

Designing An Explainable Artificial Intelligence (XAI) User Interface to Engage ADHD Learners for Complicated Problem-Solving: A Digital Rubik's Cube Design Use Case

Katelyn Wyandt¹, Dr. Dezhi Wu^{*2}

^{1, 2}, College of Engineering and Computing, University of South Carolina, Columbia, SC 29309, USA

^{*}Corresponding Author, Email: DEZHIWU@cec.sc.edu

Study Background and Motivation

- **Attention deficit hyperactivity disorder (ADHD)** is a neurodevelopmental disorder that affects behavior, attention, and cognitive control.
- According to the CDC 2019 report, over 6.1 million school-aged students have been diagnosed with ADHD, causing learning challenges, less access to future STEM workforce development, and huge educational, financial and healthcare burdens for our society. **How to effectively help and support ADHD learners is a pressing societal problem**, and thus we are motivated to explore novel technological solutions in this study.
- Prior studies have found that **ADHD learners performed better in a 3D digital environment** compared to their 2D environment with an improvement on their impulse control. However, it is still an open research area as to how we can design such digital tools to effectively engage ADHD learners to address their special needs.
- In this study, we digitized and designed **a 3D Rubik's Cube platform called ALLURE**, using cutting-edge artificial intelligent technologies to engage users in learning how to solve Rubik's Cube problems in a 3D environment.
- **Explainable AI (XAI) in Education** is a promising way to transform education with its capability to uncover the most efficient methods of problem solving. XAI brings a novel way to engage ADHD learners due to its intelligent adaptive learning design potential to facilitate effective social communication and knowledge building. ADHD learners can benefit from using XAI tools to reduce their impulsiveness and improve their attention for better learning outcomes from a personalized technological therapy perspective.

ALLURE: AI-Driven Multimodal Educational Platform

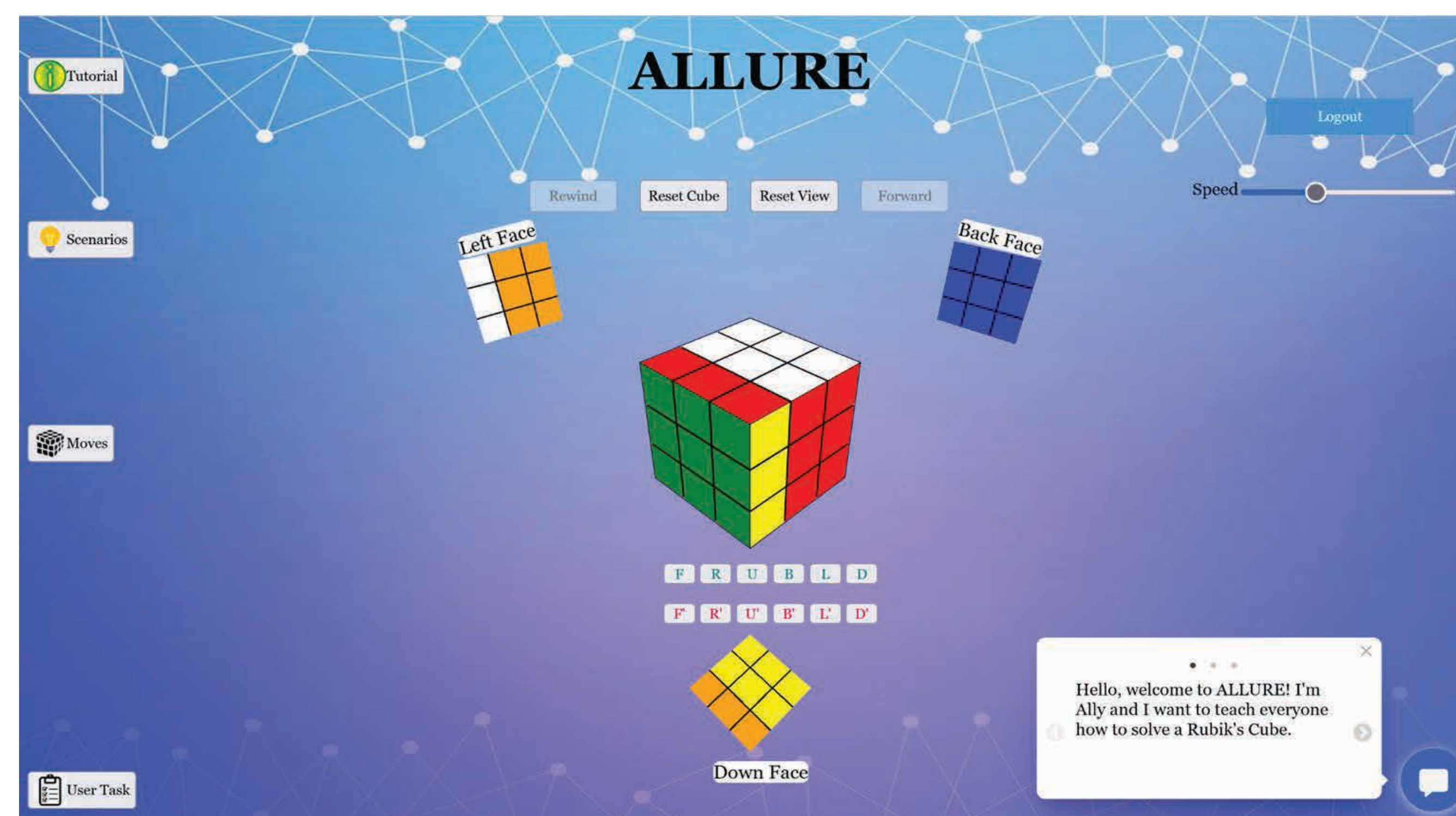


Fig 1. Interactive AI-Enabled 3D User Interface

Study Design

- We designed and conducted a **2 (Chatbot-with or without) X 2 (Task Complexity – simple vs. complex) X 3 (ADHD – officially diagnosed, suspected with ADHD symptoms vs. Non-ADHD) factorial user experiment** using surveys, interviews and think-aloud methods for data collection. We aim to address the following research questions (RQs):
- RQ1: *How can we design an AI-driven 3D Rubik's Cube digital platform to engage ADHD learners to effectively address their special needs?*
- RQ2: *What UI/UX design and pedagogical strategies can we explore and implement to assist and support ADHD learners to effectively interact with a 3D digital Rubik's Cube environment for complicated visual spatial skill development?*
- RQ3: *More specifically, how can we design engaging communication and knowledge building strategies and technological affordances with our embodied chatbot to seamlessly engage ADHD learners for more optimal and personalized learning experiences?*

Preliminary Results - Quantitative

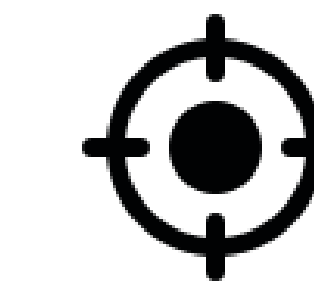
Based on the initial analysis with 52 users' responses to our pre-survey and post-survey questions, we found:

- (1) ADHD users were less motivated to make sound decisions by interacting with ALLURE.
- (2) ADHD users' improved performance in visual spatial skills using MRT tests was much higher than Non-ADHD users.

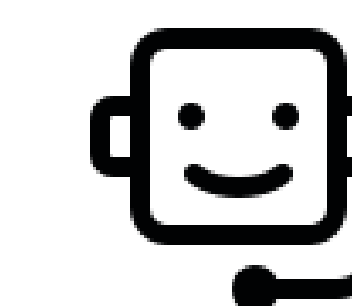
Multimodal UI/UX Design Strategies

- (1) **Chatbot** enabled with XAI explanations for solving unique scenarios encountered on the Rubik's cube
- (2) **Personalization** of user experience with functions that allow the user to reference previous explanations, adjust the speed, and rewind/forward
- (3) **Visual and written descriptions** of problem-solving solutions to provide options for breaking down the complex task
- (4) **Interactive platform design** that shows the user how the Rubik's cube sides move relative to each other independently
- (5) **Engaging user task** design to coach and test the user's retention of information and gain hands-on experience problem-solving with seamless communication, built-in motivational mechanisms and content scaffolds

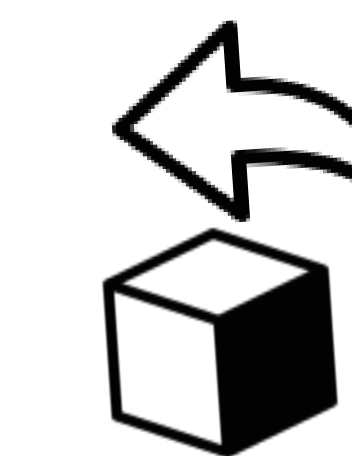
Preliminary Results - Qualitative



- **Hyperfocus** is when a task or goal supersedes other tasks which may cause a person to ignore other tasks. Many ADHD users hyper focused on the task of solving the Rubik's Cube problem rather than exploring the platform or its assistive functionalities.



- **Wordy Explanations** seemed to be less effective for ADHD users to utilize XAI strategies provided by the platform.



- **XAI UI/UX Features** can be distracting and confusing to ADHD users making the ALLURE platform more difficult for them to navigate for learning.



- **Self-Critical** descriptions such as 'oh that was my fault' and 'I guess I'm slow' are examples of thoughts users verbalized that associate mistakes on the platform with user error rather than the platform. In our initial observations we found that ADHD users were often more self critical of their performance solving the task.

Conclusion and Implications

- AI-driven assistive technology design should **foster positive attention, reduce negative distractions, and increase attention retention** to effectively engage ADHD users.
- **Simplified designs** and usage of universal UI design strategies may decrease disorientation and confusion for ADHD users on multimodal platforms.
- Because ADHD users are neurotypical learners, with **personalized design strategies** on an AI-driven platform, we can create more immersive, visually appealing and adaptive artefacts to support their problem-solving skill development.

References & Acknowledgements

References will be available upon request.

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