Chapter 13
Cognitive Apprenticeship and Artificial Intelligence Coding Assistants

Eric Poitras
Dalhousie University, Canada

Brent Crane
Dalhousie University, Canada

David Dempsey
https://orcid.org/0000-0002-3152-7185
Dalhousie University, Canada

Tavis A. Bragg
Acadia University, Canada

Angela Siegel
https://orcid.org/0000-0001-9211-1223
Dalhousie University, Canada

Michael Pin-Chuan Lin
https://orcid.org/0000-0002-7646-7024
Mount Saint Vincent University, Canada

ABSTRACT

The aim of this chapter is to examine the impact that AI coding assistants have on the manner in which novice programmers learn to read, write, and revise code. These discussions revolve around the concept of cognitive apprenticeship, a pedagogical framework informed by extensive research on tutoring dialogues and collaborative problem-solving practices. It involves guided instruction through modeling, coaching, and scaffolding. Within the realm of programming, these principles hold the key to nurturing skills in reading, writing, and revising code, thus making the learning process more effective and engaging. The chapter concludes by reflecting on the challenges and considerations of implementing cognitive apprenticeship within AI coding assistants. These insights are intended to benefit educators, developers, and researchers alike, offering a roadmap to enhance the learning experiences of novice programmers through AI support.

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INTRODUCTION

Recent advancements in deep learning algorithms have raised significant interest in utilizing Large Language Models (LLMs) for a wide range of natural language processing tasks, including code generation for computer programs. To name just a few, notable examples include OpenAI Codex, DeepMind AlphaCode, and Amazon CodeWhisperer. Students learning a programming language now have continuous access to Artificial Intelligence (AI) driven tools to help them complete their coursework. The affordances of these tools have received significant critical attention in the computing education literature, as have the potential drawbacks for introductory programming instruction (see Becker et al., 2023; Yan et al., 2023).

Novice programmers engage in self-regulation to inform their problem-solving, but the effectiveness of these efforts depends on their programming knowledge (Loksa & Ko, 2016). AI code generators assist information retrieval by generating starter code, allowing students to build upon and modify existing code rather than reaching an impasse or searching for an online resource (Denny, Kumar, & Giacaman, 2023; Finnie-Ansley, Denny, Luxton-Reilly, Santos, Prather, & Becker, 2023). These tools facilitate program comprehension through several means, including student efforts to trace the execution of code, generate analogies to real world settings, and summarize code at multiple levels of abstraction (MacNeil et al., 2022; MacNeil, Tran, Leinonen, …, et al., 2023). AI-based tools can also be designed to scaffold problem solving by reducing encountered errors (Kazemitabaar, et al., 2023), explaining error messages and reasoning about the original intention of incorrect code (Szabo, Sheard, Luxton-Reilly, Simon, Becker, & Ott, 2019), as well as providing suggestions for fixing the issues based on the input code and errors (Leinonen et al., 2023).

The focus of this chapter is on guidelines for designing instructional prompts using cognitive apprenticeship as a pedagogical approach to facilitate robust learning outcomes. According to the cognitive apprenticeship model of instruction (Collins, Brown, & Newman, 1989), instruction involves modeling cognitive skills and strategies for students while providing necessary support through scaffolding when students require assistance to complete a task. After students demonstrate competence, scaffolds are progressively removed to allow them to complete tasks without assistance. The assumption is that students should be offered opportunities to reflect on their own understanding and apply their knowledge to solve novel problems.

This chapter aims to establish a taxonomy of prompts that are classified according to both cognitive apprenticeship as a pedagogical model as well as introductory programming skills (Xie, Loksa, Nelson, Davidson, Dong, Kwik, …, Ko, 2019). The first section of this chapter will explore the existing research in computing education, providing insights into the challenges and opportunities posed by AI coding assistants. In the second section, the cognitive apprenticeship model of instruction is outlined to inform the design of effective prompts in enhancing skill acquisition. Within this section, an emphasis is placed on distinguishing three practices to facilitate the acquisition of code reading, writing, and revising skills and exemplify the relevant instructional methods. The chapter concludes with a broader discussion, elaborating further on motivational and metacognitive factors that mediate interactions with AI coding assistants and the implications for instructional practices and research in the field of computing education.

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