

GitHub Copilot and the Great Developer Squeeze

Unsurprisingly, technologists once again find ourselves faced with the dilemma of, “We can, but should we?” Wrapped up in the zealotry of ever-increasing efficiencies, GitHub Copilot could equally spell disaster and a worsening talent gap as it could be a tool every developer comes to rely on.

And, still, reliance is quite problematic when it becomes dependence.

There are notable issues that have been raised about GitHub Copilot from within the technology community, and even GitHub and Microsoft have offered some disclaimers about the dangers of implicitly trusting code and fair use risks.

However, one angle seemingly less covered in the discussion is how GitHub Copilot might affect the tech talent rising through our ranks today and in the future—squeezing them out of essential opportunities to learn and master their craft.

Which ‘topia Will GitHub Copilot Become?

GitHub Copilot is among the first true attempts to automate aspects of software development with artificial intelligence (AI). It’s been developed by GitHub (a Microsoft company since 2018) and OpenAI (an artificial intelligence research laboratory), and the version currently released is available through Visual Studio 2022 IDE.

OpenAI’s Codex (an AI model) enables GitHub Copilot to:

- Generate code from natural language
- Describe code in English
- Translate between programming languages.

As Pete Welinder, OpenAI’s VP of products and partnerships, described, “It makes coding more productive in terms of removing not-so-fun work.” He added, “And oftentimes, the things that the tools are doing is they are helping you to very quickly go through the least interesting parts of your job so that you can get to the most interesting parts of your job, which makes the qualitative experience of creating much more pleasant and stimulating and fun.”¹

¹ Microsoft. *How AI makes developers’ lives easier, and helps everybody learn to develop software.* <https://blogs.microsoft.com/ai/how-ai-makes-developers-lives-easier-and-helps-everybody-learn-to-develop-software/>

Now, more fun always sounds great. But *why* are the “least interesting parts” of software development less fun?

Is it because it’s a process you’ve done 10,000 times? What about the person who’s done it 10 times and is still learning by doing?

Our Understanding of the GitHub Copilot Problem

For decades, technologists have often been the ones offering consolations over automation, AI, machine learning, and robotic replacement of workers. Automation has become a panacea, all-too-readily applied whenever possible to every facet of the economy and our personal lives.

But what happens when we turn the situation around on ourselves?

“A lot of the goals of machine learning and deep learning is to write the software itself over time so a lot of entry-level programming jobs will just not be as relevant anymore,” stated Jack Dorsey, Twitter co-Founder (and board member up until hours before the time of writing), in 2019.²

What if Jack Dorsey is right?

So far, workplace automation has primarily been thought of as a replacement for un- or semi-skilled labor activities—aimed at creating efficiencies and reducing costs (and increasing many a share price). But the only thing holding that back from beginning to replace skilled work is the development of the necessary technological capabilities.

That will not remain true, however.

Automation Projections

Per the World Economic Forum, the first example of job automation occurred in the 1500s in the textile industry. Although it minimally impacted workers at the time, there were riots by the 1800s—coincidentally led by the same “Luddites” we’ve repurposed as a disparaging term for people considered technologically illiterate. Over the next decade, the World Economic Forum estimates that continued automation progression will have eliminated 33% of current jobs.³

² CNBC. *Twitter billionaire Jack Dorsey: Automation will even put tech jobs in jeopardy.*

https://www.cnbc.com/2020/05/22/jack-dorsey-ai-will-jeopardize-entry-level-software-engineer-jobs.html?utm_content=Tech&utm_medium=Social&utm_source=Facebook&fbclid=IwAR3DDEOp4uhSDDFXhfZOxFzsPllUEi4bH-Rxy4B_fZE_305vM8cGKyHr59k#Echobox=1651675543

³ World Economic Forum. *A short history of jobs and automation.*

<https://www.weforum.org/agenda/2020/09/short-history-jobs-automation/>

Similarly, McKinsey estimates that 1 in 16 of all workers across the eight countries they studied will need a new occupation by 2030—a pace accelerated by the COVID-19 pandemic.

Will automation result in such severe employment consequences? The factors at play make it unclear. Considerations such as how much does it cost a research and development team to automate a job or one task that falls under its responsibilities? Will that automation be competitive and market-viable?

There are still relevant considerations here, however.

Per Statista, the average US software developer earned a salary of roughly \$120,000 in 2021.⁴ Worldwide, a full-stack developer made about half that on average.⁵

Aside from employee costs, there's already a widely recognized talent and skills gap in the IT industry. If left unaddressed, this talent gap will only worsen as our economy increasingly relies on IT capabilities.

It might motivate further software development automation as a solution to that gap.

Progressive Learning and 2+2

This sentiment of “Should we?” regarding GitHub Copilot is not only rooted in the potential threats of automation, but how it may impact software developers learning their basic career skills.

In school, reaching an algebra class is entirely conditional on understanding the basics of math, from the order of operations and PEMDAS to dividing by zero. You can't begin learning—let alone attempting—how to solve for X in a complex quadratic equation if you don't already know that $2 + 2 = 4$ and the principles and concepts that make it so.

The same notion of progressive learning and foundational knowledge directly applies to GitHub Copilot here as well.

Experience, even at the lowest levels, begets knowledge that stays with software developers as their careers advance. And knowledgeable software developers can adapt the construction of

⁴ Statista. *Average salaries in the IT industry in the United States in 2021, by type of job.*

<https://www.statista.com/statistics/1293871/us-salaries-in-the-it-industry-by-job-type/>

⁵ Statista. *Average salaries of software developers worldwide as of early 2021, by role.*

<https://www.statista.com/statistics/793602/worldwide-developer-survey-average-salaries/>

well-written code and architecture to given constraints and changing circumstances. They can problem-solve through innovative methods based on their fundamental understanding of how given languages operate.

When we learn how to construct code, we learn on these lower-level and repetitive tasks to develop that understanding. It occurs somewhat in isolation, but live, higher-level coding with real stakes isn't about repetition. There's an intangible aspect that every developer must learn about *when* and *how* to apply that knowledge in a way that can always adapt.

Essentially, we're asking, "Does mastery require starting with apprenticeship-level work?"

(We believe so.)

And, "Does GitHub Copilot threaten those developer 'apprenticeships,' risking the future number of masteries?"

(Also yes—although the extent to which it will admittedly remains to be seen.)

A Similar Argument—Better Learning or Better Plagiarism?

Suppose GitHub Copilot merely becomes a tool every student and developer relies on, but it doesn't threaten their job security.

In an academic paper comparing OpenAI's Codex to computer science college students' performance, researchers determined that the AI model already "performs better than most students on code writing questions in typical first year programming exams"—and did so with broad solution variation that will likely make plagiarism difficult to detect.⁶

The study also notes two divisive possibilities that could arise from Codex's availability. On the one hand, the paper cites two studies showing students learn more from studying various solutions to the same problem. On the other hand, academic integrity and student learning may suffer if it becomes more common to rely on Codex for answers—and they cited five studies already indicating higher levels of student plagiarism in computer science than in other disciplines.⁷

⁶ ACE '22. *The Robots Are Coming: Exploring the Implications of OpenAI Codex on Introductory Programming*. <https://dl.acm.org/doi/pdf/10.1145/3511861.3511863>

⁷ ACE '22. *The Robots Are Coming: Exploring the Implications of OpenAI Codex on Introductory Programming*. <https://dl.acm.org/doi/pdf/10.1145/3511861.3511863>

Ultimately, the study—“The Robots Are Coming: Exploring the Implications of OpenAI Codex on Introductory Programming”—concluded:

“Having Codex in the hands of students should warrant concern similar to having a power tool in the hands of an amateur. The tool itself may not be intended to do harm, but with a vulnerable or untrained user, it may do just that.”

Student instances of plagiarism will generally incur a knowledge and skills debt—one that must be paid somehow. Or, with Codex continuing to pay that debt, will the AI model only become more relied on?

Even OpenAI acknowledges that the “possible over-reliance on Codex by novice programmers” may emerge.

A Potential Rebuttal from Microsoft, GitHub, and OpenAI

In the interest of honest dialogue, Peter Welinder has also stated that developers will be able to populate “comments in the code just from the nature of telling Copilot what to do... documenting the code as you go.”

So, the counter argument would likely be that beginner developers can reference these comments to learn—and them being provided in natural language will open access to coding more broadly.

Would it be a valid point? Yes, but whether it could outweigh the potential detriments remains to be seen.

Further Examination of Potential Problems

Broader criticism of GitHub Copilot generally centers around two arguments:

- **Risky and vulnerable code** – A study assessing the security of code produced by GitHub Copilot found 40% of its contributions to be vulnerable across 89 provided scenarios and 1,689 programs the tool developed.⁸
- **Fair use** – Revisiting plagiarism and intellectual property, Dave Gershgorn notes in his article for *The Verge*—“GitHub’s automatic coding tool rests on untested legal

⁸ Arxiv. *Asleep at the Keyboard? Assessing the Security of GitHub Copilot's Code Contributions*. <https://arxiv.org/abs/2108.09293>

ground”—that no judge has had to rule on a similar case regarding the transformative use of publicly available but copyrighted AI training data to establish legal precedent.⁹

- Gershgon also recurrently points out that, “if an AI algorithm turns the copyrighted work into a profitable technology,” and with only mild transformation, these legal matters become incredibly complex quite quickly.¹⁰
- OpenAI has stated in a document submitted to the US Patent and Trademark Office that “For certain tasks, that data is derived from existing publicly accessible ‘corpora’ (singular: ‘corpus’) of data that include copyrighted works.”¹¹
- GitHub’s CEO, Nat Friedman, has asserted that no copyright infringement has occurred because “training [machine learning] systems on public data is fair use.”¹²

Encouraging or Stifling Innovation?

Finally, unlike the math analogy used regarding progressive learning above, there is no absolute, one-and-only right way to write well-constructed code.

Does having an AI coding companion potentially stifle construction innovation within the software development industry?

Suppose developers do become over-reliant on GitHub Copilot. What innovations do we stand to lose—either from someone simply finding a better method or because they’re so frustrated with repetition? Copilot proponents likely promote the tool as an example of either, but there’s not enough evidence to claim it is or that negative externalities won’t outweigh the potential progress.

Where Will GitHub Copilot Take the Future of Coding?

This is not to say that GitHub Copilot is some intrinsic evil. On the contrary, there could well be a future where everything works out for the best.

⁹ The Verge. *GitHub’s automatic coding tool rests on untested legal ground.*

<https://www.theverge.com/2021/7/7/22561180/github-copilot-legal-copyright-fair-use-public-code>

¹⁰ The Verge. *GitHub’s automatic coding tool rests on untested legal ground.*

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¹¹ US Patent and Trademark Office Department of Commerce. *Comment Regarding Request for Comments on Intellectual Property Protection for Artificial Intelligence Innovation.*

https://www.uspto.gov/sites/default/files/documents/OpenAI_RFC-84-FR-58141.pdf

¹² Hacker News. *In general: (1) training ML systems on public data is fair use (2) the output belongs to the operator, just like with a compiler.* <https://news.ycombinator.com/item?id=27678354>

However, we can't achieve that outcome without acknowledging and considering the numerous and significant possible pitfalls that GitHub Copilot presents while doing our best to avoid them.

Unfortunately, it seems that despite a plethora of science fiction works always screaming at us to do so, we still ask, "Should we?" all too infrequently.

At least the science fiction creators will have some job security as they continue wailing at us and into the void.

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Existing and Potential Problems with AI

As we first touched on in our GitHub Copilot article, artificial intelligence (AI) isn't always or inherently a benefit to society—neither is much of what is often too readily labeled “progress.”

With all technology, we need to consider how a new tool or solution can be abused.

We need to be proactive about installing safeguards to predict and prevent as many abuses as possible right from the design phase and with continuous reevaluation throughout the development process. There are a number of challenges and criticisms that can be leveraged against AI—both in its current forms and in the applications and use cases on the horizon.

Some of the most pressing issues to consider, from our perspective, revolve around:

- Intellectual property (IP)
- Inherent cultural biases
- Rising AI training costs
- Access stratification

Below, we'll take a deeper look at each of these categories and consider ways tech industry stakeholders can prepare for an ethically sound and sustainable approach to integrating AI.

Intellectual Property Ownership and Theft

The intersection of AI and IP is rife with questions and issues technologists the world over have yet to solve convincingly. The primary one is that, at a base level, AI is often taught on code that's “publicly available” yet hosted and maintained primarily on privately-owned spaces.

On a structural level, these paradoxes create something like an impasse.

The World Intellectual Property Organization (WIPO) has held several sessions bringing together industry experts from around the world to discuss this intersection of IP and AI. The 16 issues identified in WIPO's most recent update to the dedicated issue paper, from 2020, include¹³:

1. How should AI and products invented wholly or partially by AI be defined?
2. For products made wholly or partially by AI, who or what is the “inventor”?
3. Should AI-generated or AI-assisted inventions be eligible for patent status?
4. Is there a “non-obvious” step in AI inventions, and does there need to be?

¹³ World Intellectual Property Organization. *Revised Issues Paper on Intellectual Property Policy and Artificial Intelligence*. https://www.wipo.int/edocs/mdocs/mdocs/en/wipo_ip_ai_2_ge_20/wipo_ip_ai_2_ge_20_1_rev.pdf

5. Are existing IP disclosure requirements applicable to AI? If so, in what ways?
6. Should AI inventions benefit from existing or *sui generis* patent protection?
7. Should AI inventions be eligible for copyright? Is the AI itself copyright-eligible?
8. Does machine learning of copyrighted works constitute copyright infringement?
9. Should copyright govern or consider deep fakes—and, if so, how should it?
10. How should AI-related copyright policy prioritize and enforce competing claims?
11. How does AI and machine learning intersect with data and IP privacy rights?
12. Do AI designs, as distinct from AI *inventions*, deserve the same protections?
13. Does AI impact trademark law (as distinct from patent and copyright law)?
14. Do existing trade secrets laws protect AI innovation and access interests?
15. How can IP policies address technology gaps in AI capacity and access?
16. Can or should AI influence decision-making in IP policy implementation?

The best way to think of these, for now, is how WIPO has—they're open questions. As such, without clear consensus, it's difficult to pin down the most ethical approach to AI and IP.

In the US, these issues are most often part and parcel of a broader dilemma.

The stereotypical Silicon Valley setup is to offer a product for free at first to raise a potential user base, then make it private after the firm's initial public offering (IPO), acquisition, or other major upswing in value.

GitHub Copilot—The IP Dilemma in Action

Our GitHub Copilot article directly touches on a concrete example of this issue.

GitHub began as a software development and version control resource where technologists, private companies, and open-source projects could save and publish their own code. Then, it was acquired by Microsoft in 2018, and all core services were made free in 2020.¹⁴

In 2021, GitHub announced the upcoming launch of Copilot, which occurred on June 21, 2022.

GitHub Copilot's AI provides coding suggestions to simplify development. But it was trained on GitHub's programming repository—which contains an enormous amount of open-source work and others' IP—and is now being offered as a for-profit service.

¹⁴ TechCrunch. *GitHub is now free for all teams*.
<https://techcrunch.com/2020/04/14/github-is-now-free-for-all-teams/>

So, in practice, there's nothing hypothetical about this situation. Even though it's muddy water, morally, individuals and businesses are going to treat the profits it can generate from their AI as *terra firma* regardless of where the data that trains the system comes from.

How AI Feeds Upon (and into) Cultural Biases

Demographic profiling and biases have been shown to reveal themselves in AI based on the training datasets and trainers' own biases—conscious or not, known or even undetectable.

One infamous example of this phenomenon from recent memory is the “Tay” gaffe. In 2016, Microsoft launched a chatbot that was supposed to learn from and reproduce the speech and behavior of a teenage girl on the internet. However, almost immediately, Tay's outputs mirrored the racist, sexist, antisemitic talking points of the then-ascendant alt-right.¹⁵

Part of the problem was the input data itself; Tay was simply reproducing things it was seeing.

But, to play devil's advocate, demographic profiling can occur in AI even without data inputs containing any demographic information. AI can come to biased conclusions from seemingly unbiased datasets, creating bias where it wasn't “there” originally—or wasn't detected.

We can recognize something as bias even if AI can't, and, like AI, we can also *miss* the bias.

But, according to the National Institute of Standards and Technology (NIST), the problem is at least in part the contexts in which AI is applied.¹⁶ In fact, technical biases are only the tip of the iceberg, so to speak. NIST identifies three key kinds of biases to consider with respect to AI¹⁷:

- **Statistical and computational biases** – If a sample is not representative of a whole population, there is inherent bias. Such relationships exist in datasets that train AI.
- **Systemic biases** – Historical practices and norms influence the ways in which people think about and see the world, whether they realize it or not. These biases, whether positive, negative, or neutral, are present and irretractable from datasets used by AI.

¹⁵ The Verge. *Twitter taught Microsoft's AI chatbot to be a racist asshole in less than a day.* <https://www.theverge.com/2016/3/24/11297050/tay-microsoft-chatbot-racist>

¹⁶ National Institute of Standards and Technology. *There's More to AI Bias Than Biased Data, NIST Report Highlights.* <https://www.nist.gov/news-events/news/2022/03/theres-more-ai-bias-biased-data-nist-report-highlights>

¹⁷ National Institute of Standards and Technology. *Towards a Standard for Identifying and Managing Bias in Artificial Intelligence.* <https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1270.pdf>

- **Human biases** – Human thought is limited by several constraining factors, including but not limited to imperfect logic, differences in perception, and subjective judgements. AI depends upon human thought in its invention and, ultimately, in its final application.

Only the first of these is fully located “within” AI. Human and systemic biases are both within and without—baked into the code and constitutive of the context in which that code is used.

The big takeaway here is that, ultimately, we’re not going to program or design away the bias AI feeds upon and (re)produces. And, *even if we could*, we’re not going to do away with human or systemic biases. Instead, we need to operate on the assumption that bias is there and adjust our expectations accordingly—practice caution, from ideation to application.

AI Training Costs are Too Damn High

Research, development, and application of AI are all costly affairs. Making AI that does more for individuals, businesses, and society as a whole requires extensive training, and that training is becoming more expensive day by day. Soon enough, it may be too expensive for anyone but the industry’s biggest players to pursue in a meaningful way—and we’ll all be worse off for that.

This is all happening despite the fact that training rates were falling as recently as two years ago.

In May of 2020, Ark Invest reported on findings that AI training costs were falling at an alarming rate.¹⁸ Relative to Moore’s Law, which assumes a doubling of computing power every two years, rate prices for AI training were falling by as much as 50x that rate—roughly 10x each year.

The problem is that, despite increases in efficiency, development requires increasing compute.

For example, Venture Beat notes that Microsoft and Nvidia’s recent breakthrough in AI language modeling, MT-NLG, uses 530 billion parameters.¹⁹ Training it required 560 servers operating at once, at an estimated cost in the millions. Even Alibaba’s M6-10T (10 trillion parameters, likely costing about \$300,000 to train), would be far too pricey for many smaller firms to replicate.

The internet and various on-ramps to “homebrew” or DIY technical learning are becoming increasingly inaccessible to the average person, and especially for anyone disadvantaged.

¹⁸ Ark Invest. *The Cost of AI Training is Improving at 50x the Speed of Moore’s Law: Why It’s Still Early Days for AI.* <https://ark-invest.com/analyst-research/ai-training/>

¹⁹ Venture Beat. *AI Weekly: AI model training costs on the rise, highlighting need for new solutions.* <https://venturebeat.com/2021/10/15/ai-weekly-ai-model-training-costs-on-the-rise-highlighting-need-for-new-solutions/>

What this amounts to is a further consolidation of an already monopolistic tech industry.

Stratification and Inequality of Access

Perhaps the biggest problem with AI, both at present and in the future, is the way it portends toward greater social stratification along digital lines. Economic divides will become increasingly prevalent as the world shifts toward Big Tech's *current* applications of AI and machine learning.

In a sense, this final issue is also a composite of the other three detailed above:

- Since the average person cannot access AI infrastructure, corporate oligarchy creates a digital caste system where all data and resources to utilize it will be owned by a few.
- Since AI feeds upon and (re)produces conscious and unconscious social biases, those controlling AI will likely perpetuate biases through it, intentionally or not.
- Since public information is utilized to train early models, what ought to be the public's own IP is going to be used against them—at their expense and for Big Tech's profit.

In effect, people are going to be leveraged *for* data, and then they will be leveraged *by* data.

There's no clear-cut solution to any of these contributing problems, much less the complex web they create weaved together. That's not to say technologists should be abandoning or ignoring AI; instead, it means that we need to think harder about AI and machine learning, with these issues top of mind, to try and mitigate the potential harm they'll do to us and society at large.

Thinking seriously about AI ethics isn't just a pie-in-the-sky moral exercise; it's good business.

[REDACTED] Transform and the Future of AI

Here at [REDACTED], we believe that the successful tech businesses of tomorrow will be ones who take ethical issues seriously today. We work with growing companies to develop sustainable approaches to AI, machine learning, and other issues rampant in the tech world and broader business environment.

We're people-focused because it's right—and it's what works.

Our [REDACTED] service will prepare your organization for the future of AI. We'll identify your strengths and weaknesses within staffing and organizational structure, then develop and implement plans to address your vulnerabilities and build on past successes.

That all starts with a free technological consultation. Get in touch to learn more!

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