HOW DOES ARTIFICIAL INTELLIGENCE CHANGE THE WAY WE TEACH PROGRAMMING?

A trial lecture for a Doctor of Philosophy (Dr. Philos) degree

Trial Lecture

Majid Rouhani
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NTNU

THE DESIRE TO REPLICATE HUMAN COGNITIVE ABILITIES HAS DRIVEN THE DEVELOPMENT OF AI[11]

HUMAN: THE PHYSICAL BODY AND THE NON-PHYSICAL MIND OR SOUL

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SCIENCE & TECHNOLOGY: ROBOT'S PHYSICAL BODY AND ITS AI "MIND" (CONTROL SYSTEM)

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HUMAN-LIKE ROBOTS

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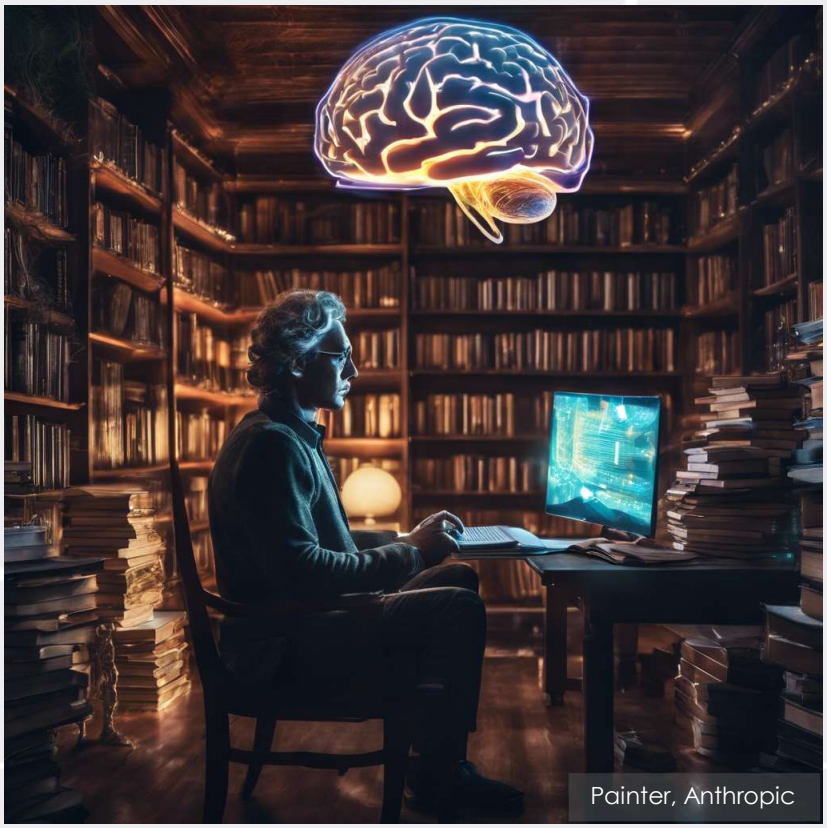
THE QUEST FOR ARTIFICIAL INTELLIGENCE



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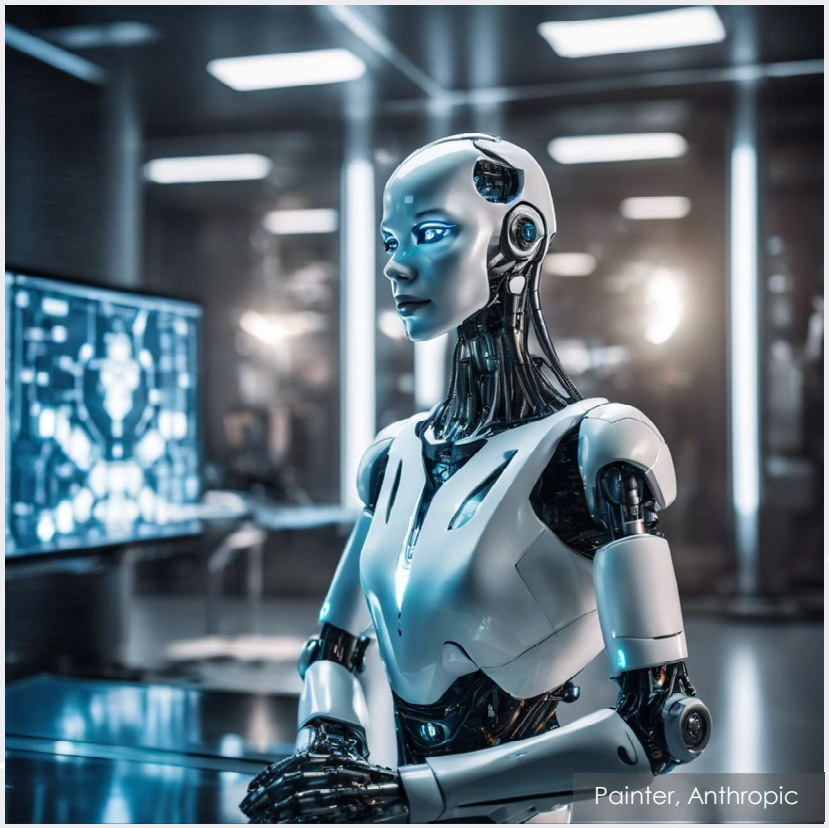

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AGENDA

- Introduction
- AI in Programming Education
- Ethical Considerations & Regulations
- Conclusions & Future Directions

THE OBJECTIVES

- Explore AI's influence on programming education
- Highlight opportunities and challenges in integrating AI tools in programming courses
- Address ethical considerations in AI adoption for programming education

DEFINING KEY TERMS

- Artificial Intelligence (AI):
  - Systems that exhibit intelligent behavior using hardware, algorithms, and data

- Generative AI (GenAI):
  - AI models that can generate new original content like text, images, music, and code

AI IN EDUCATION: EMPHASIZING KEY CONSIDERATIONS

- Recent AI models surpass the human performance
- AI systems can produce irrelevant or false information (hallucination)
- Designing prompts to create the intended results

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EXAMPLE: THÉÂTRE D'OPÉRA SPATIAL[8]

Jason Allen's A.I.-generated work, "Théâtre D'opéra Spatial," took first place in the digital category at the Colorado State Fair. via Jason Allen

THE ROLE OF TECHNOLOGY IN EDUCATION

"Teachers will not be replaced by technology, but teachers who do not use technology will be replaced by those who do." –Hari Krishna Arya [15]

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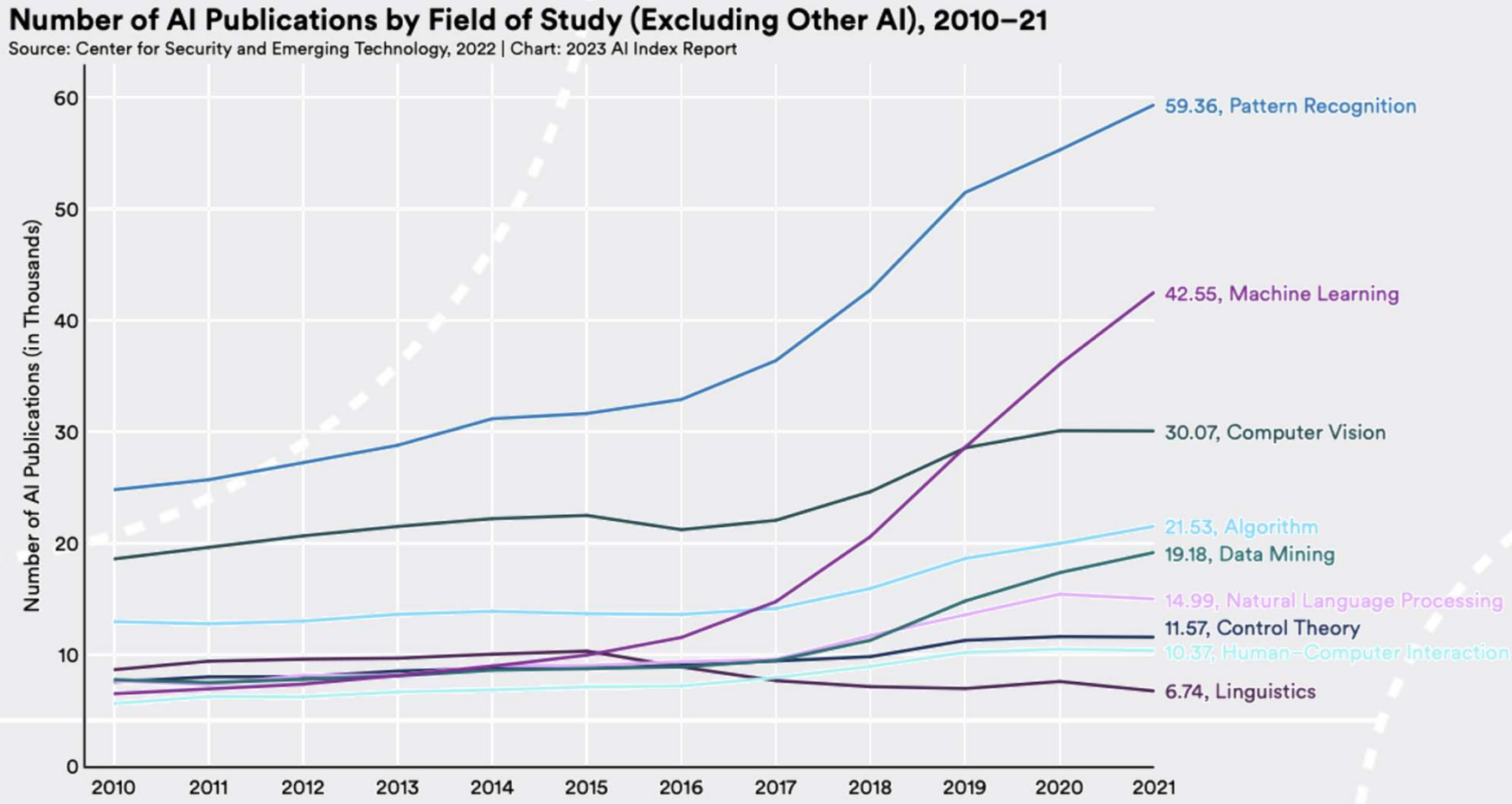
RESEARCH ABOUT AI IS GROWING RAPIDLY. CARDONA, M. A. ET AL (2023) [5]



A TAXONOMY OF AIED SYSTEMS

HOLMES, W., & TUOMI, I. (2022), [12]

- **Student-focused**
  - Intelligent Tutoring Systems (ITS)
  - AI- assisted Apps
  - AI- assisted Simulations
  - AI to Support Learners with Disabilities
  - Automatic Essay Writing (AEW)
  - Chatbots
  - Automatic Formative Assessment (AFA)
  - Learning Network Orchestrators
  - Dialogue-based Tutoring Systems (DBTS)
  - Exploratory Learning Environments (ELE)
  - AI-assisted Lifelong Learning Assistant
- **Teacher-focused**
  - Plagiarism detection
  - Smart Curation of Learning Materials
  - Classroom Monitoring
  - Automatic Summative Assessment
  - AI Teaching Assistant (including assessment assistant)
  - Classroom Orchestration
- **Institution-focused**
  - Admissions (e.g. student selection)
  - Course-planning Scheduling Timetabling
  - School Security
  - Identifying Dropouts and Students at risk
  - e-Proctoring

AI TOOLS IN SOFTWARE DEVELOPMENT

As software development becomes increasingly reliant on AI-powered tools, it is crucial to examine how these advancements can enhance programming education.

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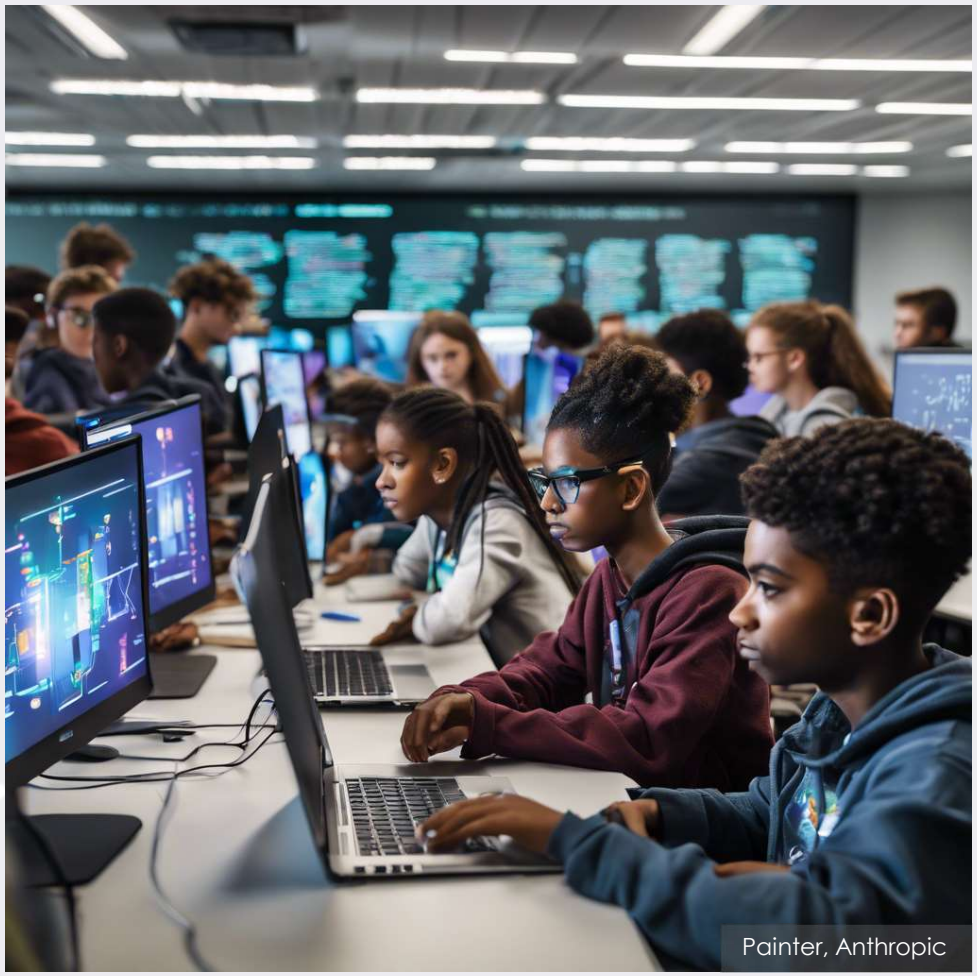
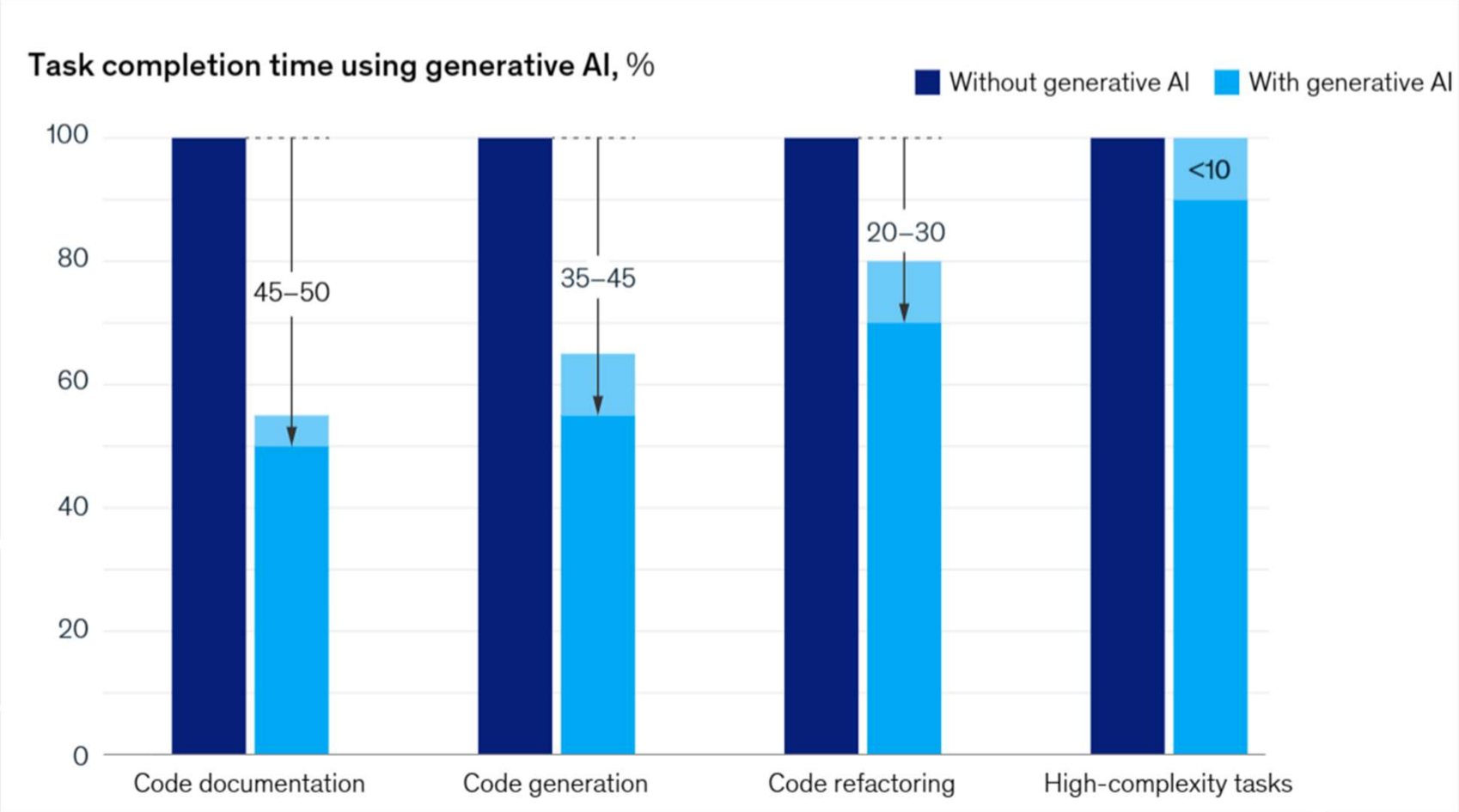


AI IN PROGRAMMING EDUCATION

RESEARCH ON EFFECTIVENESS OF GEN AI: CAN INCREASE DEVELOPER SPEED, BUT LESS SO FOR COMPLEX TASKS [10].



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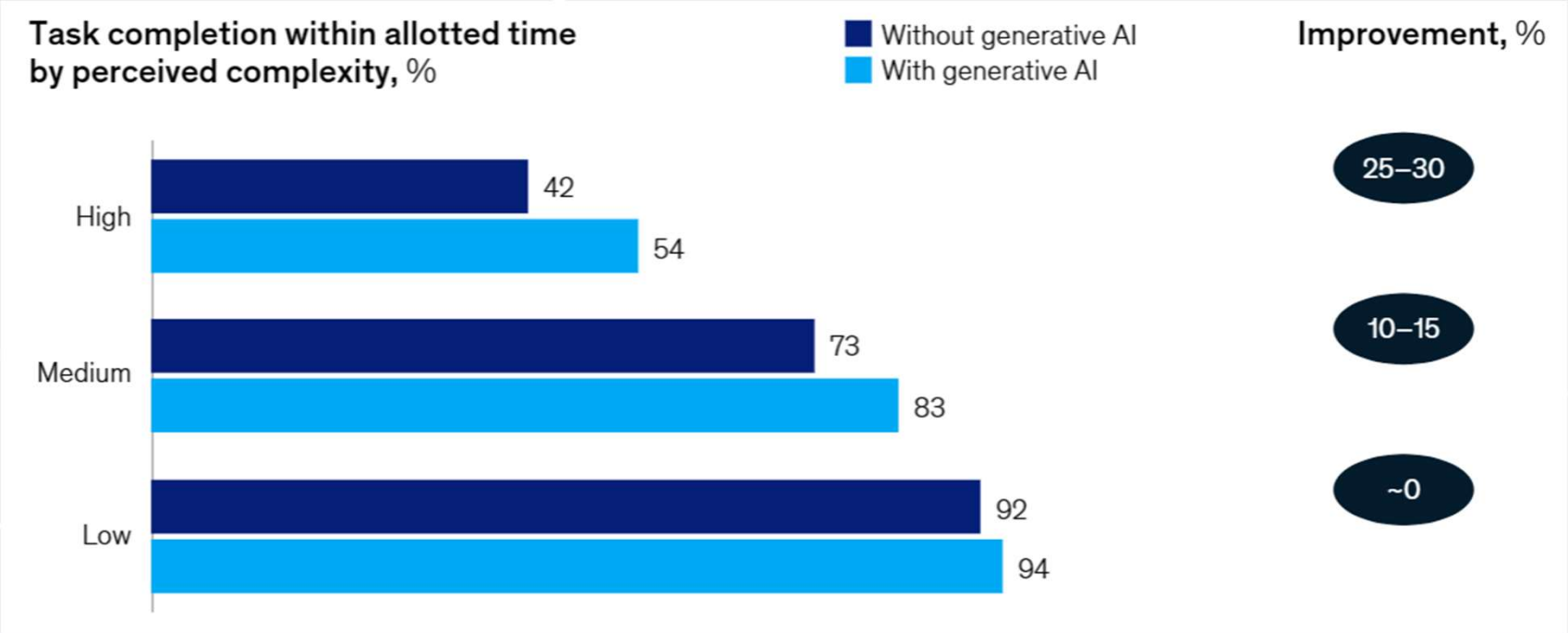
MORE LIKELY TO COMPLETE COMPLEX TASKS WITHIN A SET TIME FRAME

"Developers using generative AI to assist with complex tasks were more likely to complete those tasks within a given time frame" [10]



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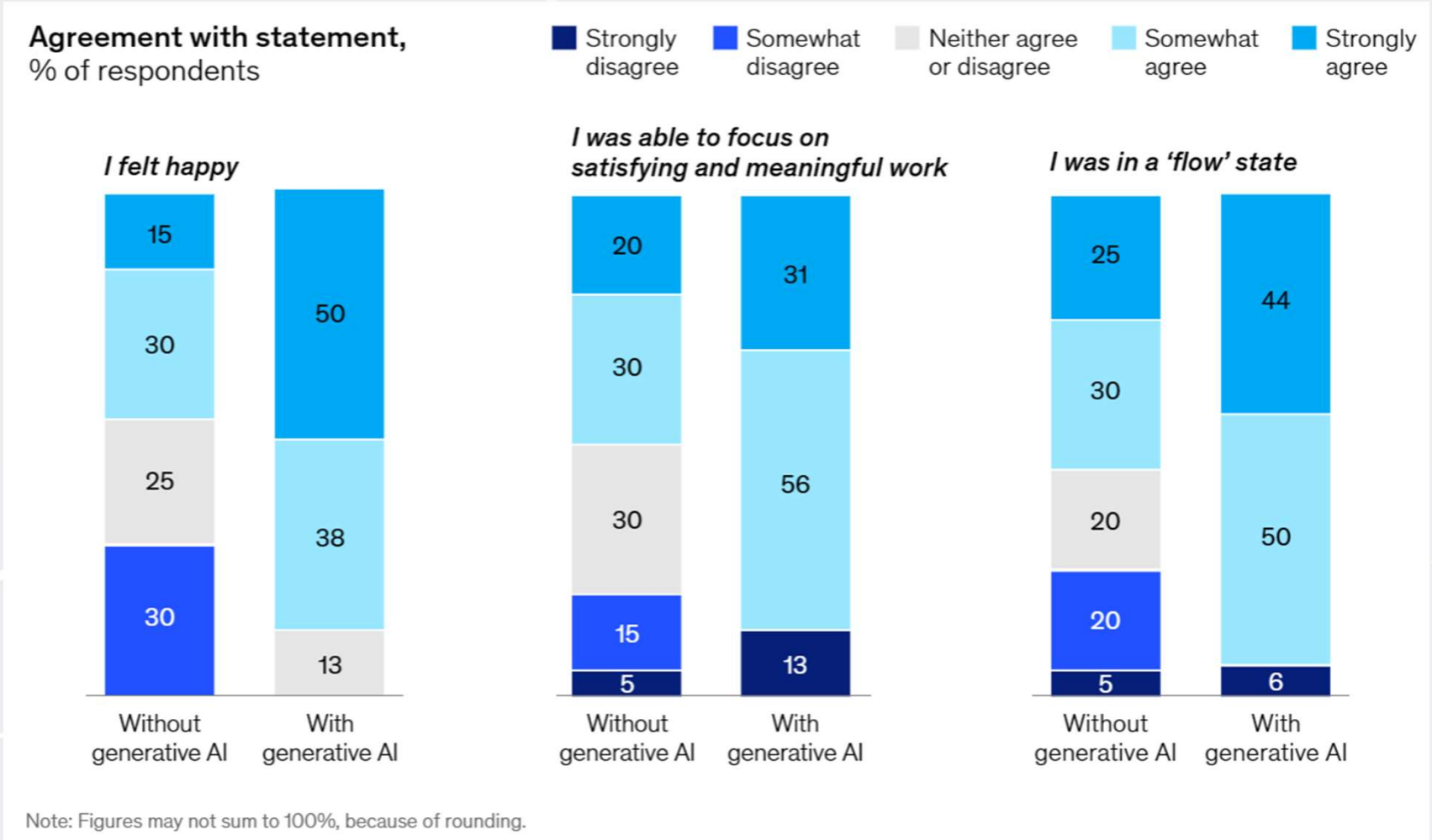
"GENERATIVE AI TOOLS HAVE POTENTIAL TO IMPROVE THE DEVELOPER EXPERIENCE" [10]



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TRANSLATION FROM PROBLEM TO CODE IN SEVEN STEPS (HILTON, A. D. ET AL., 2019, [9])

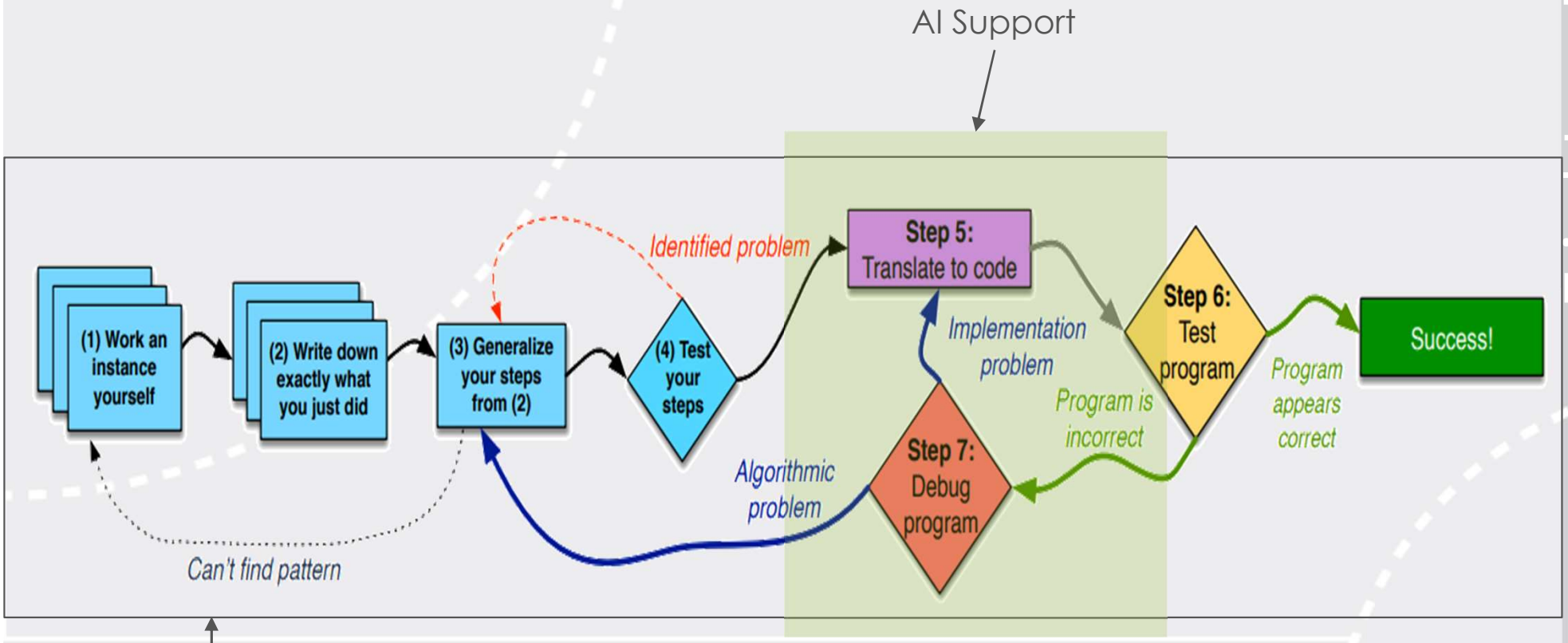
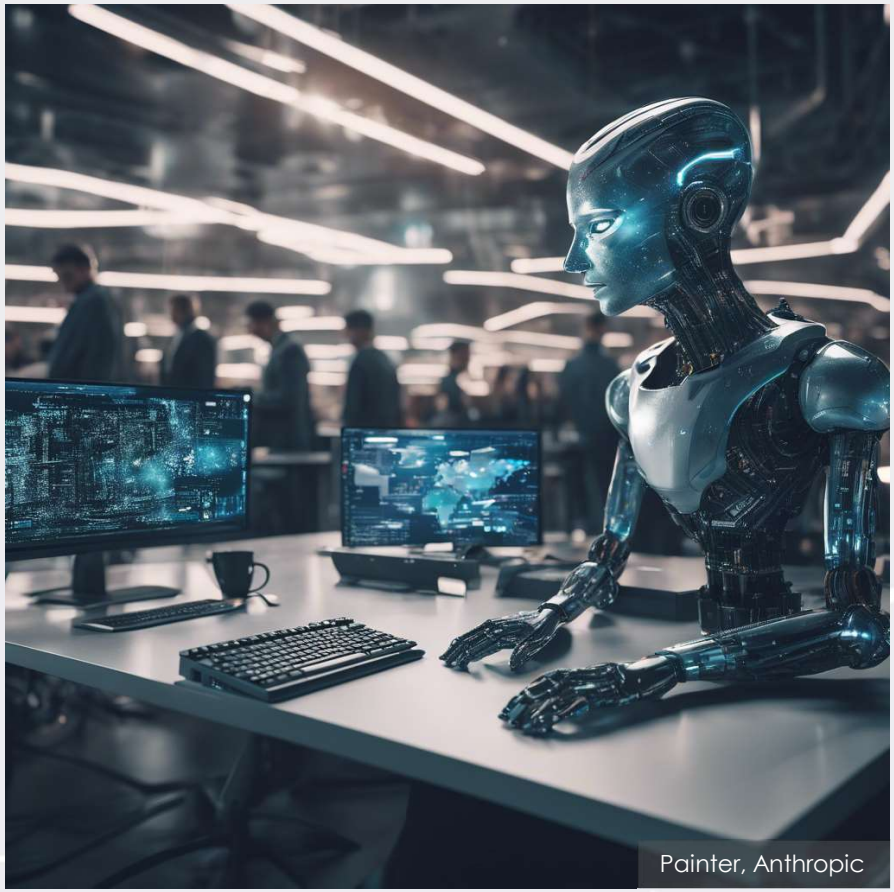


Figure 1: Diagram of The Seven Steps [9]

The responsibility of the programmer

A CHANGE IN PARADIGM

- Shifting Focus to Higher-Level Concepts
- Promoting Computational Thinking
- Students learn to think like software developer
  - approach problems systematically, leveraging AI tools as aids.



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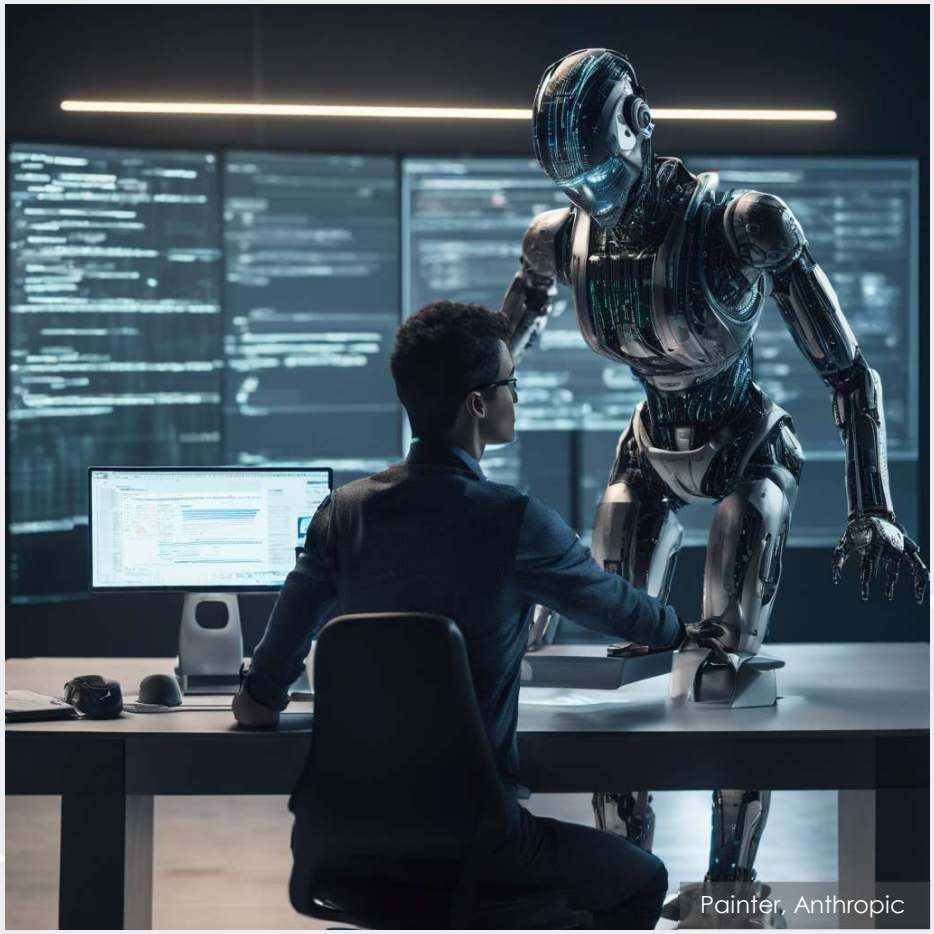
GENAI AS A 1:1 COACH FOR THE SELF-PACED ACQUISITION OF FOUNDATIONAL SKILLS IN LANGUAGES. HOLMES, W., & MIAO, F. (2023) [1]

- AI assistants as "practice students" allowing instructors to focus less on the mechanics of coding and more on pedagogy and student learning.
- GitHub Copilot, ChatGPT, Codeium, Codex, Cody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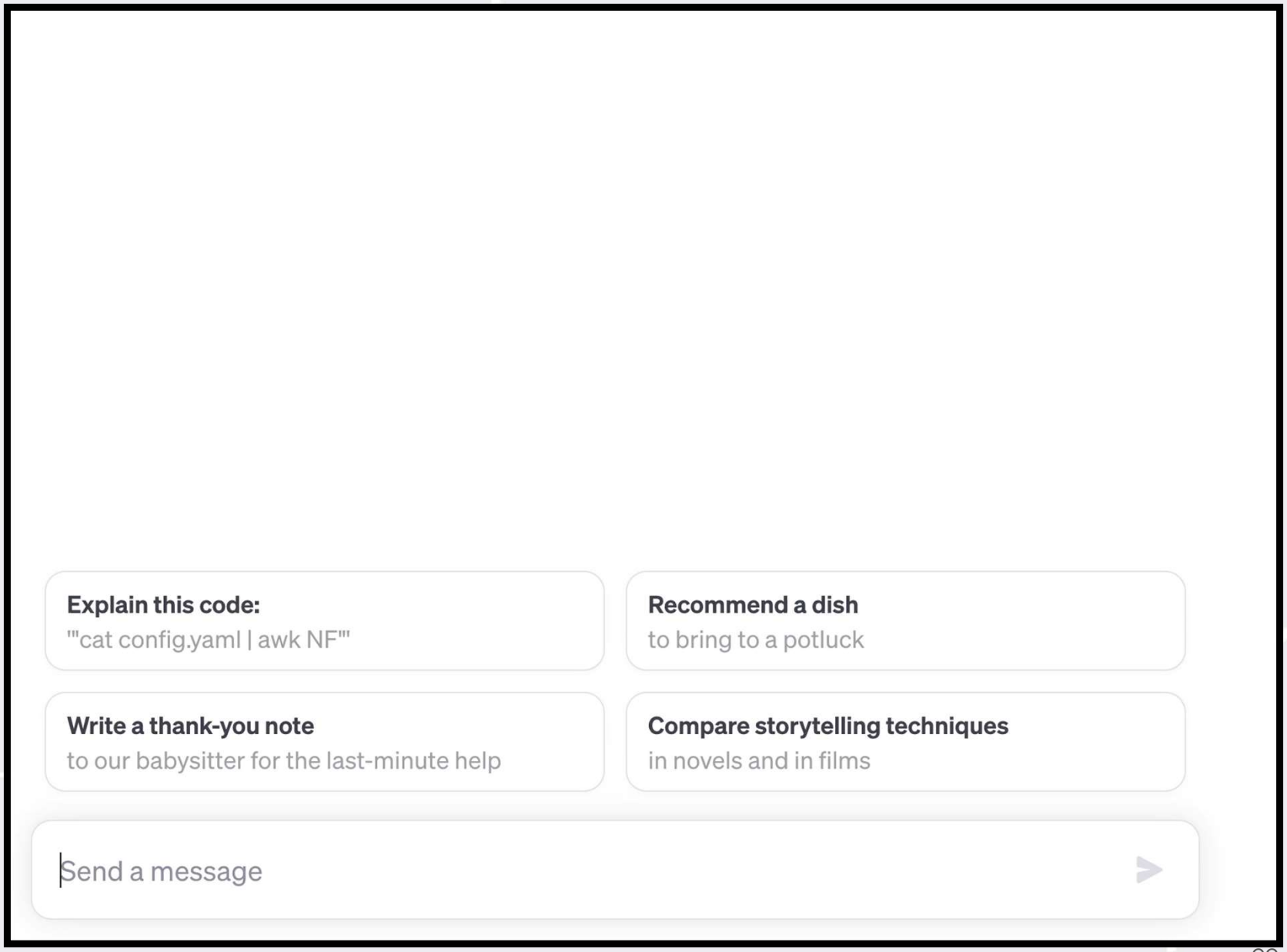
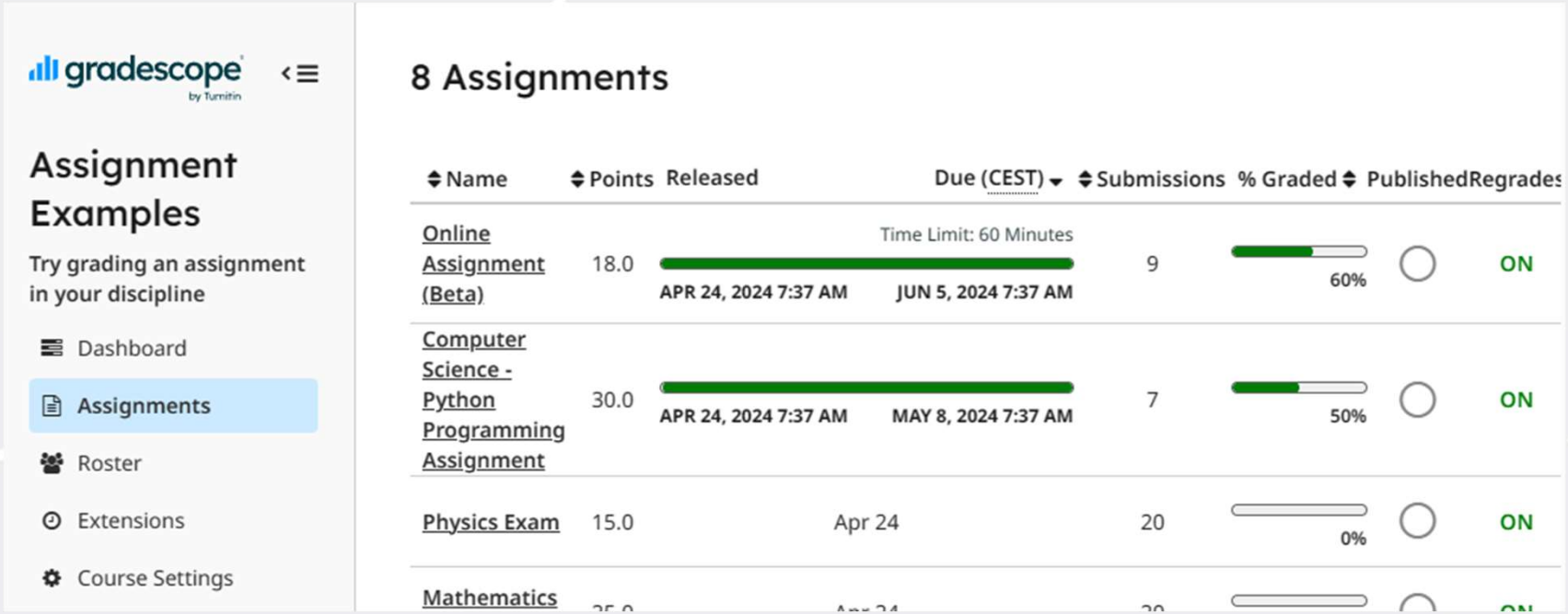
GITHUB COPILOT: AI ASSISTANT

CHATGPT AS A PEER-REVIEWER

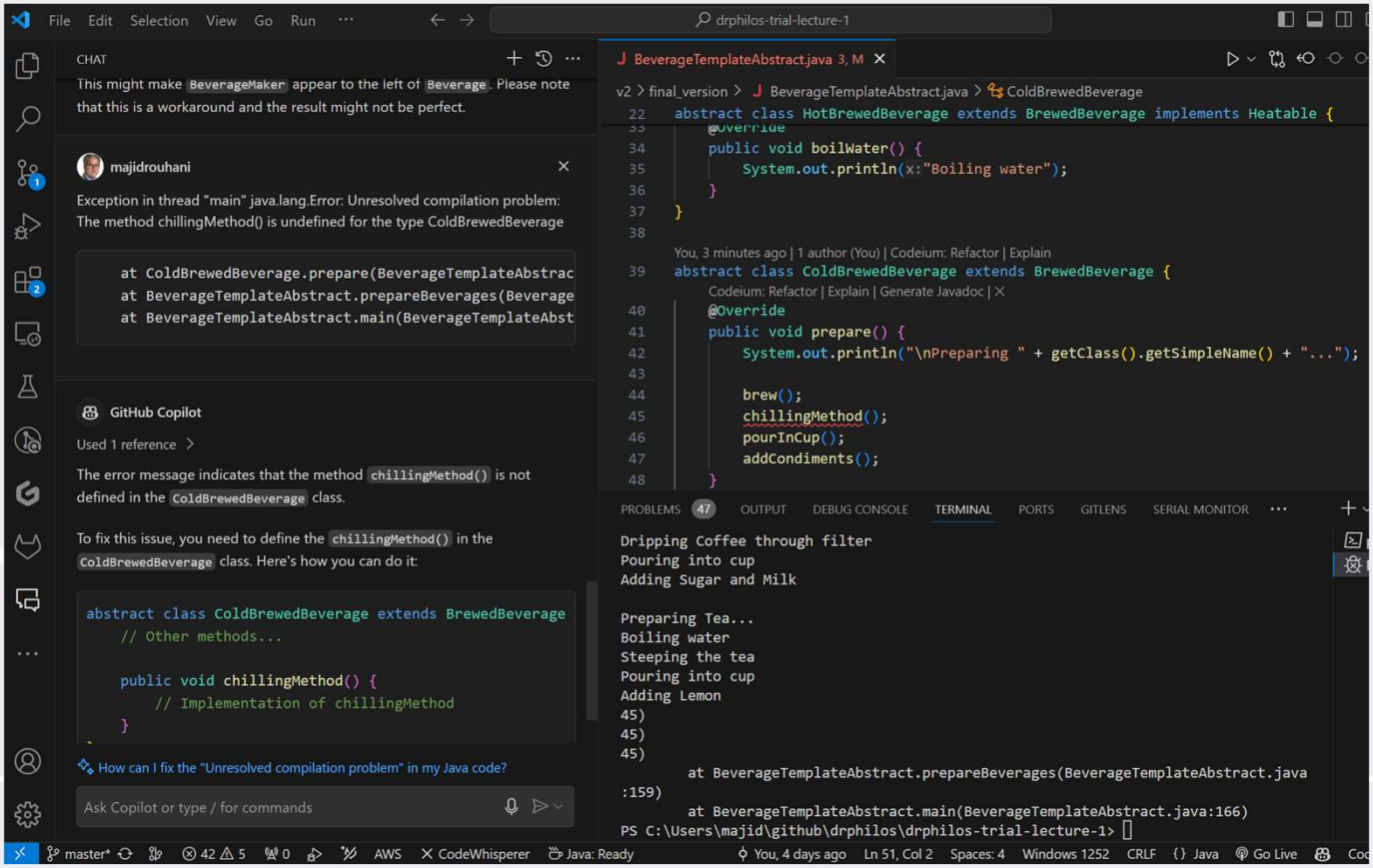


AUTOMATED CODE EVALUATION

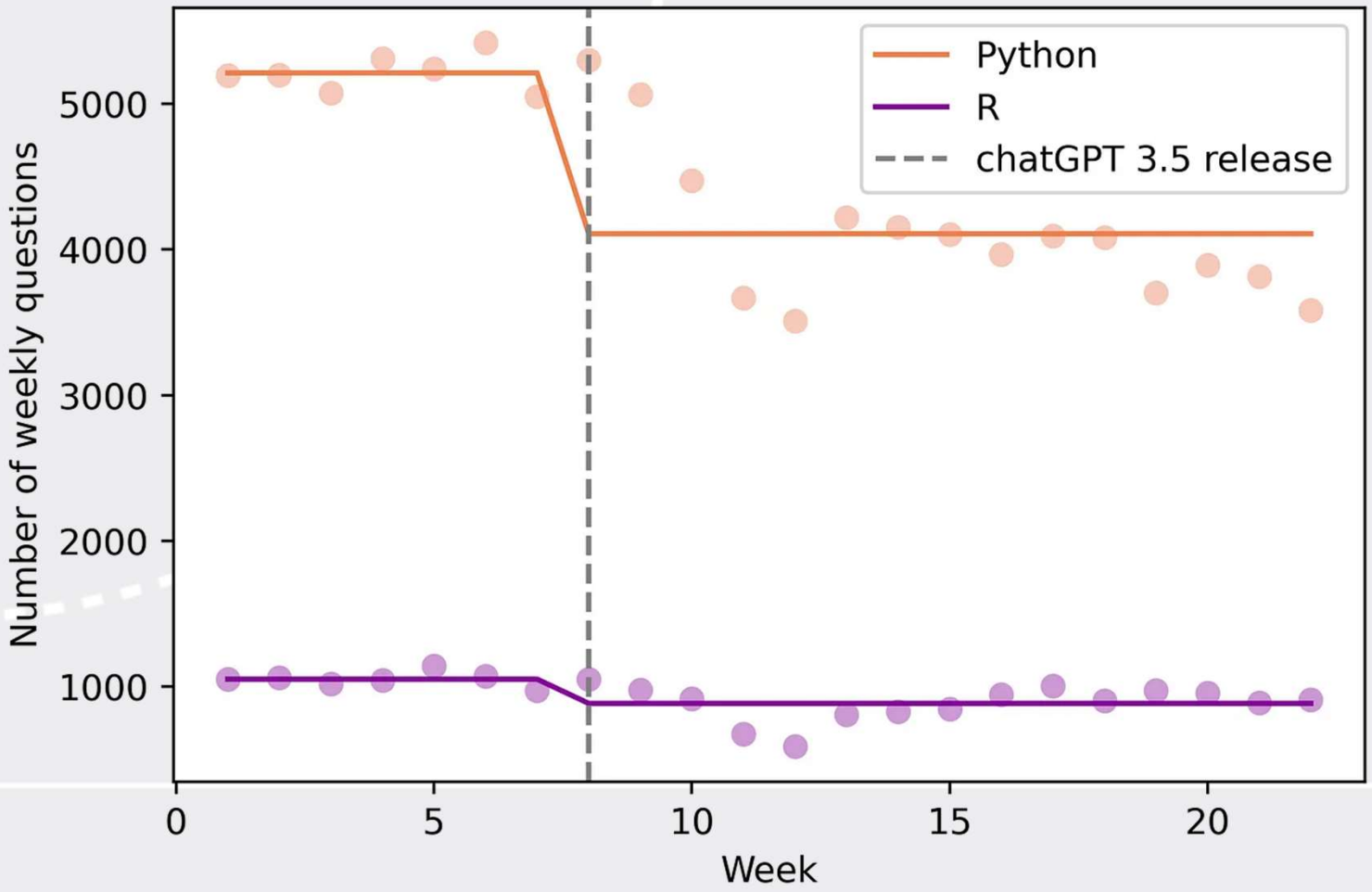


Examples: Gradescope, Codio, Codegrade, and Vocareum

HANDLING ERRORS



CHATGPT DECREASES THE NUMBER OF QUESTIONS ASKED ON STACK OVERFLOW[16]



21.2% drop

Figure 1: The effect of ChatGPT on weekly number of questions on Stack Overflow Quentin G.(2023)[16]

HOW AI IS CHANGING THE WAY WE CODE

"These findings support the view that generative AI could revolutionize our work by taking care of routine questions, allowing us to focus on more complex problems requiring expertise while boosting our productivity", Quentin Gallea (2023)[16] .

ETHICAL CONSIDERATIONS AND CONCERNS

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ETHICAL ISSUES & CONCERNS IN PROGRAMMING EDUCATION

OLSSON, E. ET AL.(2024) [14]

- Overreliance on AI-generated code by students
- Challenges in determining the boundary between authorized and unauthorized use of AI tools
- Potential negative impact on the credibility and reputation of programming education institutions if students become overly dependent on AI tools.
- Ethical considerations such as responsibility, integrity, security, transparency, explainability, and bias that should be considered when using AI in programming.

COPYRIGHT AND INTELLECTUAL PROPERTY

- Unauthorized use of copyrighted works violates exclusive rights.
- Determining ownership of generated works is increasingly challenging.
- Lack of traceability raises concerns about fair attribution.

RETHINKING ASSESSMENT AND LEARNING OUTCOMES HOLMES, W., & MIAO, F. (2023) [1]

- Key learning outcomes to consider
  - Values for human-centered technology design
  - Foundational knowledge and skills
  - Higher-order thinking for human-AI collaboration
  - Vocational skills for working with AI

FUTURE DIRECTIONS: REGULATIONS & RECOMMENDATIONS

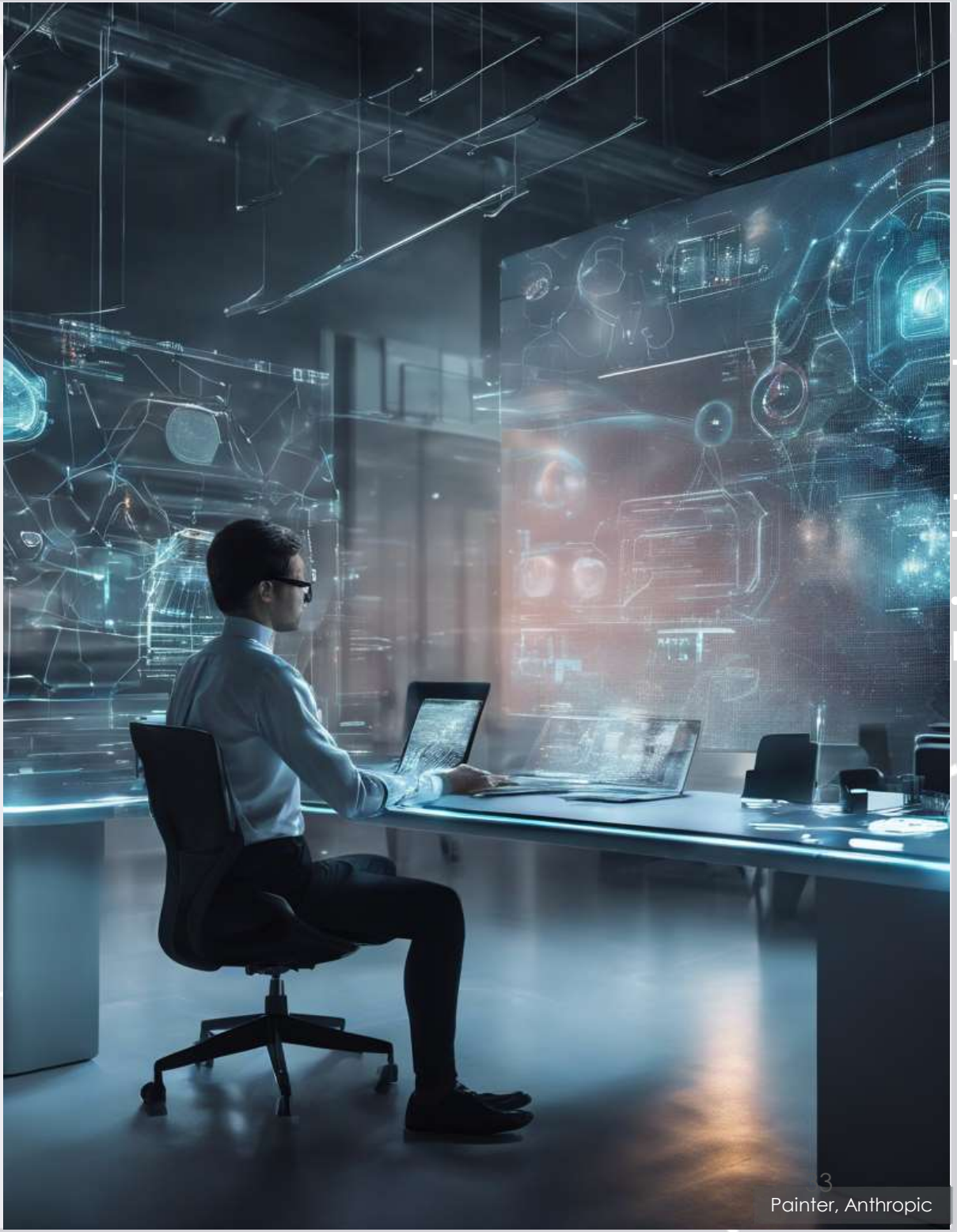
- US office of educational technologies
  - Building Ethical, Equitable Policies Together Cardona, M. A. et al. (2023), [5]

- UNESCO
  - Guidance for generative AI in education and research Holmes, W., & Miao, F. (2023), [1]

FUTURE DIRECTIONS: ADDRESSING ETHICAL AND SOCIETAL IMPACTS

- Courses addressing ethical AI, including biases, impacts, and responsible use.
- Students learn to critically examine (Critical thinking) AI-generated code and consider issues like data privacy, security, and inclusivity

GENERATIVE AI - A **COLLABORATOR**, NOT A **REPLACEMENT**



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THE THREAT OF AI

"…I try to understand the challenge presented by the prospect of superintelligence, and how we might best respond. This is quite possibly the most important and most daunting challenge humanity has ever faced. And – whether we succeed or fail – it is probably the last challenge we will ever face." (Boston, 2014)

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"We can only see a short distance ahead, but we can see plenty that needs to be done."

-Alan Turing

SUMMARY

- Personalized learning and adaptive feedback
- Opportunities: AI-driven automation of grading and feedback
- Challenges: Ethical concerns around AI-generated code and the need for clear guidelines on intellectual property rights in programming.
- Rethinking assessment and learning outcomes
- Developing human-centered policies and regulations

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