. The LF is actively trying to remedy this by involving and engaging members of underrepresented minority communities, including those less economically advantaged.

An analysis of LFX Mentorship applicant data in **FIGURE 1** shows that 72% identify as belonging to the middle class.

Khan, who directs the LFX Mentorship program, states that addressing diversity within the open source community is a complex societal issue involving equitable access to resources and opportunities. She says,

"It is an issue of people not having equitable access to resources. We have to do our part to make those resources available to people equitably so that they are easier to access, easier for people to self-learn, and thus more accessible for people to get involved in open source and break down barriers. These barriers are based on your background, the language you speak, and also your financial situation and various other reasons."

FIGURE 1

2022 LFX MENTEE APPLICATIONS BY ECONOMIC STATUS

What group or class do you identify with?

10.6%
Prefer not to answer

0.4%
Upper class

16.9%
Upper
middle class

19.7%
Working class

52.4%
Lower middle class

> "*The problem we are trying to fix is a sustainable maintenance cycle. Bringing more people into open source is part of it, but there are many more steps."*
>
> **—KATE STEWART, VICE PRESIDENT OF DEPENDABLE SYSTEMS, THE LINUX FOUNDATION**

it accessible to different needs, career transitions, etc. Our unpaid programs are well received, and we can increase the number of mentees per project."

It is clear that without bringing in these diverse groups of people, open source culture becomes stagnant, putting our projects at risk in terms of their ability to retain talent and inspire new developers to join them as maintainers or core contributors.

Angela Brown, SVP and GM of events at the LF, explains the value of DEI initiatives from the perspective of acquiring talent. She says,

> "*We have all these companies that desperately need open source talent, both now and in the coming years. How do we get people prepared for that? Diversity is a big aspect because that is where you'll find a lot of this talent since these are previously overlooked groups."*

Not only does a lack of diversity hurt the acquisition and retention of talent, but it also translates to attracting fewer developers and is detrimental to code maintenance prospects for those projects. One mentee from the Kubernetes project discussed how mentorship and other DEI programs could help introduce underrepresented perspectives into code development to the advantage of the project. As they explained,

> "*Greater representation from these groups introduces different people with different mindsets looking at a project, so when there's a problem, we can have various approaches to it, which will help it get solved even faster."*

Providing this kind of access means recognizing these barriers and tailoring services to respect the needs of diverse communities. This can take the form of offering paid mentorships in some instances and free mentorships in others. Khan explains,

> "*The goal here is to ask, how do we make it easier for people to overcome those barriers? Can we give these folks a little lift by providing resources like free training, free webinars, and paid mentorships? We have added unpaid mentorships because not everyone wants to or can get paid to access this program, as they know our program is a limited resource, and unpaid or credit-only helps us scale it without the funding constraints. So, we try to make*

The roots of mentorship programs in academia

Mentorship programs, specifically for fostering professional communities in the open source realm, have existed in the technology industry for about 17 years, with scholarly publications providing the basis for these programs dating back almost four decades.

These works are used to teach Semesters of Code, an evolving undergraduate curriculum that is being taught to computer science students at Johns Hopkins University on open source software engineering by adjunct faculty member Stephen Walli, who is a principal program manager at Microsoft's Azure Office of the CTO, a board member of the Eclipse Foundation, and a member of the LF Research Advisory Board.

Per Walli, the realization of the importance of mentorship programs began in the late 1980s with the research of Jean Lave, a social anthropologist at the University of California, Irvine, who introduced the concept of learning as participation in ongoing communities of practice. This challenged the conventional theories of learning and education, even to this day.

Her first work, *Cognition in Practice: Mind, Mathematics and Culture in Everyday Life* (1988), was a treatise about how ordinary people can do mathematical work in their everyday lives without even realizing it. Her second book, authored with Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (1991), was much more influential in education. In this book, Lave and Wenger proposed the theory that learning is a matter of legitimate peripheral participation in communities of practice.

According to Lave and Wenger, learning is not something that only happens in the classroom; it is a process that occurs through social interaction in everyday life. A community of practice is a group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.

For example, when children are born, they enter communities of practice, such as their family, and begin to learn the skills and practices of those communities. As they grow older, they move into new communities of practice, such as their peer groups, and continue to learn the skills and practices associated with those communities.

> *"My open source journey started with a question from a mentor in a workplace mentoring session. The question was, 'what are you waiting for?'"*
>
> —SHUAH KHAN, OPEN SOURCE FELLOW
> AND LINUX KERNEL MAINTAINER

The situated learning theory describes the drivers of peripheral participation in communities of practice and is very helpful in understanding how people learn in the workplace. Many companies have started mentorship programs based on this theory to help employees learn the skills and practices they need to succeed in their jobs.

Mentorship programs have also been beneficial in other settings, such as schools. In a school setting, mentorship programs allow students to learn from more experienced students or teachers. These programs can also help students develop relationships with adults who can provide support and guidance.

In work settings, mentorship programs allow employees to learn from their experienced peers as a learning pathway for career transition and advancing skills in their areas of interest.

The history of mentorships in open source and the technology industry

Open source mentorships date back to 2005 with the introduction of Google's Summer of Code, a program the company has run for the last 17 years. It targets college students and provides a stipend (of $1,500 to $6,600, depending on size and location) to work on an open source project. The program has expanded to include high school, postsecondary, and graduate students. Similarly, Google's Code-In, targeted at 13 to 17-year-olds, ran from 2010 to 2019.

Beyond Google, other companies are releasing technology industry mentorship programs, such as Microsoft, IBM, Amazon, Meta, and Red Hat. As with Summer of Code, these programs are typically 12 weeks long and take place during the summer. They are open to students at least 18 years of age who have completed one year of college.

- Microsoft Student Partners is a global program that helps students learn about technology, build their technical skills, and connect with other students. The program provides students access to Microsoft products, technologies, and programs.

- The IBM Pathfinder Mentoring Program pairs IBM engineers, designers, and business professionals with university students in the same discipline and enables those students to receive personalized career guidance.

- The Amazon Mentorship Program is a 12-week program that helps prepare participants for a career in software

development. The program includes weekly lectures, coding challenges, and project work. Participants also can shadow Amazon software engineers and attend social events.

- Meta University is a program for undergraduate and graduate students interested in pursuing a career in software engineering. The program includes coursework, internships, and research opportunities.

- Red Hat Mentorships is a program that helps students learn about open source software development. The program provides participants access to Red Hat products, technologies, and programs.

Nonprofit organizations like the Apache Software Foundation and the GNOME Foundation also offer mentorship programs.

- The Apache Software Foundation offers a 12-week mentorship program for students who want to contribute to Apache projects.

- The Software Freedom Conservancy Outreachy program provides internships for people from groups traditionally underrepresented in free and open source software, such as LGBTQ+. Outreachy does not require prior college attendance, only 18 years of age, to qualify for a mentorship. Marina Zhurakhinskaya, a Ukrainian software developer and prominent FOSS advocate, who lost her long battle with cancer in June of 2022, founded the program.

The genesis of mentorship at the LF

The idea of mentorship at the LF initially came about to bring maintainers into the fold for its Linux kernel project. As with many open source projects, the kernel's developer population has

grown organically—it is not a traditional hire and talent placement scenario. The need to replace developers over time is crucial to the stability and longevity of the project, and mentorship is one way

to achieve this. The organization decided to become more intentional about how it could help new developers get up to speed and become productive members of the open source community.

The pilot mentorship program launched within the kernel community in 2019 had a few simple objectives: to help new developers feel welcome, learn the ropes, and accept their first code contributions. Khan identified these objectives and the goal of increasing diversity. She says,

> *"We identified three reasons for starting the program: diversity, community health, and sustainability. You have to inject new talent and bring in people, new developers that can take over at some point from the aging maintainer population and step into these important roles. So, we felt that the best approach at the time would be having these developers trained by maintainer experts in those areas."*

Khan looked at previous examples of mentorship programs at other open source organizations and wanted to broaden mentorships outside of their student-centric focus by inviting industry professionals into the program. This also required unique accommodations that similar programs only previously had. Khan adds,

> *"I talked to people running mentorship programs at the time, such as Outreachy and Google Summer of Code, and how they viewed the shortcomings of those programs. One part that came up as a big thing was that it would be helpful to have it as a part-time program; thus, we added that early on. We also decided not to restrict it to students because career transition is very important. And I chose to run three sessions, spring, summer, and fall, like a college or university, so that it would be accessible to people globally.*
>
> *So, for example, the spring session is probably the one that people from the southern hemisphere could participate in because it is their summer. The summer session would be for other people and students. For others, they could fit into a three-month or six-month program."*

> *"Marina Zhurakhinskaya left an amazing legacy of initiatives to lift people up and change the lives of many. Marina's passing is a big loss to the open source community and people working toward equity in open source."*
>
> —SHUAH KHAN, LFX MENTORSHIP PROGRAM LEAD

Another approach to attract industry professionals was opening the program to anyone, regardless of employment status. As Khan explains,

> *"We don't require applicants to be unemployed; they can be fully employed, part-time, or of any kind of status. We simply say if you can spend 20 to 40 hours a week learning and advancing your skills, you're welcome to apply to our program."*

Khan also explains why they chose not to restrict participants based on demographics:

> *"Other programs restrict their mentorships to students only or women and LGBTQ+. Some of these are 100% diverse in their population, which is excellent. However, they are fishing from a smaller pond to begin with, which purposefully restricts the size of their addressable communities and programs. We didn't want to do that; we're open to everyone."*
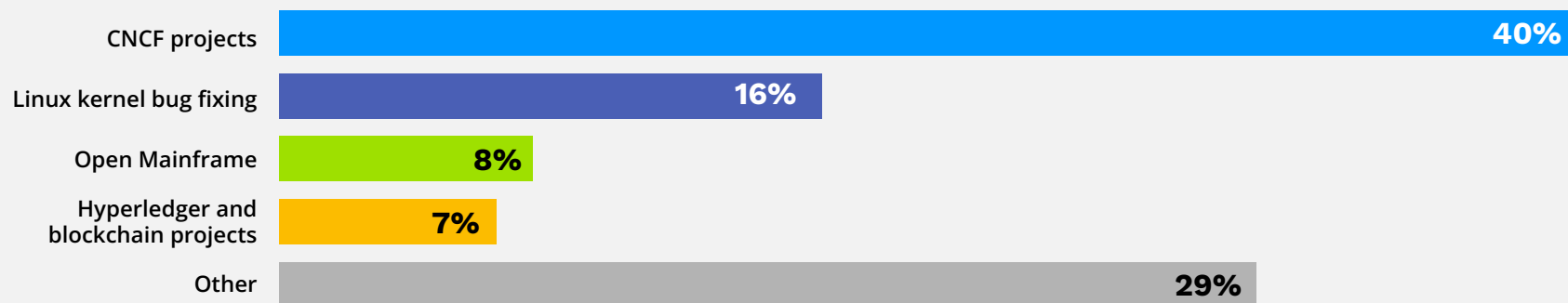
The program, now known officially as LFX Mentorships, has since been expanded beyond the Linux kernel to include other open source projects under the LF umbrella, such as Cloud Native Computing Foundation (CNCF), Hyperledger, Open Mainframe Project, ELISA, Zephyr, RISC-V, and Automotive Grade Linux. (**FIGURE 2**)

LFX Mentorships are fully matriculated; once a mentee has completed the program, they have "graduated" and are not eligible for additional mentorship for the program to provide opportunities for others. However, the possibility exists of becoming a mentor in the future. Several graduated mentees have been helping as co-mentors, sharing their experiences and realizing that mentoring is rewarding and a continuous learning path.

FIGURE 2

LFX MENTORSHIP PROGRAM MENTEES' PROJECTS

What was the name of the mentorship project you worked on?

Project	Percentage
CNCF projects	40%
Linux kernel bug fixing	16%
Open Mainframe	8%
Hyperledger and blockchain projects	7%
Other	29%

Mentorships and their impact on succession and diversity within open source

Improving diversity

Ensuring project health is not just about attracting new developers to replace the old; it's also about improving diversity in the open source community to make it more representative of the world. The code submitted to the projects themselves reflects this, where different perspectives worldwide contribute unique features that make the project relevant on a broader scale. Khan provides an example of this from the perspective of energy conservation. She says,

"We have kernel patches to improve power management on devices to help users from places like Africa and Southeast Asia, where they don't have as widespread access to charging infrastructure (for their laptops and mobile phones) as the rest of the world. They might not even have 24/7 electricity, which might be a luxury. California residents now realize they need backups with the wildfires they have been experiencing recently. So, these patches help conserve energy so that applications aren't power hogs; this is critical to companies that sell products in these areas of the world.

Different viewpoints come from diverse experiences, and open source software expresses their needs. We call this scratching our own itch, which results in unique features that benefit us all. That's where diversity of thought comes into play."

Although the program is open to everyone by design, the LF has focused on getting more women and other underrepresented groups involved in LFX Mentorship programs.

"We are trying to reach out to groups historically underrepresented within the open source community," said Khan. "We did a big push, for example, to Black colleges and Hispanic colleges in the summer of 2021 to raise awareness, as a part-time program, to give them the flexibility to work from anywhere, and we are expanding that globally.

We don't require participants to be just students, either. When we say we are inclusive, we don't say this will be just for women, LGBTQ+, or any particular denomination or group. We say this applies to anybody who wants to get involved with open source but does not know how to get started. So far, these are how our efforts have been, and we've seen more women participate. But it could be better. We have consistently improved our numbers since the program's inception in 2019. Our participation from women sits at 20% compared to 17% in 2019."

Kate Stewart, vice president of dependable systems at the LF, is passionate about bringing new talent and participants into open source projects. In fact, mentorship programs have been instrumental in recruiting new maintainers and advancing projects without direct funding, such as SPDX (Software Package Data Exchange). According to Stewart,

"My involvement in mentorship programs began with the SPDX side from the Google Summer of Code. Way back when the project started, this was the only way we were able to make forward progress on some of our tools."

> "One big reason it's fulfilling is that this makes a difference in people's lives. That little bit of encouragement, that little bit of lift, and having access to a mentor they can talk to and ask, is my patch good?"

A learning experience for mentees (and mentors)

Mentorship programs can be helpful for both the mentee and the mentor. Mentees can benefit from having someone to look up to and learn from. As Khan notes, mentors can benefit from the satisfaction of helping others grow and develop and introduce them to new approaches to software development. She adds,

"Mentors could be locked into a way of doing things, as they have been in their role as maintainers for a very long time. So, when somebody new comes in and tries something new, you look at that new approach and go, oh! That makes sense; that's another way to do things. So, the mentors themselves learn from mentoring. When I'm looking at patches for analysis sent from mentees who are fixing bugs, I am looking at different parts of the kernel that I am not familiar with in some cases. And sometimes, I need to go deep and understand what I am looking at before I can answer the questions from mentees in these areas, so it's beneficial to me."

The design of the kernel's mentorship program helps new developers familiarize themselves with the kernel development process and provide them with guidance and support from more experienced developers. The program is also open to established developers who want to contribute to the kernel but need help with the process. Working with an experienced maintainer can inspire mentees to become maintainers themselves. As one mentee told us,

"Due to the mentorship program, I was able to understand the mindset of the maintainers ... and I would happily take the responsibility of maintaining a project if anyone offers me the opportunity."

Mentors can teach new developers about the culture and customs of the open source community, as well as the technical aspects of working on open source projects. They may offer guidance and support while also being a source of inspiration for innovative concepts. In addition, mentorship programs can help build relationships between people of different ages, experiences, and backgrounds. Khan explains,

"One big reason it's fulfilling is that this makes a difference in people's lives. That little bit of encouragement, that little bit of lift, and having access to a mentor they can talk to and ask, is my patch good? Or is my communication good on this email list? Or even how we can help them respond to an upstream email conversation. As a mentor, I might ask that they pose specific questions upstream for effective communication. Or the mentee might say to me that the maintainer hasn't responded to their patch. I can then say, as a mentor, give them more time to respond. Having someone who can watch over you and be an advocate is a big help when you are getting started in open source; it makes you more confident in understanding how the communication dynamic works."

As Kate Stewart says, a maintainer requires a unique combination of technical skills and relationship management.

"There is a recognition that the maintainership tasks are different than the coding tasks. Many people like to code, but this is a different set of skills. You have to understand the technical skills to be an effective maintainer, but you also have to have a lot more social intelligence. Code is easy. People are hard. Maintainership is about people management."

Mentorship can also be a fulfilling experience for retired people who can pass on their expertise to the next generation of programmers to stay active in the technology industry. Stewart discusses the individuals she recruits in former executive roles at major corporations to act as mentors:

"Many experienced people are retiring—so how do we keep them engaged? These folks have a lot of skills, so how do they pass them on, and how can it become something they enjoy doing? A friend of mine is a couple of years older than me, and he retired from NXP. He's sitting around at home, puttering around. And I am saying to myself, how can I lure him into working on some open source projects? It's rewarding and effective for people who have had a full career, don't want to do a full-time job, but still want to keep their hand in things and be effective."

> "You have to understand the technical skills to be an effective maintainer, but you also have to have a lot more social intelligence. Code is easy. People are hard. Maintainership is about people management."

Confidence building

While any community needs some form of guidance and support for its members, this is especially true in the open source world. The development of open source software presents unique challenges. Volunteers often develop it, and they may not have professional experience. This also influences their desire to engage in open source in the first place, as expressed by 100 LFX Mentorship mentees surveyed in 2022. **FIGURE 3** shows almost two-thirds of mentees lacked some confidence in their ability to engage in open source before they joined the program.

One of the positive outcomes of surveying mentees was the reported increase in confidence that mentorship programs create. **FIGURE 4** shows that 90% of mentees report increased confidence compared to their level before starting the program.

Qualitative interviews confirmed these results. One mentee interviewed from the Linux kernel project said they decided to join the program to level up their technical skills but also gained confidence in communicating with the community for help and advice. They explained,

"I found that the kernel community was extremely patient with me ... as I dealt with the fact that I need to accept help, suggestions, and advice."

Another mentee from CNCF shared a similar reflection on their increased confidence because of the program:

"I believe my ability to explain myself or to present myself has increased ... now, whenever I face a problem, I just publicly go on Slack, and I just say I'm facing issues."

Mentorship can provide these individuals with the skills and knowledge to succeed. Khan elaborates,

"Mentees are getting direct access to experts in those projects and benefiting from the experience of maintainers. They get a one-on-one meeting with the maintainers and experts. They can

FIGURE 3

CONFIDENCE OF MENTEES IN CONTRIBUTING TO OPEN SOURCE PROJECTS BEFORE MENTORSHIP PROGRAM

Before the mentorship program, which of the following best describes your level of confidence with respect to engaging in open source?
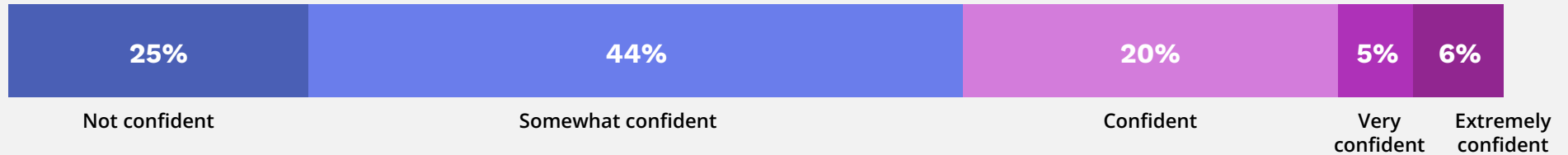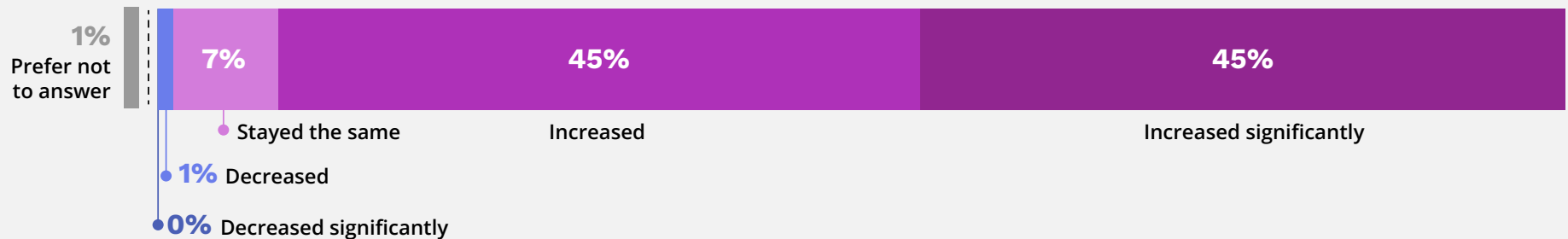
25%	44%	20%	5%	6%
Not confident	Somewhat confident	Confident	Very confident	Extremely confident

FIGURE 4

MENTEE CONFIDENCE IN CONTRIBUTING TO OPEN SOURCE PROJECTS AFTER MENTORSHIP

After completing the mentorship program, which of the following best describes your level of confidence with respect to engaging in open source?

1% Prefer not to answer

7%	45%	45%
Stayed the same	Increased	Increased significantly

1% Decreased

0% Decreased significantly

bounce ideas off of mentors before submitting their upstream contributions. That's a huge confidence-building factor.

So, for example, with the 13 mentees I mentored this last summer, some of the questions they asked me were interesting, such as, was our community open? If we send patches, will you review them? And they ask other development questions, such as the length of the

development processes of particular vendors, the ideal time to send patches, how long it takes for a maintainer to review the patches, etc. All of these are questions that come up in one-on-one conver-sations. They have to sort through a lot of information as part of being a contributor to an open source project, and sifting through that is hard for them. So, when they have one-on-one relationships with mentors, it helps."

Community building through mentorship

Mentorship can also help to foster a sense of community within the open source world. By providing guidance and support, mentors can help to create an environment where people feel welcome and valued. This, in turn, can encourage more people to participate in open source projects, which can only serve to improve the quality of the software produced. As one mentee told us,

> "Apart from the technical skills I picked up from my mentorship project, I also learned the art of communicating technical ideas with like-minded people ... I could convey my ideas properly, and even though I was just expecting clarifications on what I should not implement, I received a lot of support from the community to kickstart my first open source project."

When thinking about how mentorship programs benefit open source, it's important to consider other intangibles in addition to bringing in new developer blood and how they address diversity issues. Khan states it's not simply a balance sheet:

> "Bringing in new developers and training them is obvious, right? When new developers come in, they bring in a new point of view, injecting relevant new ideas like when companies hire new people.

> Similarly, teaching open source philosophy and the importance of open source early on, in the early part of their careers, will be beneficial to them. It's also beneficial to have more trained open source developers—they come in and already understand the ecosystem,

and part of our training helps them understand that ecosystem. All of that is beneficial—it all comes back to the question of the benefits of open source in the first place. So, it's hard to prove the bottom line. Training and mentoring new developers are part of that bottom line—all this time and money I spend is not a balance sheet. It's an intangible benefit that you cannot prove. Yes, it's beneficial, but you cannot put a dollar amount on it."

By completing the mentorship program, mentees are subject to the inner workings of creating and maintaining open source projects. This exposure inspires them to continue contributing to projects. As one mentee said, "I have been actively contributing to open-source ever since." Another mentee shared how their experience supporting a new project during the program made them confident in starting their own projects:

> "After graduating from the program, I went on to start my own open source projects in the JuliaLang community. I had seen the ins and outs of project ideation to the completion of an industry-grade software feature. I was confident enough that I could start working on my own project to attract open source contributions someday."

The LFX Mentorship program can claim a high success rate as to the disposition of mentees toward open source contribution post-graduation. Eighty-five percent of mentees are or are willing to continue contributing to the project they were involved in after mentorship, as illustrated in **FIGURE 5**.
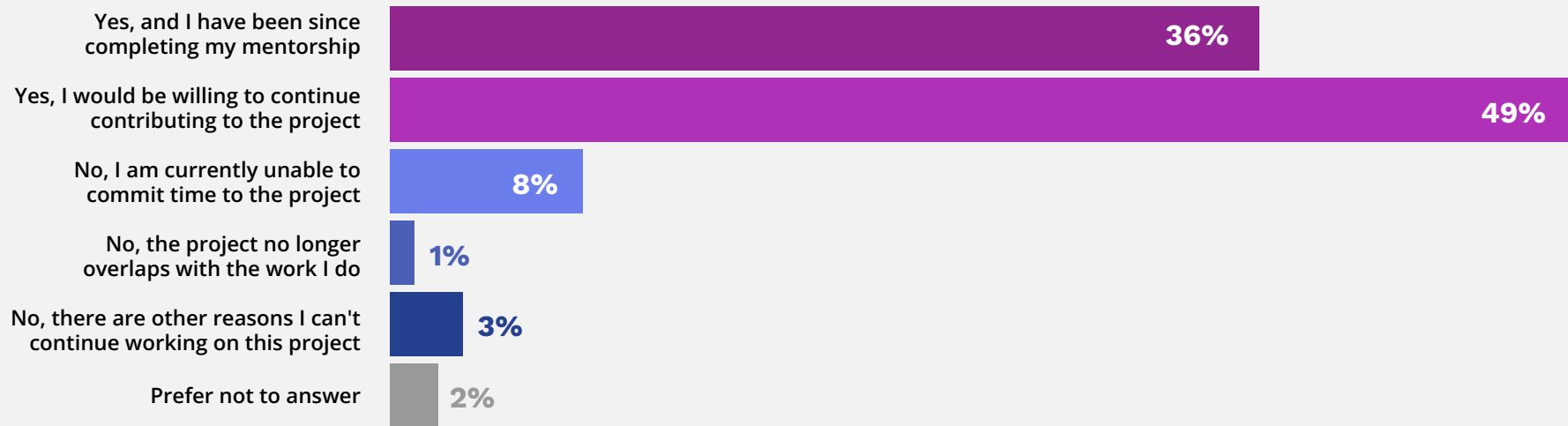
"After graduating from the program, I went on to start my own open source projects in the JuliaLang community. ... I was confident enough that I could start working on my own project to attract open source contributions someday."

FIGURE 5

DISPOSITION OF LFX MENTORSHIP PROGRAM MENTEES TOWARD CONTINUING OPEN SOURCE CONTRIBUTION POSTGRADUATION

Are you willing to contribute to the project you were mentored in?

Yes, and I have been since completing my mentorship	36%
Yes, I would be willing to continue contributing to the project	49%
No, I am currently unable to commit time to the project	8%
No, the project no longer overlaps with the work I do	1%
No, there are other reasons I can't continue working on this project	3%
Prefer not to answer	2%

Mentorship program challenges

"Financial incentives are not effective motivators for open source developers in general."

While mentorship programs can help bring underrepresented groups into the field of software engineering and help refresh the maintainer population, there is still room for improvement.

While the LFX Mentorship program has thousands of applicants every year, the selection process weeds out many people who cannot commit to the program. For one, the programs can be time-consuming and require considerable commitment from participants. In many ways, LFX Mentorship participation as a mentee and mentor follows the self-selection model of open source participation. Even more problematic is the need to get more mentors involved; a lack of mentors can lead to frustration and discouragement for the mentees.

To encourage more mentors to join these programs, Kate Stewart would like to see more recognition and incentives for the mentors themselves.

"One of our biggest challenges for mentorship is, how do we get to scale? The scientific work has illustrated that people don't stick around once they are there—some do, and some don't. So, we have maintainer burnout. So, the question is, how do you get the people who have been mentored to do the next generation of mentoring so we can scale up instead of everything falling on the maintainers?

Motivating graduates to co-mentor is proving to be successful. Some graduates view the opportunity to co-mentor with an

experienced mentor as an opportunity to learn and something they can show as an achievement. Financial incentives are not effective motivators for open source developers in general."

Mentorship programs can help bring underrepresented groups into the field of software engineering, but they face significant challenges in attracting diverse participants and ensuring they have a rewarding experience once involved. Adequate training and support for mentors and mentees can help address these challenges. Additional resources can make it easier for everyone involved to get the most out of the experience. In addition, by connecting individuals from different backgrounds and experiences, mentorship programs can help create a more diverse and inclusive community within software engineering.

Some of this support can come in the form of funding. Angela Brown, SVP and GM of events at the LF, discussed the value of funding an individual's participation in a program or event. She offers travel funding to early career professionals to attend open source events within her portfolio. When reviewing the demographics of those who have previously received funding, she notes,

> *"Most of our funding goes to diversity. Many recipients of event travel funding are women from all over the world, so it gives us a more diverse set of people participating in our events compared with what we see in the mentorship program."*

Diversity funding is one way to encourage greater representation in the network of early-career open source developers and expose them to more career opportunities within and outside of the mentorship program.

> "Most of our funding goes to diversity. Many recipients of event travel funding are women from all over the world, so it gives us a more diverse set of people participating in our events compared with what we see in the mentorship program."

But while training and other resources within mentorship programs can help improve the programs themselves, there are also fundamental problems attracting individuals into mentorship programs due to the limited supply of interdisciplinary software developers trained in embedded systems and software engineering regardless of gender, identity, or socioeconomic background.

This makes it challenging to find qualified individuals willing to participate as mentors and mentees. In addition, many potential mentees may be reluctant to join a program because they do not have the necessary skills or experience.

The problem is not necessarily a lack of technology professionals. A rebound in the percentage of computer science and information degrees conferred by U.S. universities followed a period of decline, accounting for almost 5% of all degrees in 2020, according to the National Center for Education Statistics.[1] According to the U.S. Bureau of Labor Statistics, the expectation is that employment for all computer and math-related jobs will grow 15% over the next decade.[2]

Instead, it is a question of a skill sets gap. Many of these prospective open source developers do not live in geographies where the required skills are taught in educational institutions.

These limiting factors have led to a disproportionate underrepresentation of mentees from those parts of the world. Seventy-six percent of respondents to the survey indicated that they lived in the Asia-Pacific region, whereas 14% said they lived in EMEA. Only 10% said they lived in the Americas. (See the Demographics section.)

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1   National Center for Education Statistics. 2022. Undergraduate Degree Fields. *Condition of Education*. U.S. Department of Education, Institute of Education Sciences. Retrieved 11/23/2022, from https://nces.ed.gov/programs/coe/indicator/cta.

2   U.S. Bureau of Labor Statistics. 2022. "Computer and Information Technology Occupations: Occupational Outlook Handbook". Retrieved 11/23/2022, from https://www.bls.gov/ooh/computer-and-information-technology/home.htm.

Career benefits of mentorship programs

In addition to improving community health by fostering diversity and cultivating a new generation of open source developers within these projects, mentorship programs can have a transformative economic impact on mentees' lives after they graduate.

Receiving compensation and being able to cover living expenses is a key concern for mentees when contributing to open source projects. **FIGURE 6** shows that two-thirds of LFX Mentorship mentees had no prior experience getting paid for their open source involvement before beginning the mentorship.

The lack of compensation is partially due to many mentorship program applicants still needing to fully enter the professional world. Per **FIGURE 7**, before joining the mentorship program, 85% were students; after completing the program, 63% of former mentees had at least a part-time job.

Regarding overall compensation before and after graduation, 67% of those employed and willing to discuss the subject saw their incomes increase after graduation from the mentorship program. (**FIGURE 8**)

Mentorship programs can also create new and increased career opportunities for mentees. Participating in a mentorship program can give mentees access to resources and knowledge that are difficult to find elsewhere. After graduation, many mentees find that they have a more extensive network of contacts in their chosen field, which can lead to better job opportunities.

Mentors often have a wealth of experience and can provide mentees with valuable advice on which direction to take in their careers. The connection to such an experienced individual is often invaluable for a young professional.

Mentors are often well-respected members of the industry and can provide mentees with recommendations or introductions that can help them get the job they want. As **FIGURE 9** shows, 69% of LFX Mentorship mentees have seen their career advance or new career opportunities emerge due to participating in the mentorship program.

FIGURE 6

COMPENSATION OF MENTEES BEFORE BEGINNING THE LFX MENTORSHIP PROGRAM

Before the mentorship program, did you receive financial compensation for your contributions to open source projects?

Yes, my compensation was more than enough to cover my living expenses **2%**

3%
Prefer not to answer

Yes, but not enough to cover my living expenses

Yes, enough to cover my living expenses

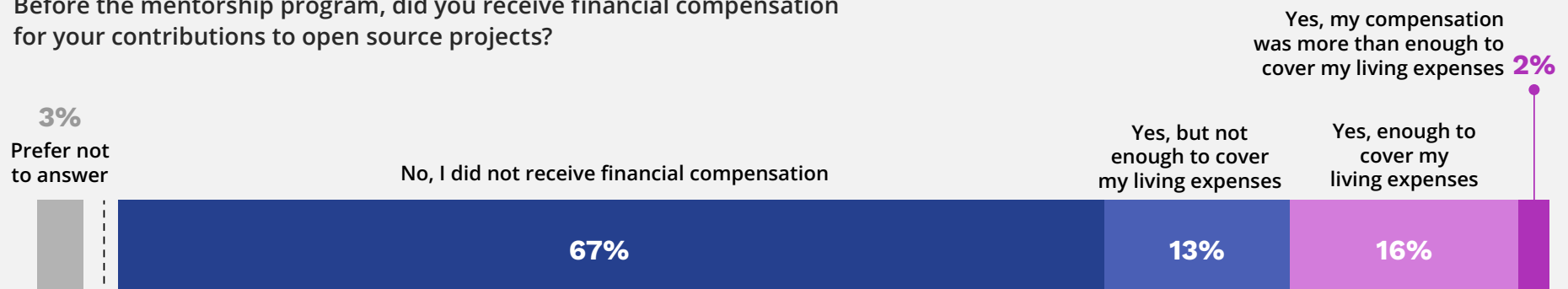No, I did not receive financial compensation **67%**

13%

16%

FIGURE 7

EMPLOYMENT STATUS OF LFX MENTORSHIP PROGRAM MENTEES POSTGRADUATION

Before and after completing the mentorship program, what best describes your involvement in open source technology projects?
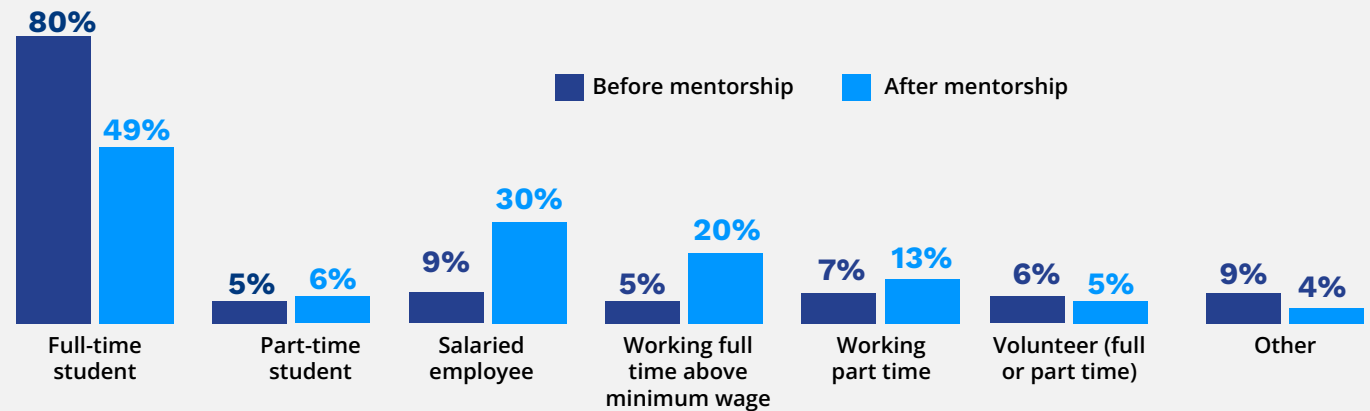
Before mentorship ■ After mentorship ■

Category	Before	After
Full-time student	80%	49%
Part-time student	5%	6%
Salaried employee	9%	30%
Working full time above minimum wage	5%	20%
Working part time	7%	13%
Volunteer (full or part time)	6%	5%
Other	9%	4%

FIGURE 8

CHANGES IN INCOME LEVELS OF LFX MENTORSHIP PROGRAM GRADUATES

If currently employed, has your income increased following your participation in a mentorship program?
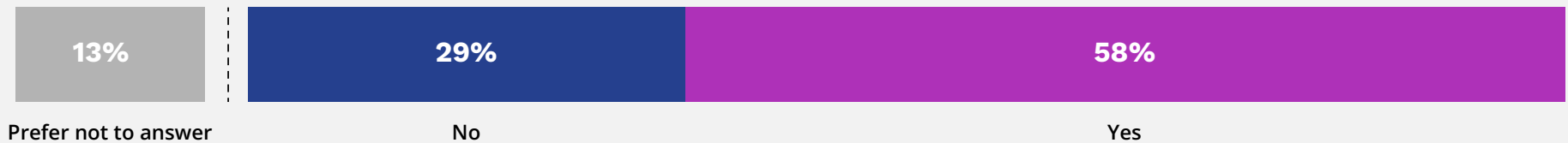
13%	29%	58%
Prefer not to answer	No	Yes

FIGURE 9

NEW CAREER OPPORTUNITIES FOR LFX MENTORSHIP PROGRAM GRADUATES

Did your mentorship program help you to advance your career (e.g., you received a promotion, a raise, or found a new job with greater opportunities)?
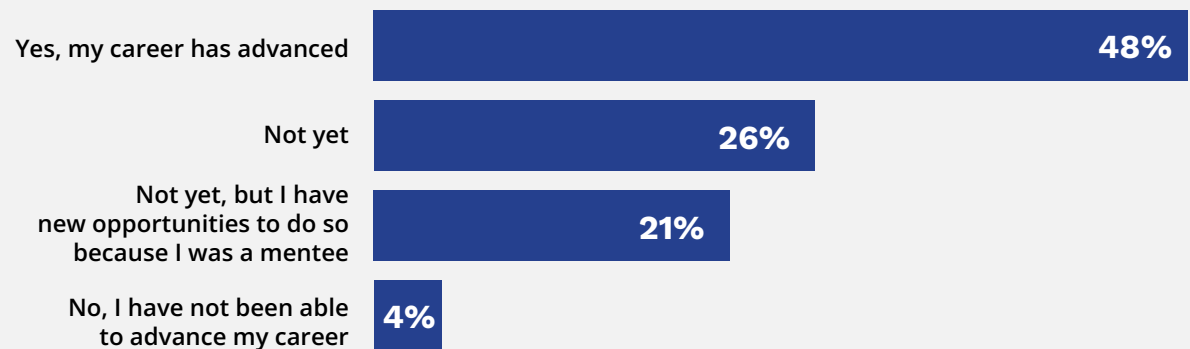
Yes, my career has advanced	48%
Not yet	26%
Not yet, but I have new opportunities to do so because I was a mentee	21%
No, I have not been able to advance my career	4%

FIGURE 10

DISPOSITION OF LFX MENTORSHIP PROGRAM GRADUATES ON THE IMPACT OF THEIR EMPLOYMENT STATUS

Did your mentorship program help you to find a new job? When did you complete your mentorship program?
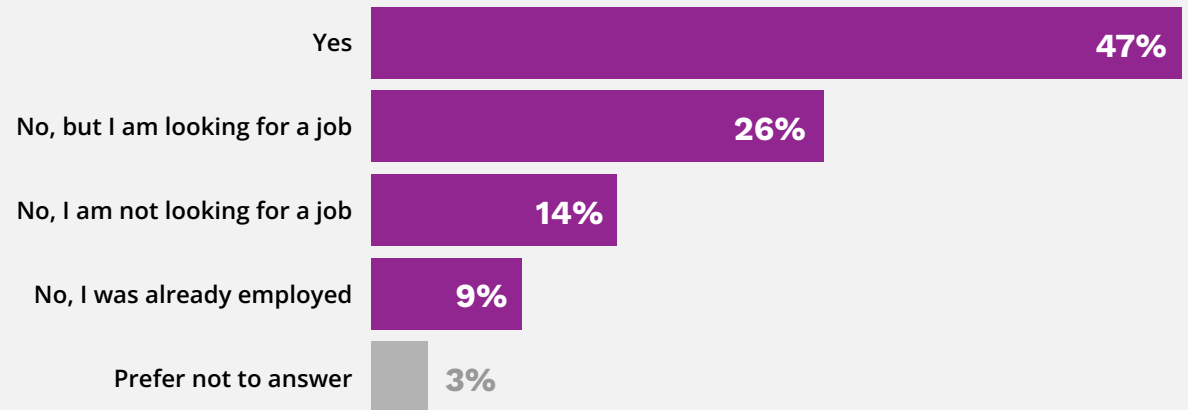
Yes	47%
No, but I am looking for a job	26%
No, I am not looking for a job	14%
No, I was already employed	9%
Prefer not to answer	3%

FIGURE 11

LFX MENTORSHIP MENTEES COMPENSATED AND UNCOMPENSATED PARTICIPATION IN OPEN SOURCE PROJECTS PRE- AND POSTGRADUATION

Before and after completing the mentorship program, what best describes your involvement in open source technology projects? Are you currently employed?
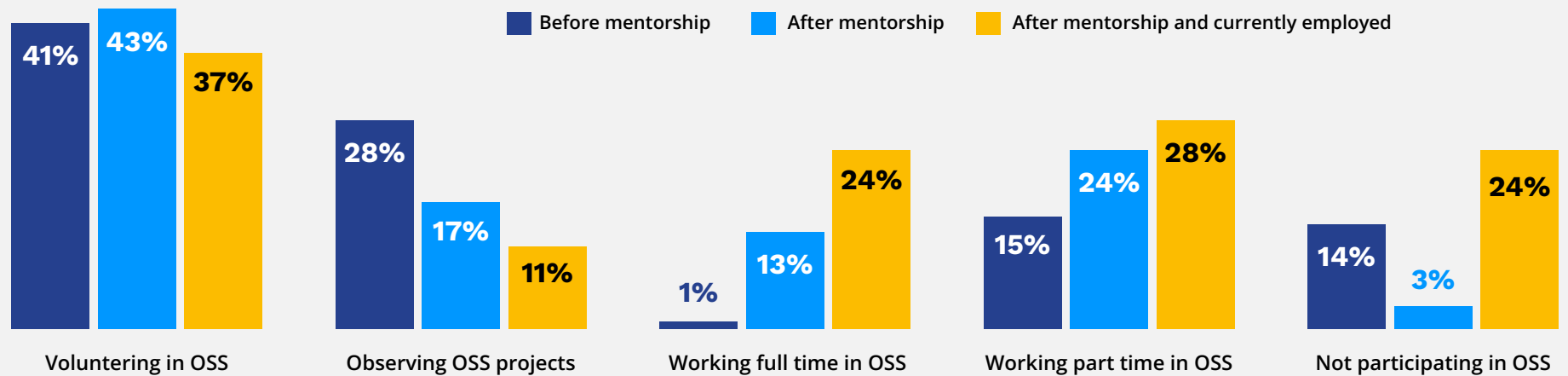
Legend: ■ Before mentorship ■ After mentorship ■ After mentorship and currently employed

	Before mentorship	After mentorship	After mentorship and currently employed
Voluntering in OSS	41%	43%	37%
Observing OSS projects	28%	17%	11%
Working full time in OSS	1%	13%	24%
Working part time in OSS	15%	24%	28%
Not participating in OSS	14%	3%	24%

FIGURE 12

PERCEIVED VALUE IN THE BENEFITS OF THE LFX MENTORSHIP PROGRAM AMONG GRADUATED MENTEES

What statement below best describes the benefit you derived from your mentorship program? (select all that apply)
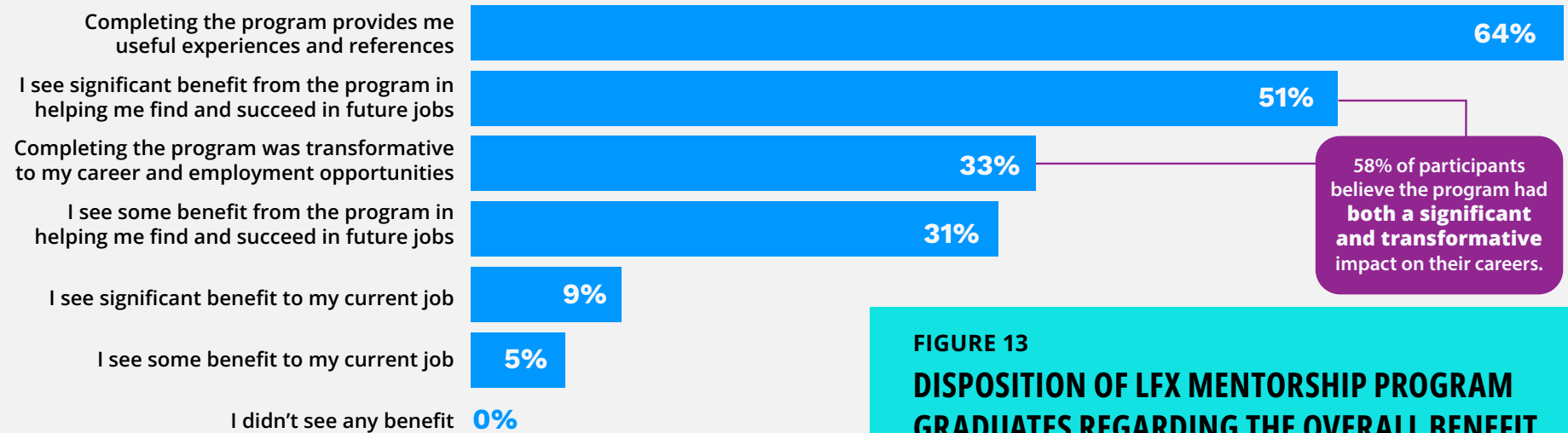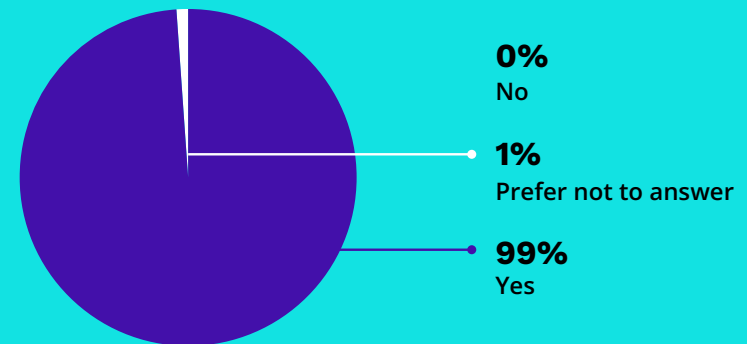
Completing the program provides me useful experiences and references	**64%**
I see significant benefit from the program in helping me find and succeed in future jobs	**51%**
Completing the program was transformative to my career and employment opportunities	**33%**
I see some benefit from the program in helping me find and succeed in future jobs	**31%**
I see significant benefit to my current job	**9%**
I see some benefit to my current job	**5%**
I didn't see any benefit	**0%**

58% of participants believe the program had **both a significant and transformative** impact on their careers.

FIGURE 13

DISPOSITION OF LFX MENTORSHIP PROGRAM GRADUATES REGARDING THE OVERALL BENEFIT

Would you recommend the mentorship program to others?

0%
No

1%
Prefer not to answer

99%
Yes

"The project clarified my vision of where I would like to take my career and where I would like to go within the mainframe. The vision that I have right now is because of that project."

Employment is often a gauge of career advancement, and 47% said that the program helped them get a job. (**FIGURE 10**)

For those LFX Mentorship program graduates who have jobs, how does this relate to being compensated for open source work? **FIGURE 11** shows that over half of those employed receive payment for their open source involvement.

The LFX Mentorship program clearly changes the lives of its mentees. **FIGURE 12** shows that 58% of participants believe the program had a significant or transformative impact on their careers. One mentee interviewed by the Open Mainframe Project told us,

"The project clarified my vision of where I would like to take my career and where I would like to go within the mainframe. The vision that I have right now is because of that project."

But perhaps the most astonishing part of the LFX Mentorship program is the level of satisfaction among its graduates. **FIGURE 13** illustrates that 99% of former mentees would recommend the program to others, and everyone involved acknowledges that the program was beneficial.

Conclusions

Despite ongoing challenges with scale, mentorship programs, including LFX Mentorship, help college and university students and young professionals gain experience with open source software development, which advances their careers and helps to build a healthy and diverse community of new contributors and maintainers across LF and open source projects.

The three primary takeaways from the study are:

1. LFX Mentorship participants had prior involvement in open source and IT from a student's perspective but lacked confidence and work experience. Their confidence improved after participation.

2. Mentees find employment and increased income after the conclusion of the mentorship, and they frequently receive payment for their contributions to open source.

3. The mentorship program is helping build a confident, diverse community of open source developers.

Actionable insights

The LFX Mentorship program is making our project communities more diverse, helping mentees find jobs, and demonstrating overall value, but where do we go to improve scale?

Educate multiple stakeholders on the program's successes.

LF projects that have invested in LFX Mentorships should be proud of their impact and aware of their return on investment for future funding consideration. Those projects that do not have mentorships in place and are unsure whether a mentorship program will benefit them at their current state of development need only to look to the example set by projects such as the Linux kernel, CNCF, ELISA, Hyperledger, and Open Mainframe—each is devoting significant resources to this effort for the outcomes this report identifies.

Additionally, we request our member companies to encourage and promote mentoring by allowing their employees to mentor.

Encourage continued financial support from the open source community.

An investment in mentorship is an investment in the future health of open source projects. The financial incentive offered to mentees to join the program meets a fundamental need for people at the outset of their careers. Similarly, it may be worth exploring ways to compensate mentors who invest significant time, which may comprise a combination of financial reward with support in the form of human resources, tooling, and other nonfinancial benefits.

As member and partner organizations benefit heavily from the open source projects themselves, they should view funding mentorship as an investment in their own software's sustainability, increasing the likelihood of a steady stream of future talent that is trained on the platforms they use. An example of this is the recently launched LFX Mentorship Showcase, which allows graduating mentees of the LFX

Mentorship program to showcase the work they completed during their session term and connect with prospective employers from our member companies.

Address geographic barriers that the report identifies.

As Southeast Asian participants represent more than 70% of the LFX Mentorship program, this is a powerful indicator that we need to understand the reasons for the gap and improve the geographic makeup of the mentee population in other regions, such as North America and Europe.

Use tooling for productivity to help maintainers mentor without burnout.

The amount of time that mentors invest directly with their mentees is significant, so the more we can use tools to create a "one-to-many" type of paradigm will improve the program's scalability. Examples of this are in play, such as the 15-minute "Speed Mentorships" recently tested at Open Source Summit North America 2022 and LF Live: Mentorship, a series of webinars held for remote learning that can be attended on demand.

Final thoughts

The LFX Mentorship program is clearly a success, and we should be doing all that we can to encourage more investment in this valuable initiative. By educating stakeholders on the successes of mentorship programs, seeking donations and funding from among our members and partners, addressing geographic barriers, and using tooling for productivity, we can ensure the longevity of the program and also create a more diverse, confident open source developer community for the long term. By leveraging the power of mentorships, we can continue to improve our open source projects and ensure they remain vibrant for years to come.

We would like to thank our mentors for volunteering their time to share their valuable experience in formal mentoring programs and in hosting LF Live Webinars
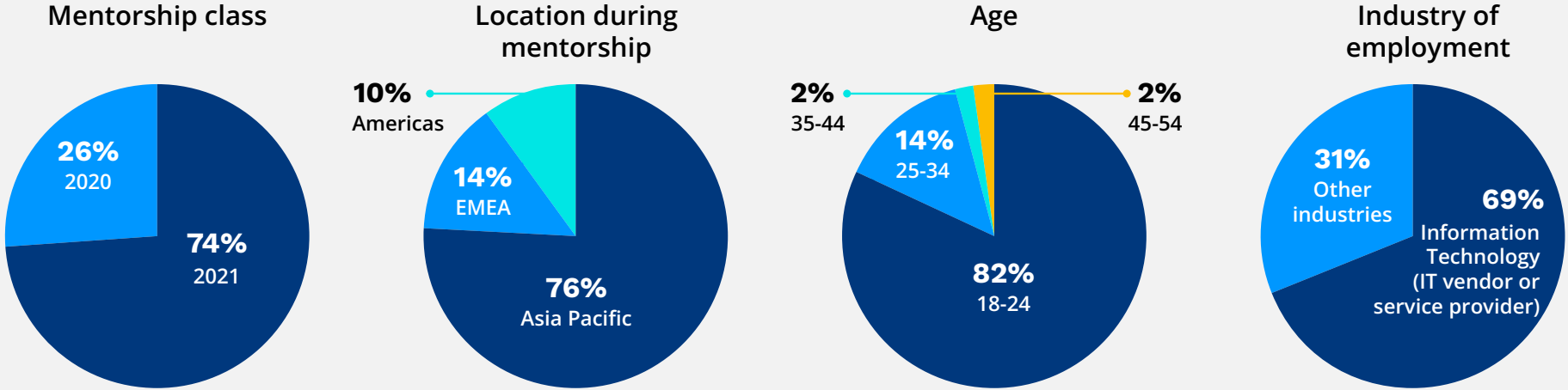
Methodology

- The completion of a survey of graduates of the LF Mentorship program took place from January through March 2022.

- After eliminating duplicate and incomplete records, this analysis is based on 74 participants who came from the 2021 mentorship class, with the remainder completing the program in 2020.

- For N = 100, the margin of error is +/- 8.2% @ 90%.

- After the completion of the initial survey, more than 20 mentees provided additional qualitative feedback.

- Percentage values may not add exactly to 100% due to rounding.

Demographics

A survey of 100 graduates of the 2020 and 2021 LF Mentorship programs yielded the results. Three-quarters of the respondents lived in an Asian country during their mentorship, and 82% were 18–24 years old. Of those currently employed, 69% work in the information technology industry.

FIGURE 14

SELECTED DEMOGRAPHICS OF THE 2022 LF MENTORSHIP SURVEY

Mentorship class
- 26% 2020
- 74% 2021

Location during mentorship
- 10% Americas
- 14% EMEA
- 76% Asia Pacific

Age
- 2% 35-44
- 2% 45-54
- 14% 25-34
- 82% 18-24

Industry of employment
- 31% Other industries
- 69% Information Technology (IT vendor or service provider)

About the author

Jason Perlow is a veteran of the information technology industry with over 25 years of experience as an independent consultant for the financial sector and a systems architect, technology strategist, and technical writer at Unisys, IBM, Dimension Data, and Microsoft. Jason led the 8th, 9th, and 10th annual LF Jobs Reports. He co-authored the 2021 State of Open Source in Financial Services research and, as editorial director, is the lead content writer, editor, and manager for LF Projects, LF Research, and Linux.com. In 1999, Jason was the founding senior technology editor of *Linux Magazine*, where he led coverage of the formation of the LF and has had an op-ed technology column on ZDNET, covering enterprise technology since 2008.

Acknowledgments

Note

This report has been updated since its original release on 01.16.23. This second version, released on 01.19.23, corrects errors found in the original text and graphics.

LFX | Mentorship

Invest in building a stronger and more diverse community of qualified developers and engineers. LFX Mentorship makes it easy to sponsor and help train the next generation of open source developers by serving the key needs of the community. The program received 10,700 applications, accepted 600+ applicants, and paid $1.5M in stipends. Since its inception in 2019, LFX Mentorship Programs have trained 414 new developers.

Several of our graduates are now gainfully employed and continuing to contribute to open source projects. We strongly believe in and are committed to providing learning pathways for new developers of all backgrounds.

THE LINUX FOUNDATION | Research

Founded in 2021, LF Research explores the growing scale of open source collaboration and provides insight into emerging technology trends, best practices, and the global impact of open source projects. Through leveraging project databases and networks and a commitment to best practices in quantitative and qualitative methodologies, LF Research is creating the go-to library for open source insights for the benefit of organizations the world over.

CLOUD NATIVE COMPUTING FOUNDATION

The CNCF, part of the LF, hosts critical components of the global technology infrastructure, including Kubernetes, Prometheus, and Envoy. CNCF brings together the industry's top developers, end users, and vendors and runs the world's largest open source developer conferences. For more information, please visit **www.cncf.io**.

ELISA
ENABLING LINUX IN SAFETY APPLICATIONS

The **ELISA** project aims to make it easier for companies to build and certify Linux-based safety-critical applications—systems whose failure could result in loss of human life, significant property damage, or environmental damage. ELISA members are working together to define and maintain a common set of tools and processes to help companies demonstrate that a specific Linux-based system meets the necessary safety requirements for certification. Launched in February 2019, ELISA works with Linux kernel and safety communities to agree on what to consider when using Linux in safety-critical systems. The project has several dedicated working groups that focus on providing resources for system integrators to apply and use to analyze qualitatively and quantitatively on their systems.

HYPERLEDGER FOUNDATION

Hyperledger Foundation is an open source community focused on developing a suite of stable frameworks, tools, and libraries for enterprise-grade blockchain deployments. It is a global collaboration hosted by The LF and includes leaders in finance, banking, the Internet of things, supply chains, manufacturing, and technology. Built under technical governance and open collaboration, individual developers, service, and solution providers, government associations, corporate members, and end users are all invited to participate in developing and promoting these game-changing technologies.

THE LINUX FOUNDATION | Training & Certification

The LF's training program features courses developed and taught by expert instructors, many of whom are well-respected professionals in the open source community. Our certification team performs comprehensive industry and job analyses to ensure every professional certification program we offer meets our exceedingly high standards. Led by our outstanding customer success team, we deliver responsive support and customized training solutions to enable individual and business to successes.

OPEN MAINFRAME PROJECT

The Open Mainframe Project was founded in 2015 as a focal point for deploying and using Linux and open source in a mainframe computing environment. With a vision of open source on the mainframe as the standard for enterprise-class systems and applications, the project's mission is to build community and adoption of open source on the mainframe by eliminating barriers to open source adoption on the mainframe, demonstrating value of the mainframe on technical and business levels, and strengthening collaboration points and resources for the community to thrive. Open Mainframe Project is home to more than 22+ projects and working groups, including ADE, Ambitus, ATOM, CBT Tape, COBOL Check, COBOL Programming Course, COBOL Working Group, ConsoleZ, Feilong, GenevaERS, Linux Distributions Working Group, Mainframe Open Education, Mentorship, Polycephaly, Software Discovery Tool, TerseDecompress, Tessia, Zowe, and Zorow.

OpenSSF
OPEN SOURCE SECURITY FOUNDATION

The OpenSSF is a cross-industry organization that brings together the industry's most important open source security initiatives and the individuals and companies that support them. The OpenSSF commits to collaboration and working both upstream and with existing communities to advance open source security for all.