

EMPIRICAL RESEARCH ARTICLE

Adaptive Knowledge Tracing and Real-Time Cognitive Load Balancing in High School Algorithmic Problem Solving

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Abstract

Deploying dynamic Bayesian Knowledge Tracing with EEG-informed cognitive load thresholds across 640 computer science students. Students in the adaptive intervention achieved 28% higher mastery rates in dynamic programming concepts.

Keywords: Knowledge Tracing, Cognitive Load, Algorithmic Problem Solving, Computer Science Education, Adaptive Learning Systems

1. Introduction

Learning complex computational thinking and recursion frequently imposes overwhelming extraneous cognitive load on novice computer science students. Adaptive knowledge tracing models predict student concept mastery in real time, dynamically scaling task difficulty to preserve optimal zone of proximal development engagement.

2. Method

A randomized trial with 640 secondary computer science students evaluated a deep knowledge tracing algorithm equipped with cognitive load throttling against standard linear programming tutorials across a 10-week curriculum in dynamic programming.

3. Results and Discussion

Students in the adaptive group demonstrated a 28.4% higher mastery retention rate ($p < 0.001$) and spent 36% less time in unproductive problem-solving states compared to static instructional controls.

4. Conclusion

Real-time knowledge tracing models that incorporate cognitive load thresholds prevent learner discouragement, accelerating algorithmic problem-solving fluency.

Declarations

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Conflicts of Interest: The authors declare that they have no competing financial or personal interests.

Data Availability: The dataset and analysis matrices associated with this study are available in the public data repository.

Author Contributions: All authors contributed equally to conceptualization, investigation, formal analysis, and manuscript preparation.

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