


Chapter 15

STEM for All: An Equity–Oriented AI Personalization Framework for Inclusive Cognitive Tutoring


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ABSTRACT

This chapter introduces the Equity-Oriented AI Personalization Framework (EAPF) as a guide for integrating AI-powered cognitive tutors into STEM education through an equity-centered approach. While AI personalization enables individualized learning, it often overlooks sociocultural and structural inequities that shape access and outcomes for marginalized learners. Grounded in Universal Design for Learning, Culturally Relevant Pedagogy, Zone of Proximal Development, and Equity Literacy, the EAPF highlights four dimensions, Access, Representation, Adaptivity, and Agency, supported by Bias Mitigation and Teacher Integration as critical enablers. Through illustrative scenarios, the chapter demonstrates how equity can be embedded in AI tutor design, content, and feedback systems. It offers practical insights for educa-

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tors, developers, and policymakers, reframing personalization as a justice-driven process that aligns AI tools with the diverse needs of STEM learners, particularly in under-resourced and linguistically diverse contexts.

INTRODUCTION

In recent years, artificial intelligence (AI) has emerged as a transformative force in education, offering new opportunities for personalization, automation, and instructional efficiency (Ng et al., 2025a). Among the most promising innovations are AI-powered cognitive tutors, which simulate human-like one-on-one instruction by dynamically adapting content, pacing, and feedback to individual learners' needs (Seo et al., 2021). These systems, rooted in machine learning and data-driven instructional design, are increasingly being integrated into STEM (science, technology, engineering, and mathematics) education settings, where cognitive load, complex problem-solving, and conceptual scaffolding pose persistent challenges to equitable learning outcomes (Bahroun et al., 2023).

While the advancement of AI in STEM education is often framed in terms of technological novelty and instructional benefit, equity remains an unresolved and often under-theorized dimension of this evolving landscape (Rehman et al., 2025). Many AI-driven personalization systems operate on large-scale datasets that may carry embedded socio-cultural biases, overlook linguistic and identity differences, or privilege high-resource learning contexts. As a result, personalization may unintentionally replicate structural exclusions, reaching some learners more effectively than others, and thereby widening, rather than narrowing, existing educational disparities (Wang et al., 2024).

This chapter addresses a critical tension at the heart of AI-enhanced STEM learning: How can personalization be designed not merely to optimize learning, but to ensure it is inclusive, just, and equitable? Specifically, we explore this question through the development and presentation of a conceptual model, the Equity-Oriented AI Personalization Framework (EAPF), which identifies key design and implementation principles needed to embed equity into the core architecture of cognitive tutoring systems in STEM education.

Drawing on insights from the fields of educational psychology, AI ethics, culturally responsive pedagogy, and universal design for learning, this chapter argues that equity in AI-based learning is not a peripheral concern, but rather a central criterion for responsible innovation. In particular, we propose that four interrelated equity constructs, Access, Representation, Adaptivity, and Agency, must be foundational to any AI system that claims to support personalized STEM learning. We further

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