Developing Open-Source Adaptive Learning Textbooks for Accessible Computer Science Education

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Research question : How can the integration of knowledge tracing, interactive learning platform facilitate a cost-free, highly personalized, and scalable adaptive learning experience for computer science education?

LEARNING

Preliminary Observations: Early pilot tests indicate that interactive coding exercises improve students' concept retention and engagement. Adaptive modules show promise in providing personalized feedback loops.

Enhanced Engagement: By introducing adaptive quizzes, learners receive instant feedback and remediation paths, keeping them motivated.

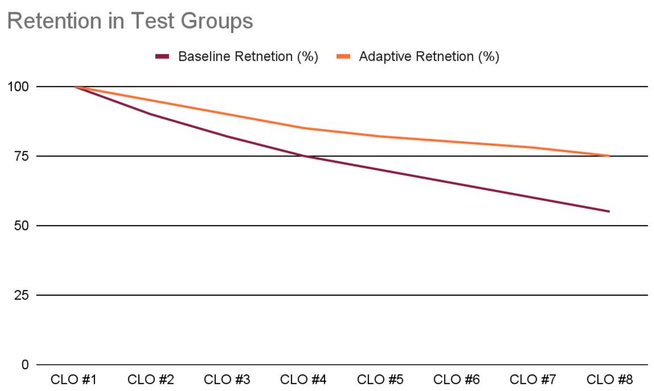
BACKGROUND

• **Need for Adaptive Learning:** Proprietary platforms provide interactive and adaptive features but are cost-prohibitive; free platforms either lack robust adaptivity or are limited in real-time personalization.

• **BKT & IBKT in Education:**

– *Bayesian Knowledge Tracing (BKT)* is widely used for modeling student mastery and predicting when a learner is ready to advance.

– *Individualized BKT (IBKT)* refines this further by adapting the parameters of the model to each student, yielding a more tailored learning path.



METHODS USED

Adaptive Learning Framework (BKT/IBKT)

- Implemented Bayesian Knowledge Tracing (BKT) to estimate each student's mastery of specific skills or Course Learning Outcomes (CLOs) after every practice attempt.
- Employed Individualized BKT (IBKT) to adapt the parameters (e.g., slip, guess, learning rate) to each learner's unique performance, providing more accurate, personalized mastery estimates.

Course Learning Outcomes (CLOs) and Assessment Design

- Divided the course material into eight CLOs, each representing a key concept or skill area.
- Created a series of quizzes and interactive lessons targeting each CLO.
- Students received immediate feedback on these tasks, and mastery updates were applied through the BKT/IBKT models.

Retention Measurement

- Defined **retention** as the percentage of students who successfully completed the tasks tied to each CLO (e.g., demonstrated mastery or remained actively engaged).
- At each CLO checkpoint, captured how many students met or exceeded the mastery threshold to remain "on track."

OUTLOOK

• **Further Integration:** Explore deeper adaptive algorithms—such as machine learning-based progress tracking—to refine how learners are guided through material.

• **LMS Compatibility:** Expand integration with institutional learning management systems (e.g., Canvas) for unified grading, analytics, and adaptive content assignment.

• **Cross-Disciplinary Expansion:** Apply this model to other STEM fields, creating adaptive learning environments for physics, mathematics, and beyond.

FUTURE WORK

• **Preliminary Observations:** Early pilot tests indicate that interactive coding exercises improve students' concept retention and engagement. Adaptive modules show promise in providing personalized feedback loops.

•**Scale to Real world Class :** Transition from a controlled pilot to a full classroom deployment, involving a diverse student population across various skill levels.

• **Enhanced Engagement:** By introducing adaptive quizzes, learners receive instant feedback and remediation paths, keeping them motivated.

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