# AI-Based Estimation of the Zone of Proximal Development in Programming Education

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## Abstract

The *Zone of Proximal Development (ZPD)*, introduced by Vygotsky [4], describes the range of learning tasks that learners can successfully complete with appropriate support. Closely related to this concept, the notion of *flow experience* emphasizes the balance between task challenge and learner skill as a key condition for sustained engagement and intrinsic motivation [1].

Recent research suggests that *artificial intelligence (AI)* can support ZPD-oriented adaptation in modern educational environments by dynamically adjusting task difficulty and feedback [2]. However, practical and lightweight implementations of such approaches in programming education remain limited.

This paper presents a *proof-of-concept* AI-based system for estimating learners' ZPD using a minimal set of background information and task interaction data. The approach builds simplified learner profiles based on task success, error frequency, and completion time, and recommends subsequent programming tasks with adjusted difficulty levels.

The system is developed as part of the continued evolution of the *Codia* gamified programming education platform, building on earlier findings related to student motivation in secondary school programming education [3]. The design focuses on feasibility and pedagogical plausibility rather than predictive accuracy. The

study examines whether a simplified AI-supported approach can approximate ZPD-aligned task selection in introductory programming education.

# References

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