Developing an Adaptive Learning System for Personalized Computer Science Education at UVA

A Technical Report submitted to the Department of Computer Science

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2024

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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CS4991 Capstone Report, 2024

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ABSTRACT

The growing interest in computer science at the University of Virginia, combined with its rigorousness and complexity, indicates the critical need for a better educational strategy to address students' different approaches to learning and demands. I propose personalizing teaching with AI algorithms. The Adaptive Learning System (ALS) will examine students' learning styles, preferences, and performance to adjust content and pace to their needs. This method is expected to improve engagement and understanding of complex computer science concepts by simplifying complicated theories and principles, making them more accessible to a broader student population. Initial results in other institutions demonstrate encouraging improvement in student involvement and comprehension of complex concepts. The following steps will focus on evaluating the ALS's performance at UVA, improving its AI capabilities, and potentially exploring its use across multiple academic disciplines.

1. INTRODUCTION

Adaptive Learning Systems (ALS), powered by Artificial Intelligence (AI), can potentially revolutionize learning. They are known to deliver customized content and adapt to specific student needs, which differs from traditional generic teaching techniques. This versatility is critical in addressing students' different problems and needs, ensuring that learning experiences are personalized and effective.

The latest developments in AI have contributed significantly to developing more advanced ALS, which uses AI to assess and adapt to each student's distinct learning habits, progress, and preferences. Changing information delivery and difficulty in real-time provides a dynamic and responsive learning environment that differs significantly from the static educational methods (Kabudi, et al., 2021).

2. RELATED WORKS

The most current work on ALS indicates tremendous progress and increased interest in this technology field for education. Two significant studies provide information about the development and effectiveness of these systems.

The first study(Wang, et al., 2023) focuses on the personalization of the learning experience through the use of various learning algorithms such as AI, machine learning, and item response theories. This study compares the efficacy of the Squirrel AI Learning system to traditional teacher-led training in large and small group situations. Students who used Squirrel AI Learning outperformed those who received traditional teaching.

The growth of ALS over the last three decades emphasizes its potential for modeling human tutoring interactions. These systems often have a "closed loop" architecture, which collects data from the learner to estimate progress, recommend activities, and provide specific feedback. Increasing interest in ALS includes notable examples such as Knewton, ALEKS, and i-Ready. Research, notably in US schools, has shown that these systems can effectively increase student learning, with multiple studies reporting strong positive results (Wang et al., 2023).

In China, where adaptive learning is still in its early phases of development, these systems have considerable potential to solve educational disparities. The vast class sizes in Chinese schools, frequently mentioned as a source of unfairness, make personalized instruction challenging. Adaptive learning provides a solution by customizing training to each student, independent of class size or skill level. The quick adoption of Squirrel AI Learning, one of the first Chinese ALS, indicates a significant need for such technology in the Chinese education sector (Wang et al., 2023).

Li, et al. (2021) emphasize a more particular component of adaptive learning: developing personalized learning plans using deep reinforcement learning. This work focuses on a less-explored aspect of adaptive learning: assuming continuous hidden traits in learners. It presents a model-free deep reinforcement learning system, specifically, the deep Q-learning algorithm, to determine optimal learning policies based on data about learning processes. This method is beneficial for dealing with the uncertain transition model of learners' continuous latent features.

Both of these sources provide substantial contributions to the literature on adaptive learning by demonstrating the usefulness of these systems in boosting educational outcomes and the promise of advanced AI algorithms in personalizing the learning experience.

3. PROCESS DESIGN

The ALS for the University of Virginia's Computer Science (CS) program will collect and analyze information on students' learning behaviors. This system will track many factors, including how much time students spend studying, doing homework, quizzes, and tests. The data collection process will be automated through a centralized learning platform, providing real-time monitoring of students' progression.

A pilot program will start with a randomly selected group of students enrolled in the Introduction CS class (CS1110). This initiative will serve as a testing ground for the effectiveness of ALS. All course materials, including lectures, homework, and exams, will be integrated into a single platform to streamline the learning process. The platform will initially focus on teaching fundamental CS topics, followed by practice questions to assess students' understanding.

The ALS will utilize AI algorithms to dynamically change the difficulty and material of quizzes and assessments based on individual performance. Topics where students frequently lose points in practice assignments will receive higher priority in later quizzes and examinations. The system will analyze mistakes to identify each student's weaknesses, providing a personalized learning experience.

4. ANTICIPATED OUTCOMES

Throughout the pilot program, data will be collected and analyzed to understand student engagement, learning progress, and the adaptive learning system's overall effectiveness. Feedback from students and professors will be critical for identifying the

system's strengths and areas for improvement.

The pilot program is expected to improve the learning experience for students by helping them understand CS knowledge better. The ALS intends to increase student engagement, improve academic performance, and provide a more individualized educational environment. With the pilot program results, changes will be made to improve the system's algorithms and content delivery methods, enabling the best possible results for potentially more UVA CS classes.

In the long run, the ALS will benefit UVA's computer science program and serve as a model for adaptive learning in other academic areas. The pilot program's potential success will create opportunities for developing the system to include more courses and even different departments, leading to a more inclusive and effective educational environment.

5. CONCLUSION

The Adaptive Learning System (ALS) at the University of Virginia will represent an essential technological breakthrough, particularly in computer science education. This system personalizes the learning experience for each student by incorporating artificial intelligence algorithms. The value of this initiative comes not just from its innovative approach, but also from its potential to make complicated computer science concepts accessible to a diverse student body. The ALS's capability to adapt content and pace in real-time provides a practical educational experience, improving student comprehension and retention of complex material. In conclusion, the ALS project offers the potential to transform the educational landscape at UVA and add value to the ongoing discussion about individualized education and the role of AI in the future of learning.

6. FUTURE WORK

In the future, the following steps of ALS include completing the platform's development, conducting a pilot program in the Computer Science department, and evaluating its results for scalability and enhancement. This testing phase should yield results that can be used to assess the system's adaptation to various learning styles and its impact on student performance. After a successful evaluation, the project can be expanded to include other courses in the Computer Science program and potentially other departments, adjusting the AI algorithms and models based on specific disciplinary requirements. In addition, developing collaborations with other educational institutions and technology companies could offer new insights and resources for enhancing the ALS, ensuring its adaptability and effectiveness.

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