Personalized Learning in Action: Exploring AI and Robotics for Early Childhood Education

Nicholas Abram

Howard University
nicholas.abram@bison.howard.edu

Abstract

The lack of personalization in early education can often leave students with weak foundational skills, causing said students to be behind in their studies. Personalized learning, the idea of tailoring a unique lesson plan to a student, has been shown to improve the understanding of content learned. Robots utilizing personalization techniques in educational settings, coined social robots, have been able to form a connection with students, thereby keeping them engaged while learning. This proposal seeks to study the effects of AI-driven social robotic tutors coupled with personalized learning on early childhood education. The study will consist of five groups of K-4 students: two groups learning while utilizing both a social robot and a tablet (one group with personalized learning and the other without), the two groups interacting with only the tablet (with and without personalization), and the last group learning utilizing both a non-personalized learning tablet and a non-social robot. This study aims to determine whether the combination of robotic interaction and personalized learning leads to better outcomes than solely tablet-based or non-personalized methods. This study will focus on teaching mathematics to the participants. Pre and post-tests will measure learning progress, and the influence of robot interaction on student engagement will also be evaluated. It is expected that the students with social robotic tutors and personalized learning tablets will show the greatest knowledge retention, outperforming all other categories. These findings could have significant implications for the integration of AI and robotics in early education, potentially revolutionizing how personalized learning is implemented therefore improving educational outcomes for young learners.

Introduction

Traditionally, education systems utilize a one-size-fits-all approach when teaching students. However, this methodology does not account for each person's unique learning needs. The introduction of technology to education has helped mitigate this issue to some extent, as educators have access to resources that allow them to better address the diverse needs of students. Similarly, recent developments in artificial intelligence (AI) have the potential to revolutionize education. Although it is still evolving, AI could allow each student to have a learning plan catered to their unique pace and learning style, positively impacting students on a greater scale. (Pai et al. 2024), (Bhutoria 2022), (Ayeni et al. 2024). Despite these advancements, maintaining students' interest in the subject matter is still an issue. Even if they have a perfect learning plan in front of them, if they are not interested, the plan is undermined. This issue, however, is mitigated by robotics. It has been shown that the use of robots in education can improve student engagement when learning (Ekström and Pareto 2022). Due to these developments, this research aims to explore how these technologies can improve learning experiences and enhance engagement among younger students. Overall, seeking to see if these additions can holistically improve the education system.

Background

Personalized Learning with AI

Personalized learning is, as it sounds, making a unique lesson plan based on each student's learning needs. In a traditional classroom setting, creating individualized lesson plans catered to each student is often impractical due to the size of the class and limited resources. However, AI is seemingly able to mitigate these challenges as it is able to analyze data made up of student records and utilize adaptive algorithms to provide feedback tailored to the student. Moreover, as the student grows and develops on their academic journey, the AI can continuously refine its feedback, allowing it to grow with them (Ayeni et al. 2024). One prominent example of AI's application in this context is Intelligent Tutoring Systems (ITS). Research has demonstrated that students using ITS not only show increased engagement but also an improvement in their overall understanding of the material (Akyuz et al. 2020).

Human-Robot Interaction with Children

Research has shown that younger children can form a strong connection when interacting with robots that employ personalization techniques, such as taking an interest in the students' days. These methods often cause the children to perceive the robots as entities with emotions and human-like qualities. These robots are commonly referred to as social robots (Westlund et al. 2018), (Pai et al. 2024). In educational settings, these robots can positively enhance the learning experience, making it enjoyable to the point where some

children opt to interact with them during their free time, such as recess. In some cases, children have expressed a preference for robotic tutors over their human counterparts (Pai et al. 2024). Furthermore, social robots have the potential to positively influence students' mindsets toward learning. This is shown in a study conducted by Dr. Hae Won Park at the MIT Media Lab, where these robots helped children develop a growth mindset, influencing them to embrace challenges and see them as a learning opportunity (Park et al. 2017).

Approach

The aim of this study is to assess whether personalized learning with social robotic tutors results in an increased rate of learning. Additionally, the study seeks to ascertain the effect that novelty has with children interacting with robots and evaluate its influence on learning outcomes. The study will involve five groups of kindergarten through 4th grade (K-4) students, who will either interact with a robot connected to a tablet or a tablet alone, following a setup similar to that used in studies run with Dr. Hae Won Park (Westlund et al. 2018), (Chen et al. 2020). The groups will be structured as follows:

1. Social Robot with Personalization: A group interacting with a social robot equipped with personalized learning via a tablet.
2. Social Robot without Personalization: A group interacting with a social robot, and a tablet but without any personalization features.
3. Robot without Personalization: A group interacting with a non-social robot, and a tablet but without any personalization features.
4. Tablet with Personalization: A group interacting only with a tablet, which personalizes the learning experience.
5. Tablet without Personalization: A group interacting only with a tablet, with no personalization features.

The learning task will be structured as a simple game where students must answer a set number of questions correctly to reach a goal. If the students answer incorrectly, the system will utilize text-to-speech features to explain why the answer is incorrect. In the robot groups, the audio will come from the robot's mouth, mimicking a human-like explanation. In the personalized learning groups, if students answer incorrectly, they will be prompted to provide feedback on the explanation given—whether it was helpful or not—with a simple yes/no button response on the tablet. Based on this feedback, the system will give different types of explanations until the student is satisfied. This will allow the system to refine its explanations and adjust the type of questions asked to better suit each student's learning needs.

Evaluation

A written examination will be given to the students before and after the study's completion. The pre-test will serve as a baseline for the student's mathematical knowledge, while the post-test will seek to ascertain how much the students have learned during the study. This data will be used to assess the impact of robot interaction on student learning outcomes. The effect novelty has on students will be accessed by comparing and contrasting the robot and tablet groups without personalization or sociality.

It is expected that the students in the robot groups will have a higher overall learning rate when compared to the students in the tablet groups. If the results align with these expectations, the implications for the field of AI in both education and society are significant. The personalized social robot tutor's ability to provide a more engaging and effective learning experience would suggest that further research into the use of robotics in early education across various subjects is necessary. This could potentially offer a transformative solution for enhancing early childhood education.

Conclusion

This study aims to research the challenge of providing personalized learning in early education through the intersection of AI-driven personalized learning and social robots. Furthermore, the study seeks to evaluate how the novelty of robot interaction impacts students' learning. Through the use of pre and post-tests on groups of K-4 students, the study will assess the effectiveness of these methods in teaching mathematical concepts.

The potential benefits of this project are significant. If the expected outcomes are realized, AI-powered social robotics could become a valuable tool for enhancing early childhood education. Their potential to provide engaging, tailored learning experiences that allow students to gain a deeper understanding could pave the way for future research with robots in various subjects, ultimately transforming early education positively impacting all students.

Future Work

While the implementation of this idea is out of the scope of this paper, some issues must be addressed in order for this project to be as beneficial as possible. Firstly, the ethical and logistical challenges involved in dealing with young children will be significant. For example, the length of the sessions should be dependent on students' stamina and availability in order to be respectful to all parties involved. Secondly, a more detailed evaluation may be needed as test-taking skills vary among students, which could result in a wider margin of error. Lastly, the number of participants could also affect the margin of error. Addressing these issues will ensure that the project will have a meaningful and scalable impact.

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