
LearnCraft VR: A Gamified Virtual Reality and AI-Driven Approach for Inclusive Education

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Abstract.

Children with learning disabilities, such as dyslexia, dysgraphia, and dyscalculia, often find it hard to cope in traditional learning environments with no adaptive feedback. However, with new technological advancements in the form of VR and AI, there are now unique possibilities to build immersive learning systems for people with learning disabilities. The purpose of this study is to conduct a review of existing studies that investigated the effectiveness of different VR applications for learning, diagnosis, personalized feedback, and gamification. In addition to reviewing different applications of VR technologies for improving phonemic awareness, learning hand writing, developing numerical logic, and increasing students' engagement in class, this research will address the effectiveness of speech recognition software, handwriting assessment programs, and adaptive algorithms as tools for automatically giving learners feedback and measuring performance metrics. Based on existing weaknesses of current VR and AI systems, a brief description of the framework, called LearnCraft VR, designed for creating a unified system for building an immersive environment using VR and AI technologies, will be given.

Keywords. Virtual Reality; Learning Disabilities; Dyslexia; Dysgraphia; Dyscalculia; Gamified Learning.

1. INTRODUCTION

Learning disabilities such as dyslexia, dysgraphia, and dyscalculia can be rather common in adolescents and can negatively affect their learning process if not diagnosed in time. Dyslexia affects language acquisition and phonics, dysgraphia affects writing skills, and dyscalculia affects arithmetical skills. These disorders often go hand in hand and can become the obstacle to proper literacy skills development. Traditional class learning is based on the development of reading and writing skills which require visual perception and are not suitable for every individual. Multisensory teaching and continuous help can be very beneficial for students with SLDs [1, 2].

Computing technologies have allowed the creation of the software for dyslexic readers [3, 4] and the computer systems that diagnose dysgraphia [5, 6]. Although highly flexible and efficient, all these applications are made specifically for a particular disorder and the development of a particular skill only. Computerized learning systems with exercises for dyslexia and dyscalculia have been developed [7, 8], but there are no platforms that work in several dimensions and can evaluate the learner's performance. Not much work has been done in the direction of developing a platform that combines all three elements - gamification, virtual reality, and artificial intelligence.

2. RELATED WORK

Research into SLDs via technology has progressed from standard clinical assessments to the application of advanced technological techniques using artificial intelligence, video games, and immersive media. Research into dyslexia showed how it occurred due to issues in phonological abilities and brain functioning [10, 11]. Rello et al. suggested guidelines for website structure design to reduce the cognitive load on people with dyslexia [3, 4]. Even though these developments contributed greatly, they were limited to two-dimensional textual interfaces without live adaptation and feedback. Research into dysgraphia was done in connection to kinematics and writer's movements. Rosenblum et al. noticed the difference between process and product in developmental dysgraphia [12]. Next steps involved classification of handwriting based on the analysis of stroke segments to identify abnormalities [5, 6]. In a similar manner, the research of Geary [1] and Butterworth [13] paved the path for computerized screenings and remediation software [14, 15] in dyscalculia. Gamification has also been used to make practice interesting. Yalu was designed by Kularathna et al. for dyslexia screening [7], and it has been found that motivation-based user interfaces encourage the reading time [8, 16]. But in these approaches, there is no assessment of efficiency in terms of error metrics. In the field of immersive media, VR-assisted cognitive training shows higher attention and motivation in case of problems in reading [9]. But in most cases, the research is limited to prototype development in the individual areas only.

3. PROPOSED FRAMEWORK

The LearnCraft VR system is designed as an integrated solution that incorporates immersive learning environments, game-based learning activities, and AI-based learning analytics. The architecture includes three major components: immersive learning modules, AI analysis modules, and performance monitoring modules.

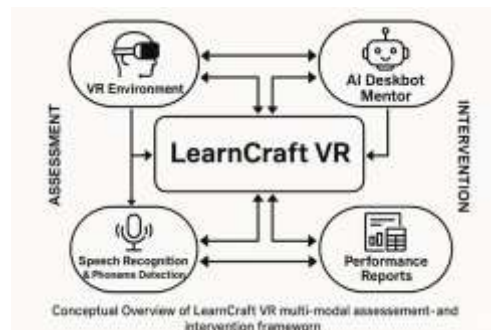


Figure 3.1. Conceptual overview of the LearnCraft VR multi-modal assessment and intervention framework.

4. COMPARATIVE ANALYSIS

Table 1 Comparison of existing approaches with the proposed LearnCraft VR framework

Approach	AI-based Analysis	Gamification	Immersive VR	Multi-skill Learning
Dyslexia web tools [3, 4]	No	No	No	Reading only
Handwriting analysis [5, 6]	Yes	No	No	Writing only
Dyscalculia tools [14, 15]	Limited	No	No	Mathematics only
Gamified dyslexia systems [7, 8]	Limited	Yes	No	Reading skills
VR learning systems [9]	Limited	Yes	Yes	Limited scope
LearnCraft VR (proposed)	Yes	Yes	Yes	Reading, Writing, Mathematics

5. DISCUSSIONS

According to the existing literature, while the use of technology for learning has many benefits, the efficiency of the system is restricted by its fragmentary nature. Each tool is designed specifically for one aspect of learning, forcing teachers to utilize different tools. The gamification process increases the level of student engagement [7, 8]; however, the platform is set for working within rigid task constraints. Technologies of automation such as handwriting and speech recognition decrease the necessity of manual evaluation [5, 6], but there are limitations in their application. Immersive VR environments offer structured learning with multi-sensory experience in terms of visual, auditory, and motion, which helps maintain student attention [9, 18]; nonetheless, many VR applications work independently without data analytics and adaptive learning systems. LearnCraft VR provides a solution by combining the elements of VR, machine learning, and gamified learning into one adaptive environment.

6. CONCLUSIONS

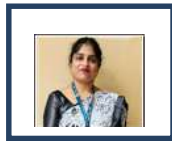
Innovations such as digital learning systems, AI-enabled diagnostics, gamification of learning systems, and virtual reality environments can be used effectively to enhance the learning process for dyslexic, dysgraphic, and dyscalculic children. Although many applications are available in an individual form, they tend to act separately and not as an integrated learning system. LearnCraft VR system fills this gap by integrating VR technologies, gaming techniques, and learning analytics via AI within one learning environment. The inclusion of speech recognition and handwriting analysis features, along with automatic assessment of results, makes it useful for enhancing learning processes as well as identifying issues at an early stage. Further research will aim at conducting empirical studies in classroom settings.

7. REFERENCES

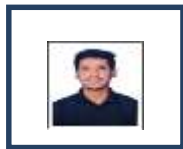
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