The Psychological Effects of AI-Assisted Programming on Students and Professionals

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***Abstract*—Artificial intelligence (AI) tools have become integral to the coding workflow, facilitating productivity through auto-completion, code suggestions, and chat dialogues. More than ever, the psychological relationship between software engineers and AI partners requires further exploration, mirroring the need to understand the psychological aspects of pilot-navigator roles these tools partly simulate, as highlighted in earlier studies. [Goal] The presented research aims to investigate the programmer behavior change and psychological effects of AI-assisted programming on professionals and undergraduates. [Methods] The authors performed a series of seven experimental programming sessions on the undergraduate student sample, subjecting them to programming in solo, pair, and AI-assisted settings. Following the experimental sessions, five semi-structured interviews were conducted with the experimental participants from the academic realm and another five with experienced users of AI programming tools from the professional realm. The interviews were analyzed using thematic analysis in an essentialist way, allowing for a comprehensive understanding of the participants' experiences, feelings, and attitudes toward AI-assisted programming. [Results] A total of ten themes were identified, half shared across the two realms, with 51 constituent codes selected from the professional and 35 from the student interview transcripts. The realm-agnostic themes were: "Effectance", "Intrinsic Motivation", "Perceived AI Personality", "Dynamics of Human and AI Pairing," and "Paradigm Shifts". The realm-specific themes included: "Personal Growth and Development", "Prospects", "Ethical Considerations", "Safety", and "Effects on Learning Processes". [Conclusion] The presented research illuminates the profound potential of using AI as a programming partner in simulated pilot-navigator roles in both professional and academic realms. It underscores the importance of understanding its effects on psychological well-being and human experience. Incorporating the revealed psychological aspects of human-AI interaction, its benefits, limitations, and dynamics will be pivotal for successful AI implementation and continued evolution in software engineering contexts.**

Keywords—ChatGPT, software engineering, psychological well-being, Self-determination theory, thematic analysis

I. Introduction

Artificial intelligence (AI) has become an integral part of the software tools of our everyday lives. Large-language models (LLMs) utilizing reinforcement learning with human feedback (RLHF) are replacing the static inference engines based on supervised learning. LLMs with RLHF posit themselves in a positive feedback loop where they interact with humans on a daily basis, which is essential for their improvement. As they improve, they can offer a broader range of use cases, increasing their omnipresence and leading to even more interaction with humans. Currently, they can be found in common and specialized software such as web search engines, integrated development environments, translators, news channels, social media, streaming platforms, chat assistants, tutorials, and others.

The latest extensions to AI-human interaction challenge the current software engineering paradigms with AI-assisted programming tools like ChatGPT and Copilot. When pairing with AI, software engineers simulate the well-researched pilot-navigator tandem and cooperatively produce solutions combining human and artificial intelligence. This underscores the need to investigate AI's impact on our psychological well-being. The authors will investigate the psychological effects of AI-assisted programming on undergraduates and professionals by finding answers to the following three research questions:

- *RQ1: "Does AI interaction motivate and satisfy us?"*
- *RQ2: "How does AI change programmer behavior and affect (in their opinion)?"*
- *RQ3: "Do we credit ourselves or AI when solutions are produced using a mix of both intelligences?"*

This study sets to provide the answers using emerging results coming from (i) the experimental study of solo, pair, and AI programming conducted on a sample of undergraduates from the applied informatics course and (ii) subsequent qualitative analysis of semi-structured interviews conducted with five of the experimental subjects and five software professionals who have not been subjected to the experiments but have had prior substantial exposure to AI tools in their jobs. The study focuses on investigating psychological aspects of AI-assisted programming and tapping into ethical considerations, prospects, paradigm shifts, safety, and effects on learning processes in the software engineering discipline.

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II. BACKGROUND

A. ChatGPT and GitHub Copilot

The authors selected two AI-assisted programming tools, namely, ChatGPT and GitHub Copilot. These tools fall under the category of "generative AI," i.e., AI systems capable of generating text, images, or other media using generative LLMs, and were the most suitable technical basis of our research because all members of our sample from the academic and professional realms have had previous exposure to them.

The release of ChatGPT v4.0 on March 14, 2023, has taken scientific and industrial communities by surprise. While the former is now striving to protect academic integrity [4], the latter battles commercial data privacy concerns. Researchers appeal to the importance of providing guidance for using generative AI and integrating it into software engineering courses rather than accepting its unsupervised use by students, which could negatively impact their education [5]. Similar guidance is needed for professionals.

B. Self-Determination Theory and Locus of Causality

The Self-determination theory by Ryan & Deci [7] forms the theoretical framework for investigating the effects of pairing with AI on psychological well-being. At its core lies the revolutionary concept of "intrinsic motivation" that stems from White's 1959 landmark paper [11], which, contrary to previously prevalent theories, posits that behaviors such as exploration, manipulation, and play could be considered not as drives but as "innate psychological tendencies" endowed in every developing organism. White has labeled these propensities as a motive to produce effects, or "effectance motivation", a concept that represents the theoretical forerunner of *intrinsic motivation*.

Effectance motivation involves a desire to understand and master one's surroundings, which causes people to experience pleasure by being competent and effectively bringing desired effects and outcomes in their social environment. It is prototypically manifested in intrinsically motivated activity and is one of the sources of healthy human development [11].

White's approach gradually took hold, and de Charms [6] subsequently added that intrinsically motivated behavior resulted from a need to feel personal causation. Perceived locus of causality (PLOC), a phenomenon identified by de Charms [6] in 1968, describes whether we believe that the origin of our actions is internal or external. By definition, behaviors motivated by internal PLOC are autonomous and intrinsically motivated. They are experienced as being volitional and emanating from one's self. When people are intrinsically motivated, their interests and values align with their actions, which become *biologically* distinct from controlled behaviors [8]. Consequently, autonomous motivation leads to higher creativity, better problem-solving, increased performance (particularly in heuristic activities like programming), positive emotions, and psychological and physical wellness [7].

White's, de Charms', and Ryan and Deci's theories are integral to answering the RQs.

III. METHODS

A. Research Settings

The research consisted of a convenient sample of five software engineering professionals and thirty-eight students from two undergraduate software engineering classrooms. The professionals have had five or more years of experience and substantial exposure to AI tools in their jobs. They have not participated in the experiments and were interviewed based on their industrial experience with AI.

The experiments were designed to train the undergraduate student sample in solo, pair, and AI-assisted (ChatGPT and Copilot) programming settings and allow subjecting them to subsequent qualitative inquiries.

B. Experimental Design

The authors ran seven controlled experimental sessions of 60 minutes of net programming time each, where the subjects were assigned to different treatments and carried out the same predetermined set of 21 tasks in both control and treatment groups. Each of the seven sessions consisted of three rounds per twenty minutes of net programming time, and in each round, the participants were assigned to carry out one task. The tasks were continuous and have been designed to require a similar number of steps to solve.

Each of the thirty-eight experimental participants experienced seven sessions: one in the pilot training session, one in the solo programming control group, two in the pair programming control group, and three in the AI treatment group. In terms of treatment randomization, the laboratory sessions should be viewed as a quasi-experiment because the treatment was assigned conveniently. All students belonging to classroom A were treated, and all students in classroom B were untreated controls. The classrooms alternated between being the treatment vs. control through the seven sessions, with the first being a pilot session during which students were instructed on how to perform pair and AI-assisted programming.

While most experimental subjects were willing to participate in the subsequent interviews, only five were needed.

C. Interview Design

Shortly after the last experiment, research sample members were queried by email to participate in a recorded semi-structured interview using the MS Teams platform. The interviews were set in the qualitative research paradigm to interpret phenomena based on explanations that subjects bring to the researcher [12].

The professional and academic realm interview protocols were composed of a flexible set of 58 and 60 questions, respectively, and lasted from 38 (student interview "SE") to 85 (professional interview "PΔ") ($\bar{x}$ = 63.2, s = 16.1) minutes. The questions were grouped into seven topics: (i) Introduction, (ii) Familiarity with AI, (iii) Applicability of AI in Various Tasks, (iv) AI's Personality and Emotions, (v) Psychological Aspects of AI, (vi) Effectance and Effectivity, and (vii) Future Prospects.

In total, five undergraduate and five professional interviews were conducted until the point of saturation was reached [1].

D. Thematic Analysis

The interview transcripts were evaluated using the theoretically flexible thematic analysis method. The authors have chosen the essentialist's inductive (bottom-up) way of identifying patterns. Inductive essentialist analysis was used to code the data without trying to fit it into a pre-existing coding frame or the researcher's analytic preconceptions [3].

Seven steps by Braun and Clarke [2] were applied flexibly to fit the research question and data: *transcribing*, *becoming familiar with the data*, *generating initial codes*, *discovering themes*, *reviewing themes*, *defining themes*, and *writing up*. Professional AI tools (Descript, v67; Atlas.ti, v23) were used for initial transcription and AI-assisted coding. The transcripts and codes were imported into a computer-aided qualitative analysis tool (MAXQDA, v22), reviewed, and analyzed for themes.

IV. Results

A. Industrial Sample

Table I provides structured results of the thematic analysis performed on the five semi-structured interview transcripts of professional software developers (PA, PB, PΓ, PΔ, PE) with substantial experience ($\bar{x}$ = 11.2, s = 7.6 months) of using AI tools in their jobs. The first column lists the discovery of nine themes and six subthemes, the second offers 32 authentic excerpts, and the third displays the 51 theme constituent codes.

TABLE I. THE PSYCHOLOGICAL AND ETHICAL ASPECTS OF **PROFESSIONAL** INTERACTION WITH AI PROGRAMMING TOOLS

Theme	Participants' Quotes	Constituent Codes
Effectance (subthemes: Effectivity, Creativity, Innovation, Dependence)	• PA: *"I now work much faster because I do not have to google that much anymore."* • PB: *"The AI tools save me time and prepare the code until I have to change some small parameters/nuances. They make me more effective and creative."* • PΓ: *"…. if I did not have CoPilot at my disposal I would feel like I miss it and my productivity would shrink by 30 %. In this way, I am dependent on AI."* • PΔ: *"I have become lazier and dependent. Before doing something, I prompt ChatGPT, then I take and edit it. Sometimes I feel I am chatting with the tool for five minutes and maybe it would have been quicker if I did it on my own."* • PA: *"Sometimes it makes me lazier. There are things I could do myself and I still prompt the AI."*	"Takes care of mundane tasks" "Less web browsing" "Faster problem-solving" "Creative work" "Source of inspiration" "Innovative generated ideas" "Induced laziness" "Dependency"
Intrinsic Motivation (subthemes: Internal PLOC and Satisfaction)	• PΓ: *"When it provides the correct solution, I feel delighted because that means I provided the correct input prompt for this problem. Of course, the credit belongs to me more than the AI tool for the correct solution! Without me, AI is useless."* • PΔ: *"I am satisfied when I can do something innovative and creative. It is hard, but not with AI."* • PE: *"It influenced my satisfaction levels positively as I do not have to worry about commenting, typing, or generating documentation."* • PΓ: *"The challenge was learning, but with ChatGPT, you have well-structured knowledge at hand."*	"Internal Locus of Causality" "Increased motivation" "Satisfying" "Excels at documenting" "Creates tests structure" "Structured knowledge"
Perceived AI's Personality	• PA: *"ChatGPT and Bard act as subordinates. They would do anything you ask and never refuse."* • PA: *"I would like my AI tool's personality like mine: sarcastic, using a lot of irony, writing to the point, no digressions. If I could choose a character, I would go for Bender from Futurama."* • PE: *"I like communicating with AI more because emotions do not stand in the way."* • PΓ: *"Yes, I experience different emotions with AI than humans. With AI, I am more focused on problem-solving. When I talk to a real human, I cannot be as focused as I am when talking to ChatGPT. I do not know why."*	"Neutral non-sentient servant" "Unable to refuse" "Personality like mine" "Comfortable companion" "Fictional or real characters" "No emotions in way" "AI facilitates focus" "Confident in wrong answers"
Dynamics of Human and AI Pairing	• PA: *"AI does not match up to a human collaborator. When I speak to my colleague, he is really fast, he can grab my computer and dive into the problem and solve it."* • PE: *"When I communicate with a human colleague, it is more about how to explain to the person in a way that does not exhaust them. With AI, it is more relaxed."* • PE: *"With a human, it (pairing) is more energetic and stressful and can lead to better results than with an AI tool. With AI, it is more relaxed."* • PΔ: *"I am quite an introverted person so definitely prefer the AI tool. With a human, I am always a little nervous or trying to show off how I can do things. With AI I do not care."*	"Humans are irreplacable" "Powerful human energy" "Difficult human interactions" "Relaxed dynamics with AI" "Social anxiety" "Introvert-AI alignment" "AI as choice for simple tasks"
Paradigm Shift	• PΓ: *"I believe we moved from the imperative programming paradigm into declarative. Because, as I stated, I moved a lot into DevOps and I declare what I want and it does the heavy lifting for me. I do not investigate how it does it. – The same goes for AI."* • PΓ: *"AI tools can do very good code reviews and they could support Agile practices.* • PA: *"Tasks where you need to do some kind of research and don't know where to start. Ask AI to push you in the right direction."*	"AI similar to DevOps" "Declarative paradigm" "Divide and conquer" "AI facilitating Agile practices" "Exotic topics explorer" "Research assistant"
Personal Growth and Development	• PA: *"I would like to start my own company. It has always been my dream. With the help of AI, I do not need to hire employees in its beginnings."* • PΓ: *"My trajectory is different than I thought a year ago. Now I want to do many things because I don't have to go deep into one specific technology. Now you have AI that provides assistance."* • PE: *"Trying to get my software development to the purest and simplest form that people can understand. And making the development process more effective and faster."*	"Self-starting companies" "Ambitious career aspirations" "Learning assistant" "Mentor and guide" "Purest form of software"
Prospects	• PΓ: *"AI tools will serve the way that Google served ten years ago. It will not supersede (us)."* • PΔ: *"AI tools can replace traditional programming. They can really replace programming because it is pretty smart and if it gets even smarter then I can imagine it taking a task assignment and converting it into a functional pull request."* • PE: "*AI has already brought a new generation of computer viruses. AI-generated viruses."*	"Servant like Google" "General problem solver" "Next-gen computer viruses"

Theme	Participants' Quotes	Constituent Codes
Ethical Considerations	• PA: *"The possibility of leak of private data."* • PB: *"Where I am a contractor, we have signed some NDA and we cannot share code. So it is forbidden to copy and paste our code to the AI."* • PE: *"Yes, the biggest disadvantage is that it takes the data and learns from it. It poses potential lawsuit threats. That is the biggest disadvantage and risk."* • PΓ: *"Potential risk: A leak of API keys. It happened in my company."*	"Data privacy concerns" "NDA vs. AI tools" "Lawsuit dangers" "Ethical and law implications for autonomous entities"
Safety	• PΓ: *"Replacement should also not be a problem because if you learn how to work with AI successfully, you will never be replaced by it."* • PA: *"I was really impressed and happy when I started to use AI because I always dreamt about using something like this. I like new technology. There was no anxiety or relief. The word 'excitement' would describe my feelings best. Everyone should try it and not be scared."*	"Symbiosis" "Dream come true" "No fear of replacement" "Excitement, not apprehension" "Safe for new users"

B. Educational Sample

Table II offers the results of performing thematic analysis of interviews with five experimental undergraduate student participants (SA, SB, SΓ, SΔ, SE). The first column lists the discovery of six themes: Effectance, Intrinsic Motivation, AI's Personality, Dynamics of Human and AI Pairing, Paradigm Shift, and Effects on Learning Processes, and three subthemes. The second column offers 25 authentic excerpts annotated with anonymized interviewee identifiers, and the third displays the 35 constituent codes that formed the selected themes.

TABLE II. THE PSYCHOLOGICAL ASPECTS OF **STUDENT** INTERACTION WITH AI PROGRAMMING TOOLS

Theme	Participants' Quotes	Codes
Effectance (subthemes: Explaining)	• SA: *" I had to explain a lot to ChatGPT. First I had to explain it to myself to explain it to ChatGPT."* • SB: *"CoPilot is better when you want a little help, ChatGPT when you want the whole solution."* • SΓ: *"It had an impact on unit testing. Because I do not like it and with AI I started writing them because you can have them in seconds with ChatGPT. And it does a very good job on those."*	"Takes care of mundane tasks" "Understanding by explaining" "Pilot vs navigator AI"
Intrinsic Motivation (subthemes: Internal Perceived Locus of Causality and Satisfaction)	• SΔ: *"You feel like you did it yourself because you are the one writing the questions to AI. I like the feeling that I have accomplished something complicated alone."* • SB: *"It is satisfying when you feel like you did something on your own, but you have the help of AI."* • SΓ: *"I think the most motivating about programming with AI is when you learn something new and you find how some problem can be solved. It really motivates me to be able to do something new."* • SA: *"(With AI m)y motivation was growing because it is a new thing to try and I really wanted to know how it works and can improve coding skills and provide new solutions for you. Chat-GPT4 boosted my motivation to learn programming and just continue this way."* • SE: *"I feel more satisfied with AI because it helps me to make my project and code right."*	"Internal Locus of Causality" "Sense of autonomity" "Discovery vessel" "Accelerated learning" "New and interesting" "Motivational booster" "Satisfying" "Better quality code"
Perceived AI Personality	• SΓ: *"ChatGPT success rate is way better when you prompt it in English (80%) than Slovak (50%)."* • SB: *"It should learn how I think and save us time by understanding my ways of asking it."* • SE: *"You must know more about programming when you use CoPilot than when you use ChatGPT"* • SΓ: *"I don't think it's hard to be compatible in personality with the AI because it is neutral."* • SΓ: *"It can be challenging when ChatGPT gives you a wrong answer more than once. It can give you negative feelings, so (its) apologizing can help you. But I do not write 'Thank you' to ChatGPT."*	"Language inequality" "Should read my mind" "Neutral personality" "ChatGPT understands me" "Repetitive when wrong" "Apologetic" "Often misunderstands"
Dynamics of Human and AI Pairing	• SA: *"Pairing with humans should remain because it is an interesting experience. You just feel it."* • SΓ: *"I was more comfortable pairing with a human because I do not have much experience. But if I were more experienced, I could use AI better. But I still did a lot more with AI than I did solo."* • SE: *"I would prefer the real human for pair programming because humans are more correct and it's also faster because sometimes it takes time to describe your problem to ChatGPT."* • SB: *"If the human is on the same level as you, AI is better. But if the human were an expert programmer, it would be the opposite."*	"Human pairing is unique" "Novices prefer humans" "Pilot and navigator roles" "Skill-level is crucial" "AI requires entry knowledge"
Paradigm Shift	• SA: *"I did not have to open StackOverflow for 3 months since the ChatGPT4 appeared."* • SB: *"ChatGPT is better when you know 'what' the resolution to the problem should be, but you do not know 'how' to solve the problem. But CoPilot is better when you are already coding and know how to resolve the problem, and it just helps you to like think with you and think faster."* • SΓ: *"The 'process' is different. Because traditionally, you understand first and after you write the code. But here, you first get the working code and then understand how each line works."*	"Dropping old tools" "Knowing 'what' is enough" "AI solves the 'how'" "Reverse understanding" "Novel thought processes"
Effects on Learning Processes	• SA: *"If you are starting to learn to program, it might become harder to learn from the ready-to-use solutions provided by ChatGPT. I am thankful I learned the basic concepts without the ChatGPT."* • SE: *"I feel I would learn more without AI because I would have to use my brain more."* • SB: *"Split education into two parts. One, where students program solo and learn about the fundamental principles of programming, and the other, where they apply the knowledge using AI."* • SΓ: *"I use ChatGPT for providing explanations in different subjects, not just informatics-related ones. But it does work better in programming than in economics subjects."* • SΓ: *"Even though you have access to AI, you should not stop learning on your own. It is just a tool and does not really replace you."*	"Hinders learning the basics" "How to keep using my brain" "Provides but also explains" "Solo for learning" "AI for applying" "Universal teacher" "Keep studying" "Anchoring effect"

V. Discussion

A. Answering the Research Questions

The thematic analysis of the interviews with professional developers and students illuminated the diverse psychological effects of AI-assisted programming on professionals and undergraduates.

First, the academic and professional realm samples provided information that constituted several *mutually shared* themes with similar constituent codes: Effectance, Intrinsic Motivation, Perceived AI Personality, Dynamics of Human and AI Pairing, and Paradigm Shift, and two subthemes, Internal Perceived Locus of Causality and Satisfaction.

Second, the two realms produced five exclusive themes: Personal Growth and Development, Prospects, Ethical Considerations, Safety, and Effects on Learning Processes, and also differed in certain codes for the mutual themes.

The following sections will address the research questions and provide a quick overview of additional information revealed by using essentialist qualitative research. All opinions of the sample are attributed to their respective realm and authors.

1) Does AI interaction motivate and satisfy us?

Both realms concord that AI has vast beneficial effects on the motivation of individuals interacting with it. On the other hand, AI-assisted programming fails to meet the satisfaction levels of traditional pair programming with human partners.

Motivation: For instance, both professionals and students find AI tools beneficial in improving their effectiveness and efficiency in programming tasks, as they both mention faster development, better quality of work, and fewer bug occurrences (PB, PΓ). Members of both realms consequently feel elevated effectance and intrinsic motivation, as AI is alleviating the burden of performing tasks that are not intrinsically motivating for humans. They are abandoning previous tools like the Google web search and StackOverflow programmers' forum (PA, PΓ, SA) and enjoy that AI takes excellent care of mundane tasks, such as writing tests and documenting the code (PE, SΓ).

Satisfaction: Positive feelings of satisfaction and compatibility originated in professionals from being assisted by "obedient" AI with neutral and adaptable personalities and a good understanding of software engineering. They particularly liked AI for productive conversations without unnecessary emotional obstructions (PE, PΓ). Nevertheless, the majority of both realms posits that human partners are superior to AI-simulated pilots and navigators as they are more proficient, provide specific energy, and induce unique "you just feel it" experiences (SA), confirming the earlier results of [10]. They might also have referred to the activation of the "Hawthorne effect" during pair programming, which encompasses all positive effects on someone's work when he or she is "being observed" or is in the presence of someone [9]. That might be missing during AI-assisted programming.

Additionally, some students struggled with AI due to their insufficient skills, misunderstandings, and the inability of AI to read their minds (SB). They preferred a more skilled human partner over AI and AI over performing solo (SΓ). On a brighter note, participants who identified themselves as introverts expressed that they "definitely prefer" partnering with AI over humans and also rather than being solo because, with AI, they can easily be innovative and creative, which satisfies them (PΔ).

2) How does AI change programmer behavior and affect (in their opinion)?

There are several positive and negative changes to programmer behavior and affect perceived by themselves.

Behavior: Both undergraduate and professional software engineers sense a paradigm shift in their discipline that they react to with changed programmer behavior. For instance, professionals believe AI has shifted programming into an ever more declarative way and gives it more resemblance to DevOps (PΓ). The students, on the other hand, noticed that the cognitive chain of understanding and creating is now reversed in software engineering: *"(T)raditionally, you understand first, and after you write the code. But here, you first get the working code, and then understand how each line works."* (SΓ). It is becoming sufficient to know *what* the solution should be without knowing *how* to achieve it (SB), and for tasks where neither *how* nor what is known, i.e., research in its essence, AI could show the directions (PA).

Affect: In regard to attitudes and emotions toward AI, both groups are heavily opinionated. The professionals had taken advantage of AI's inability to say "no" and treated it as a mechanic servant who can be asked anything and never refuses (PA). They exhibit fewer emotions in their conversations with AI compared to those with human peers (PE). The emotional makeup of the conversations with AI is less complex and more oriented toward reaching the end goal (PΓ). In contrast, undergraduates have focused on finding ways to establish rapport between them and AI (SB).

Lastly, undergraduates and professionals alike confess that AI makes them lazier (PΔ, PA) and use less of their brains (SE).

3) Do we credit ourselves or AI when solutions are produced using a mix of both intelligences?

The question is a paraphrase of the well-known "attribution bias" phenomenon that is part of human reasoning fallacies. The phenomenon roughly says that humans tend to attribute their successes to indications of their character and skill but failures to external circumstances, but for others, they do it in the opposite order. Have these fallacies been transferred to AI-assisted programming in our sample?

Unsurprisingly, the reports indicate humans attribute all success in producing correct solutions in cooperation with AI to themselves and failures to AI. They feel like they did it on their own (SΔ, SB), and without them, the AI would be 'useless' (PΓ). Meanwhile, AI attributes its mistakes to itself, apologizes for those, and offers another solution (SΓ). Nevertheless, AI's polite behavior is not always met with adequate reaction, and some participants even expressed they use the option to turn off AI's verbosity (PE). Others cared about AI and its personality, giving it polite answers and wishing it would have a personality like their own (PA).

While moralists might frown (and rightfully so) on the unfair treatment of AI and the self-centered behavior of humans, we

can conclude that when human and artificial intelligence are combined, the human PLOC is internal. That is, humans feel *they* are the ones being competent and having an effect on their surroundings. The human innate need for having personal causation becomes satisfied in the pilot-navigator tandem with AI. That presents a positive contrast to some cases in pair programming, where more dominant partners might need to be told by their partners: "Yes, I can do this on my own." to stop reducing the partner's effectance motivation and pleasure [10].

As a result, AI is beneficial in increasing competence and intrinsic, autonomous, and effectance motivations. That consequently influences the inner workings of their human partners on the biological level [8] and leads to positive outcomes commonly observed in our sample, such as higher creativity (PB, PΔ), better problem-solving (SΓ, SE, PΓ), increased performance (SA), positive emotions (SΔ), and psychological wellness (SA, SB, SΓ, PΓ).

4) Additional essentialist themes

Using an essentialist approach to thematic analysis, the researchers did not restrict the method to revealing just what they wanted to find but looked for other and outwardly incompatible information as well.

Specifically, professionals using AI feel imbued with an unprecedented power to self-start their own companies (PA) and pursue broader career paths (PΓ). They eloquently promote positive near-future prospects of AI, with "general problem solving" and "converting task descriptions into solutions" being mentioned in multiple interviews (e.g., PΔ). Both ChatGPT and Copilot tools are considered a "dream come true" (PA), and while there are shared data privacy concerns (PA, PB, PΓ, PE), the professionals deem AI as safe for new users and recommend it to everyone (PA). Lastly, professionals suggest overcoming the fear of replacement by becoming symbiotic (PΓ).

Finally, students expressed mixed feelings about the effects on learning processes. They believe the basics of software engineering must be taught without AI and before AI-assisted programming (SA, SE, SB). They are concerned with the adverse cheating and anchoring effects, also expressed in earlier studies [4, 5]. Undergraduates in our sample have used AI for various university subjects and agree with professionals on AI not being a replacement threat for us humans (SΓ).

B. Threats to Validity

The subjective nature of interpretation poses threats to the validity of our qualitative results. However, the data have been processed systematically and in an epistemological way that introduces as little subjective bias as possible.

Internal validity in our research context mainly refers to the suitability of our theoretical frameworks and interview protocols for answering the research question, as discussed in sections 2, Background, and 3 Methods.

C. Limitations and Generalizability

The results might not be applicable to AI other than ChatGPT (v3.5 and v4) and Copilot (July 2021 – June 2023).

VI. Conclusion

The current study has investigated the effects of using ChatGPT and Copilot on the psychological well-being of professional and undergraduate software engineers of various skill levels on various tasks. The vast psychological effects are mostly positive, with unanimous effectance, effectivity, and creativity increases, but also slight feelings of dependence and laziness. AI's personality is compatible with humans and is perceived as mostly 'neutral' and 'inobtrusive.' All commands are accepted without the emotional makeup of human pair-programming interactions. Students struggled with being misunderstood and wished that AI could read their minds. Professionals, on the other hand, had no trouble expressing themselves clearly to AI. Importantly, the perceived locus of causality in interactions with AI is internal, increasing effectance and intrinsic motivation and improving psychological well-being.

Both educational and industrial realm samples see the prospects as positive and do not fear replacement by AI but rather perceive specific benefits, such as the ability to self-start companies and pursue broader career paths. Students insist that fundamental concepts are better learned without AI. Professionals are facing ethical aspects of using AI, mostly related to data privacy.

Our findings can inform the integration of AI tools in professional and educational settings to facilitate well-being.

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