ICT-based Technologies and Their Use in the Battle Against Dyscalculia:

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Abstract

As of the past recent years, there have been multiple advancements made in the use of ICT (Information and Communication Technologies) in the education process of students suffering from Dyscalculia, a learning disorder that affects an individual's capacity of understanding number-based information. This paper aims to explore a myriad of different studies and experiments made with children with Dyscalculia, and how the implementation of ICT in education positively affects their learning capabilities to the point that it could become a core part of the future of the global education process. However, there are still many parameters to be investigated.

Keywords: assessment; ICT; intervention; dyscalculia; online applications; mobile applications

1. Introduction

From the Greek "dys" and the Latin "calculia", Dyscalculia is a learning disability that affects an individual's capacity for processing numerical data and understanding mathematics, mainly the basic arithmetic operations such as addition, subtraction, multiplication, and division [1]. dyscalculia can appear throughout the whole spectrum of intelligence, and it is wrong to assume that those who possess a high degree of difficulty with mathematics necessarily have dyscalculia. The disability itself covers a broader range than just sheer mathematical ability, as it is associated with specific numerical disorders [2] that include but are not limited to having difficulty with handling money, telling the time on an analog clock, or correctly reading maps [3]. There are many known factors that may cause an individual to develop.

The most well-known causes of dyscalculia are low intelligence, genetic predisposition, neurological disorders, mathematical anxiety, and improper teaching [4]. The estimated prevalence of dyscalculia in the world's population is of 3% to 6%.

The most common way to identify dyscalculic children is to discover whether they suffer from some sort of reading disability. An estimated 40% of children with dyslexia also suffer from dyscalculia. Other disorders such as Dysgraphia, finger agnosia, Attention-Deficit, Hyperactivity, and difficulties with left-right discrimination have also been associated with dyscalculia [5]. It is also evaluated that 25% of the children with dyscalculia have ADHD (Attention Deficit and Hyperactivity Disorder).

Learning disabilities such as dyscalculia often remain throughout life. However, an early diagnosis and appropriate intervention can significantly reduce the impact the disorder can have on an individual's life [6]. The introduction of ICT to the treatment of children and teenagers suffering from dyscalculia has shown to be an effective strategy in aiding their numeric and arithmetic skills. This paper will review a plethora of studies and experiments that made use of adaptive software and different approaches to reducing (and potentially nullifying) the disorder's effect.

The exploration of dyscalculia will be done in two parts. Firstly, there will be an exploration of the ICT methods for the diagnosis and prognosis of dyscalculia. Secondly, there will be an analysis of different methods used to treat the disorder.

2. Assessment

2.1. Web Applications

In 2006, Beacham and Trott developed an online screener called DysCalculim. It served the purpose of analyzing the understanding of numeric concepts and quantitative comparisons, with the intention of separating students who presented difficulty with mathematics due to dyscalculia, or due to some other type of neurodivergence such as dyslexia. After the student accesses and completes the DysCalculium portal without a time limit. Their answers are processed and automatically analyzed; DysCalculim provides individual profiles for students with 11 subcategories, indicating which parts they might be weaker at, and a general score that attempts to predict whether the student is at risk of having dyscalculia. [7]

2.2. Artificial Intelligence

Jain et al (2012) proposed, through the use of soft computing technique, a Fuzzy Expert System-based (FES) model that was capable of classifying learning disabilities into their respective subtypes. At the time, the current models could only detect whether a child had a learning disability or not. The FES-based model consisted of four core parts: fuzzifier, rules of classification, inference engine, and defuzzier. It was capable of detecting whether a child was suffering from dyscalculia, dyslexia, dysgraphia, or some combination of the three with an accuracy of 90%. [8]

3. Intervention

3.1. Web Applications

In 2005, Hesselbring et al. developed FASTT (Fluency and Automaticity through Systematic Teaching Technology), an intervention software program that assists students in developing mathematical fluency. FASTT uses unique features and resources to connect the facts and their answers. A study was conducted to evaluate the efficacy of the software, and the conclusions revealed that upon going through ten 54-minute sessions of the FASTT, math-disabled students displayed a performance in basic arithmetic operations that was equivalent to non-math-disabled students trained in traditional fluency methods.

Another impressive find was that the same students retained a high level of their attained math proficiency even after the summer break [9].

3.2. Virtual Environment

Marcus Vasconcelos et al. investigated the effect of a Virtual Environment on children with dyscalculia. A study was conducted with 26 dyscalculic children averaging eight years of age, all 2nd-grade students in a school in São Paulo, Brazil. The children were randomly divided into a Control Group and an Experimental Group.

The Experimental Group interacted with networked computers and games specifically developed for dyscalculia, while the Control Group had the children participate in reinforced learning using traditional teaching methods. The children in the Experimental group were given 1-hour virtual environment sessions twice a week for 5 weeks. According to the study's results, the use of a virtual environment not only improved the mathematical skills of the participants but also kept them motivated through the use of an interactive and entertaining tool (a computer) in opposition to a static notebook and blackboard [10].

3.3. Artificial Intelligence

Anthony et al. (2008) proposed a prototype system based on intelligent tutoring systems for students learning how to solve algebraic problems. Designers of the system hypothesized that handwriting an input could bring better results as opposed to typing it. The recognizer used the Freehand Formula Entry System (FFES). To train the recognizer, the researchers collected data from 40 different handwriting styles of high-school and middle-school algebra students. The study concluded that students who were introduced to mathematical questions through handwriting were considerably faster and less prone to errors than those who were typing. A total of 80% of the 46 students involved in the experiment claimed to prefer handwriting. [11].

4. Conclusion

Based on the studies analyzed in this paper, ICT can be a powerful tool to assist not only in the diagnosis but also in the reliable treatment of children and teenagers suffering from dyscalculia. ICT can create an accessible way for diagnosed children to develop abilities on par with their non-neurodivergent colleagues, and the analyzed benefits could potentially improve education as a whole even outside the area of disorder suppression. Although further analysis is required for a more concrete conclusion, it is fair to assume that ICT will become a prevalent tool in global education in the short to mid-term future.

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