Responding to the Threat They Created: Software Engineers and Automated
Software Development

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On my honor as a University student, I have neither given nor received unauthorized aid on this
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Top computer science programs in America provide their students with an education that covers everything from programming fundamentals to computer theory while granting exclusive opportunities to work with state-of-the-art technologies (MIT, 2023). Computer science programs in higher education still must adapt to the proliferation of artificial intelligence (AI). In seconds, code-generating AI tools such as Chat-GPT can produce sound programs (Botpress, 2023). AI also has profound implications for industry. Amazon, for example, implemented 750,000 smart machines to assist in packaging 1 billion items (Quinlivan, 2023). Chipotle integrated Pepper, an AI chatbot, to resolve customer service requests fully virtually (Ajao, 2022). Companies use AI to automate processes and thereby reduce labor costs. Automation has already begun to displace higher skilled jobs performed by college graduates. Universities must adapt their computer science curricula to such trends.

University CS programs let students choose elective courses that suit their interests. Humans, however, may not outpace AI in technical tasks, and CS programs must adapt accordingly. Surpassing AI in performance is not the purpose of a college education. As a result, it is necessary to evaluate the efficacy of current academic programs. This involves examining the AI adaptations made by entry and senior level software developers, analyzing research advancements in AI, and identifying the adjustments made by CS employers and Big Tech companies to integrate AI into their operations. The additional efficiency in the workflow achieved through artificial intelligence is beneficial for developers and employers alike, however, universities need to modify their curriculum to support this new age of software development.

Due to the increased usage of AI, entry-level software developers will need to possess more than just superb coding skills. Some may say that AI will completely overturn the software development industry, but it is a more popular opinion that engineers will adapt by cultivating a unique blend of creativity, critical thinking, and ethics; characteristics that they can leverage to be more desirable during the rise of artificial intelligence.

Review of Research

Many experts in artificial intelligence and machine learning claim that the rise of AI will cause job displacement (Petropoulos, 2018; Chen et al., 2022). While some focus on the impact of AI on software development (Webb, 2019; Acemoglu, 2018), others develop such programs (Yilmaz, 2023). Some researchers analyze the ethical feasibility of AI (Liao, 2020; Muller, 2020), while others research if AI models themselves are creative (Amabile, 2020). None of these publications successfully provide an analysis on how and why ethical training is necessary in a society more reliant on AI.

In a publication that examines the preference of human-generated artwork over pieces generated by AI, Bellaiche (2023) demonstrated that human touch will always be critical in creative endeavors. While evaluating what gave favor towards human-created art, "various dimensions, including liking, beauty, profundity, and worth" were significant (Bellaiche et al., 2023). In his secondary analysis where he includes more judgment criteria, "narrative and perceived effort in artwork significantly moderated preferences based on the art's purported origin (human vs. AI), especially for judgments related to sensory appeal like liking and beauty" (Bellaiche et al., 2023). The study displays the intrinsic reality where content developed by AI will have difficulty being accepted by humans, highlighting the importance of determining when and how AI should be utilized, if at all. When considered under a societal context, this theory can

display the potential rejection of products with AI contribution in the future, questioning the desirability of methods that will be used to incorporate AI solutions in practice.

All undergraduate engineers enrolled at the University of Virginia are required to take Science, Technology, and Society classes. Instead of taking traditional English, writing, and public speaking classes, engineers instead learn about the "social and ethical issues of science and technology from humanities and social science perspectives" (University of Virginia, 2024). This doesn't mean that UVA engineering graduates won't receive a background in humanities as "writing and speaking skills continue to be stressed in these courses, the focus shifts from skills to the course's content and the broader objective of improving students' grasp of the social and ethical issues of science and technology" (University of Virginia, 2024). The modifications to the engineering curriculum at UVA demonstrate the value of ethical and professional development. When applied to the modifications necessary in the US educational framework, this approach reveals the benefits of ethics education and could become a template that other institutions can utilize to begin their transitions.

Artificial Intelligence isn't Creative

Artificial intelligence itself is an innovation, the usage of AI isn't innovative. According to a published AI researcher, "AI not only represents a way to achieve cost and productivity benefits, but also presents itself as a fundamental innovation upon the tools through which we innovate" (Cockburn, 2019). In a controlled trial of GitHub Copilot, an AI pair programmer that suggests code implementations real time, "the treated group completed the task 55.8% faster than the control group," with "Developers with less programming experience, older programmers, and those who program more hours per day benefited the most" (Peng et al., 2023). While creating AI applications may be an innovative practice, a book on the innovative uses of artificial

intelligence states that "AI may just be an 'efficient method of imitation.' Machine Learning sees what "works" (by some criterion) and finds ways to exploit that relationship" (Mitchell, 2019). Based on Barber and Martin's fundamental understanding of autonomy (1999), Verdicchio, who studies AI conscience "insists on AI's inability to set its own goals. "Machines" ...are designed to perform specific tasks and functionalities with predetermined, externally supplied goals. "…Even the most advanced products of cognitive robotics and self-aware system research act on the basis of preprogrammed desired behaviors" (Verdicchio, 2017). Those who create artificial intelligence are innovators, those who utilize artificial intelligence are master imitators, but most people only utilize artificial intelligence.

Creativity is often linked to subjective experience, intuition, and emotions - qualities that AI systems currently lack. Li and others argue that "consciousness is one of the unique features 6 of creatures" and that "up to now, all machines and robots haven't had consciousness," (Li et al., 2021). Gamez, an AI expert also states that creating machines with "full blown 'perspectivally' organized conscious experience" can only happen in a technological utopia (Gamez, 2018). Critics may say that these claims are based on a lack of understanding in the realm of creativity and consciousness as recent advancements in AI have shown that AI systems can generate art and music. Though these modern models can generate new content, the machines can only create based on the data they are fed (Li et al., 2021). Because these machines can only create content on command, these machines don't possess qualities of self-awareness, "the primitive step to a low-level consciousness" (Li et al., 2021). Since qualities like emotions and intuition are far more conceptually-advanced than consciousness, AI models are currently advanced power tools.

AI systems train and generate outputs based on the data they are given. Their "creativity" is limited to the trends and qualities of their training data. According to a publication about

machine learning models, "There are four main limitations of machine learning models. …they learn through observation, and they only know the data with which they have been trained. …Once trained, …models become inflexible and cannot multitask. …Finally, they are currently programmed and supervised by human AI experts, who set a given problem's optimization function and input variables, thus revealing a lack of self-sufficiency, a characteristic of human intelligence and creativity" (Redin et al., 2022). An analysis of an AI model states "...with any form of information processing, they are subject to the limitations of information linked to the way in which information evolves in information ecosystems" (Walton, 2018).

Artificial Intelligence has Ethical Issues

In large training models, societal prejudices can be inherited, causing biased outcomes based on sensitive characteristics such as gender and ethnic origin, creating the need to enforce interdisciplinary approaches to tackle digital discrimination (Ferrer, 2021). Machine learning models that were classified neutral, have shown biased behavior, shown by the variance displayed when searching for different racial groups on Google, exemplifying AI's susceptibility to social bias (Niemiec et al., 2022). Biased hiring algorithms and discriminatory credit scoring systems further display the impact of AI-driven discrimination, prompting discussions to create strategies that ensure fair AI practices (Datatron, 2022). To foster an equitable digital environment, thorough examinations and strategies are needed to prevent AI from magnifying prevalent social inequalities.

The increasing dependence on AI for decision-making processes neglects human skills and qualities. For the college admissions process, Duke University decided to remove numerical ratings for standardized testing and essays, due to applications heavily modified, and sometimes, entirely generated by artificial intelligence (Lu, 2024). An AI company named Cognition,

implemented Devin, the first fully functional AI software engineer that's able to build full applications given a requirements document (Desk, 2024). Fortune 500 companies have universally adopted Applicant Tracking Systems, which filter candidates based on preset priorities, reducing their recruitment processes to algorithmic systems (Henderson, 2024). Being over-reliant on AI alternatives can strip humanity from social interactions.

Understanding the "black box" nature of AI systems is important as its decision-making processes will be otherwise obscure, undermining the responsibilities behind using artificial intelligence. In an epistemological examination by Manuel Carabantes, an AI model concluded that "the highest performing models are the least explainable" (Carabantes, 2019). Upon facing criticism of their AI model, Google CEO Sundar Pichai, replied that "Google's Bard is getting a lot of 'hallucinations'", but "...it's expected. No one in the field has yet solved the hallucination problems. All models do have this as an issue" (Ngila, 2023). "We need to develop AI in a way that we can be accountable to it…". This emphasizes the importance of understanding the artificial intelligence we create. Nikita Brudnov, CEO of BR Group, stated in response to a lack of transparency that "In recent years, much attention has been paid to the development of techniques for interpreting and explaining decisions made by AI models, such as generating feature importance scores, visualizing decision boundaries and identifying counterfactual hypothetical explanations," but with "no guarantee that they will be effective in all cases" (Jagati, 2023). Highlighting the ethical implications of AI systems are necessary when their mechanisms remain mostly uncertain.

The integration of artificial intelligence into various industries leads to job displacement, affecting the livelihoods of "low-skilled" laborers, increasing economic inequality. In the coal mining industry in Queensland, Australia, "labor replacement estimates from Alphabeta and

Fleming-Muñoz state that automation could see around 10,000 coal mining jobs being replaced in the near future" (Paredes et al., 2021). An AI simulation, conducted by Klaus Prettner, "high-skilled workers enjoy wage growth when the economy is growing. By contrast, wages of low-skilled workers are constant when factor shares are constant. Technological progress raises the productivity of high-skilled workers by the introduction of new machines. At the same time, however, new machines do not raise the productivity of low-skilled workers" (Prettner et al., 2020) According to a CNBC report, "from a survey of 750 business leaders using AI from ResumeBuilder, 37% say the technology replaced workers in 2023. Meanwhile, 44% report that there will be layoffs in 2024 resulting from AI efficiency." While the efficiency of the company will be increased as a whole, even white-collar jobs could be at risk (Curry, 2023). An increase in economic inequality was inevitable; companies became more profitable at the cost of their employees.

Shortcomings of the Academic System

Placing the focus on a curriculum revolving around standardized testing limits the scope for creativity and critical thinking. When comparing practice to policy within the schooling systems of England, author Anna Croft states "For, whilst creativity was being encouraged, the means by which this and other educational goals were being achieved were extremely constraining for teachers. In response to the tightening framework within which teachers were to work, creativity became, for some, a tool for personal and institutional survival" (Craft 2003). She later claims when questioned about curriculum organization that "...the way in which the curriculum is presented and organized within the time available in a school day may offer greater or fewer opportunities for fostering learner and teacher creativity" (Craft 2003). According to the Irish Institution of Education, "School is basically an evaluative institution where the student

must become 'used to living under the constant condition of having his words and deeds evaluated by others'" (Madaus 10 et al., 1971). Standardized tests cause students to be conditioned to produce the "correct" results to be evaluated as "smart", which leads to an "input-output" way of thinking, limiting further, high-level analysis and creativity.

Educational institutions can be slow to adopt updated teaching strategies that foster creativity, critical thinking, and ethical reasoning. When computer technology became more prominent in the early 2000's, teachers did not incorporate new technologies due to fear that making these large financial investments would even positively impact student learning. (Burnham et al., 2000) To vouch for increased computer integration in education, various consideration such as: "(a) awareness of what the technology can offer; (b) opportunity to explore technology integration; (c) time to learn the technology; (d) application of technology to teaching; and, (e) reflection on teaching" (Sprague et al,. 1998) were considered. These tenets can be directly applied to the usage of AI for schoolwork today. Randy Ventayen, University Director at Pangasinan State University stated that, "students are more likely to cheat in competitive academic environments, where there is a high level of competition for grades and academic honors" (Waltzer & Dahl, 2022). The evolution of controversial yet revolutionary technologies will eventually get incorporated into society, following ethical considerations. The disconnect between theoretical learning and practical application in education leaves students underprepared for real-world challenges. According to a newsletter about university education, "practical experiences are of utmost importance for preparing students for the workforce," but traditional liberal arts education often falls short in offering those opportunities (Lederman, 2023). The University of Chicago's journal states that "the study of the art of college teaching has centered in subject matter rather than in the learning-processes of 11 those taught"

(Snedden, 1910), portraying favor towards teaching abstract content over applicable skills. Chicago's journal then follows, "the college seeks these rare teachers who are strong in native ability, but has not learned the art of producing them" (Snedden, 1910), displaying the college's priority in recruiting gifted professors over developing effective teaching strategies for professional application. Methodologies used by university institutions don't produce graduates ready for the professional workforce.

Adaptations from Software Engineers

Embedded automated systems are being used by software engineers in many fields. Researcher Elfriede Dustin (2009) stated that automated software testing saw an 40-60% increase in efficiency. Instead of running manual tests, engineers ran thousands of lines of code using a suite of testing scripts. With the usage of Continuous Integration (CI) technologies such as Travis CI and GitLab, developers are able to automatically test entire codebases without initiating a test process (Laster, 2017). This greatly reduced resources spent on testing and created an industry-wide movement into test-driven development (TDD), an approach where tests are written before any software is developed. In software development, "automation" was limited to highlighting syntactical errors and filling previously declared variables. This evolved to development environments generating entire methods and classes based on specified user inputs. These features were designed to be an aid for development, but recently, the scope of automation changed entirely. Around the year 2021, large language models (LLM) and AI-driven code generation tools were introduced. With the capability to generate entire code bases given user requirements, these tools were capable of replacing the skills of an entry-level software engineer entirely (Botpress, 2023). When an entry level role can be replaced by an LLM, further advancements in this technology may end up changing the role.

The sudden surge of AI-generated code software has forced early-career professionals in computer science to upskill. Even if code can be easily generated, companies will need people who can efficiently use (Quinlivan, 2023) and develop AI tools (Yokoi, 2023). Yokoi states that middle management groups at large companies will focus more on critical thinking skills and higher-level concepts when evaluating their team members. While technical skills used to be the greatest criterion when determining an entry engineer's skill, methods to measure performance have inevitably evolved as "job roles reshape in ways that involve more high-value activity" (Doorn, 2022). Big-tech companies such as Amazon, Google, Microsoft, and Salesforce recognized the need for upskilling their workforce. To ensure their employees possess necessary skills, they have invested billions of dollars in educating employees (Newman, 2020). As technological advancements occur, the necessary skill set will increase. Analyzing how companies reach this standard shows how to adapt AI methodologies.

Conclusion

Artificial intelligence is becoming a factor that will permanently shift the software development industry along with society as a whole, which will require a thorough reevaluation of our job markets, ethical standards, and educational system. As digital innovations continue to evolve and impact human lives, it will be necessary to decipher the technological aspects where AI will have an advantageous use and what it won't ever replace. AI's automated and imitative nature magnifies the irreplaceable human attributes of creative insight and ethical judgment.

The technologically-dependent field of software development already requires engineers to continuously improve their skills; the introduction of AI developers only amplifies this matter. This transition emphasizes the need for educational institutions to aggressively integrate ethical and creative aspects into their curricula. When these skills are introduced to students at a young

age, they are given more opportunities to develop ethically. The transition made by students as they go from an educational to professional mindset at university will no longer be abrupt, but rather gratifying, as they will be able to utilize the skills they've been developing and curating over their academic career.

Nothing the world has seen will be more influential than the age of AI. Finding the critical balance of utilizing artificial intelligence to enhance our lives is of utmost importance. This balance has demanding requirements, ones for which professionals will need to augment their innovations by leveraging AI's strengths, while guiding these decisions with human qualities like empathy and creative problem-solving. As artificial intelligence takes on greater responsibilities, engineers will eventually become mediators with an expert background, innovators that utilize AI to bring their visions to reality. Through the cultivation of a new environment where human intelligence merges with AI, a revolutionary paradigm of human growth unlocks. When a better option is offered to mankind, it will be pursued. It becomes the job of engineers to stand at the forefront of development and guide humanity in the right direction.

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