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POSSIBLE CONSEQUENCES FOR THE TEACHING OF COMPUTER ENGINEERING IN LIGHT OF NEW TECHNOLOGIES FOR INSTRUCTION IN MATHEMATICS FOR STUDENTS WITH DYSCALCULIA

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ABSTRACT

The integration of ICTs (Information and Communication Technologies) into the curricula of children with learning difficulties has made great strides in the last several years. This paper summarises research that shows how valuable information and communication technologies (ICTs) may be for assessing and helping children with dyscalculia, particularly through the use of mobile learning applications. Although there are still many aspects that need to be explored, the studies do show that ICTs can be useful in the classroom, particularly for students with dyscalculia. This suggests that they could play a significant role in global education in the future.

KEYWORDS: Assessment; Information; Communication Technology; Intervention; Dyscalculia; Web-based Tools; Mobile Apps

INTRODUCTION

The inability to do simple mathematical operations like adding, subtracting, multiplying, and dividing is the hallmark of dyscalculia, a learning disability [1–5]. Dyscalculia affects individuals with IQs ranging from average to very high. It is incorrect to assume that all students with poor arithmetic scores suffer from dyscalculia, as only individuals with particular numerical impairments fall into this category [6–13]. Several factors, including genetic predisposition, low intelligence, poorly structured curricula, inadequate teaching in school, mathematical anxiety, and neurologic deficits, can cause dyscalculia, which manifests in daily activities such as handling money, telling the time, following directions, or reading maps [13–19]. Between three and six percent of the global population is thought to suffer from dyscalculia.

The Latin word "calculia" and the Greek word "dys" form the word dyscalculia. A mathematic learning disability can be described using a variety of words. The Czechoslovakian psychologist Ladislav Kosc coined the term "Developmental Dyscalculia" in 1974. We utilised the phrase "Arithmetic Learning Disabilities" in our 1996 study by Koontz and Berch. While Temple and Sherwood (2002) call it "Number fact Dis-order," Hich favours the name "Specific Arithmetic Difficulties" [32–43].

Working memory problems, such as remembering a sequence of numbers, are directly related to dyscalculia. According to Geary, there are three parts of MLD that deal with cognition. Some examples of this include doing mathematical operations after storing them in long-term semantic memory and methods for resolving mathematical issues and the capacity to visually depict and understand mathematical data [44–51].

Since an estimated 40% of children who have dyslexia also have a math difficulty, the presence or absence of reading disabilities is the most prevalent criterion for subtyping dyscalculic youngsters. Also linked to dyscalculia include dysgraphia, finger agnosia, ADD/ADHD, and problems differentiating between the left and right sides of a room. Also, attention deficit hyperactivity disorder is present in 25% of children who have dyscalculia [7, 8]. Different types of developmental dyscalculia are defined by another classification (Kosc 1974): verbal, pragmatic, lexical, graphical, ideognostical, and operational [52–73].

Dyscalculia and other learning disabilities persist throughout a person's life, but with prompt diagnosis and the right help, they can make great strides towards progress [74–88]. By utilising assistive technology, the goal of integrating ICTs into special education is to include kids with special education requirements. Therefore, building adaptive software based on neuroscientific insights on the fundamental impairment in dyscalculia is a potential strategy [89-102]. This page compiles research that look at how different learning apps (educative, psychological, and mobile) have helped in dyscalculia diagnosis and treatment. Anyone curious in dyscalculia or any other learning condition may find out all the information they need on the internet, which is currently the biggest database of information. Furthermore, several application programmes have been developed during the past 20 years.

These apps may be accessed on several devices, including personal computers, cellphones, and tablets [103-114]. Also included in this study are several applications that make use of virtual environments, as well as those that rely on AI methods. Studies show that compared to traditional teaching approaches, using ICTs in the classroom can improve students' achievement more quickly and serve as an extra motivation for them to actively participate in class. Additionally, it promotes independence and autonomy in the classroom, as the majority of apps let students practice on their own.

We divided the studies into two primary parts to display them. The first one has instruments for evaluation and diagnosis, while the second one is for implementing changes. Depending on the software king, each of these sections is further subdivided.

Assessment

Online programmes

To identify kids who may be experiencing arithmetic difficulties as a result of dyscalculia, dyslexia, or another neurodiversity, Beacham and Trott created Dys-Calculium in 2006. This online screener assesses students' grasp of numerical concepts and quantitative comparisons. There is no time constraint for students to complete the Dyscalculium portal online; afterwards, the findings are immediately evaluated. A student's risk of dyscalculia may be determined by looking at his or her Dyscalcium profile, which has 11 subcategories that show where the student is weakest [13].

Educational Psychologist Ltd.'s Wadeson Street Dyslexia Centre created and offers the free online assessment tool Dyscalc to students with average academic aptitude who are 14 years old and older. Twenty questions make up the test, which aims to evaluate a wide range of mathematical abilities, including computation, number sense, fundamental arithmetic, and mathematical reasoning. After the exam is over, the automated system considers the user's time and quantity of right answers to determine if dyscalculia is a possibility. Students with dyscalculia took the Dys-calc exam, along with a control group. According to the findings, it can be a helpful tool for identifying kids who may have mathematical difficulties [14].

A reliable and fast method for diagnosing Dyscalculia was created by Butterworth (2003). The gadget is capable to within a personal computer and is controlled by keystrokes. The majority of the tests included in "Dyscalculia Screener" rely on numerical order and dot counting. There are three standardised computer-based exams represented by the screener: enumerating dots, comparing numerical values, success in mathematics. Simple response time, the amount of time it takes for a kid to complete an assessment, is an important factor in determining their performance [115-124].

Computer programmes

In order to categorise different forms of learning disabilities, put up a model that relies on Fuzzy Expert Systems and the soft computing method. This model can diagnose if a child has Dyslexia, Dysgraphia, Dyscalculia, or a combination of these three disorders with an accuracy of approximately 90%, whereas previous diagnostic methods could only detect if a child had one learning disability or not. The model's four main parts are the fuzzifier, Rules of Classification, inference engine, and defuzzer. Data is recorded in Excel sheets and the system is Java-based. The researchers claim that this model may achieve even higher levels of accuracy if they could just determine the right mix of algorithms [17].

In order to automatically evaluate pupils, created a web-based analysis system that uses their answers to mathematical problems. A database contains the answers that the teacher entered into the system, and the parser compares each student's response to those answers. There are three distinct steps involved in processing the responses: matching, numerical evaluation, and analysis. The approach classifies each part of the answers as either necessary, incorrect, missing, or right. As a result, the parser can distinguish between structural, conceptual, and computational mistakes made by the pupils. Using a combination of natural languages and artificial intelligence, the experiment demonstrated that the students' faults could be successfully detected. According to the results of the study, the parser's overall scaring was quite similar to the human score [18, 19].

METHODOLOGY

E-Learning and Adaptive E-Learning are components of Computer Assisted Instruction (CAI), which Bhavithra created. Using entertaining software with speed limitations, auditory feedback, and many degrees of difficulty based on the students' progress, these tools were developed to teach pupils the names of numbers, how to count, and how to compare numerical values. Online education allows students to improve one's grasp of basic arithmetic concepts like counting, knowing the names of numbers, and basic addition and subtraction. Using 14 distinct levels of assessment, adaptive e-learning provides youngsters with engaging puzzles tailored to their own performance level. This research aims to assist children with dyscalculia, a variety of forms, up to the age of eight by laying the groundwork for their mathematical and cognitive development [20].

Concerned about the difficulty of the equations and the methods needed to answer them, Lontrup et al. designed and evaluated a product for seventh through tenth graders that consisted of six Sifteo cubes and a computer programme. In addition to detecting titles and screen presses, the Sifteo cubes can sense whether other cubes are arranged side by side. At the outset, the user is supplied with a plethora of helpful features, including colour assistance and automated calculations. In order to advance to the next, more challenging level, the learner receives bonus points for each equation that is answered. So, they ran an experiment to see if the product might help students in grades 7–10 better grasp mathematical concepts. The research concluded that real-world objects aid in the comprehension of mathematical problems. [21]. In their study, O'Connel et al. provided two illustrative examples of how Apple assists students with mathematical disabilities in their learning. As a math student in eighth grade, Peter struggles to retain course material, particularly when it comes to graphing equations. on aid him, the instructor posts audio recordings of class lectures made using the iPhone's Voice Memos app on the class website. Grapher, a programme for visualising mathematical problems, is also installed on Peter's Mac. Dyscalculia affects Georgia, a third grader. To help with her homework and to reach out to her teacher via email if she has any problems, Georgia uses the calculator app on her Mac computer. It "speaks" for each key she presses and writes down the individual results on paper.

Mathematical computer exercises for preschoolers called MathemAntics were created by [23] and are based on research. The researchers found that computers facilitate collaborative learning in mathematics by means of interactive visual models, touch screens, and other technological aids, and that computers also aid in the enhancement of mathematical abilities. For the software, they suggested six cognitive design principles:

Coordinate children's activities with their cognitive and mathematical abilities.

Create efficient representations of abstract concepts.

Promote effective and precise approaches.

Find and remove errors and other misunderstandings.

Create suitable physical engagement

Combining mathematical principles with storytelling and stories

Thirdly, web-based programmes

To help students become more fluent mathematicians, an intervention programme called FASTT (Fluency and Automaticity via Systematic Teach-ing with Technology). To facilitate users in drawing connections between facts and their responses, FASTT Math makes use of a number of distinctive characteristics. Based on the study's findings, math-disabled students who were given 54 10-minute sessions on the FASTT performed nearly as well as non-mathematically-disabled students who were trained using traditional fluency methods when it came to basic mathematical operations. The fact that pupils demonstrated great levels of retention when evaluated again after summer break is the most remarkable aspect of this intervention software programme [24].

For youngsters who struggle with mathematics, Laurillard et al. (2009) created a programme that uses digital interventions. They built an interactive website (low-numeracy.ning.com) where teachers could find links to download the programmes and discussion forums for their comments and feedback. They also tested current software against adaptive software and created two programmes, "Dots2- Digits" and "Dots2Track," to help students attach numerosity in dot patterns to its representation as digits. According to educators, students can gain significantly more hands-on experience with digital games compared to traditional classroom settings [25, 26].

The cognitive process and development of math abilities in two adaptive computer games were investigated by Ra¨sa¨nen et al. in the same year, using results from neuroscience as its basis. Thirty kids who were struggling with math were split evenly between two groups that received interventions. One group participated in the game "Number Race," while the other had the opportunity to play "Graphogame-Math," a game developed at the University of Jyvaskyla. The key distinction between the two games is that Graphogame-Math begins with smaller sets of numerically similar dot patterns, which means that in order to compare, you have to count dots. For three weeks, each group practiced for the games for ten to fifteen minutes every day.

According to the study's findings, kids scored much better when it came to comparing numbers, but that progress didn't carry over to their counting or math skills. Despite this, the instruments' information input allows the kid to modify his behaviour in regard to the objective [27].

Calcularis, a computer-based training programme for fundamental numerical cognition and mathematical abilities, was created by Ka¨ser et al. There are ten distinct game types in the training programme, and they all focus on various aspects of mathematics, including word puzzles, arithmetic operations, and representations of numbers using coloured blocks. Users can begin at the easiest difficulty level and work their way up as their abilities improve. A total of 32 German-speaking primary school kids from Switzerland's second through fifth grades who were having trouble with mathematics were involved in the study. Students reported that the training helped them enhance their mathematics skills in a feedback form they filled out at the end of the research [28, 29].

The adaptive gaming software "Number Race" was developed by Wilson et al. (2006) with the purpose of helping individuals with dyscalculia. It is a multi-platform programme in Java, consisting of three difficulty dimensions: numerical distance, response deadline and conceptual complexity In Number Race, students take out a numerical comparison assignment, picking the greater of two numerosities, within a defined timescale. The more the youngster does well, the harder the stages get, until eventually he has to use addition and subtraction to create comparisons. Any combination of spoken number phrases, symbolic Arabic numerals, or non-symbolic format can be used to represent amounts in the game's missions. The number race website offers software downloads in many languages, including English, French, Polish, and Swedish [30].

Apps for mobile devices

Two well-liked iPad apps that aid kids with Dyscalculia were highlighted by Dr. Nagavalli et al. For example, there's "MathBoard," an app that's great for elementary school kids since it uses basic addition and subtraction problems; "Long Division," an app that's great for students because it walks them through the process of long division and helps them practice what they've learned [31].

Four instructors and eighty-seven third graders from a school in the Midwest took part in a nine-week research in 2011 (Mobile Learning Intervention = 41, Comparison = 46). Students at MLI practiced multiplication using commonplace iPod touches loaded with math applications like Multiplication Genius, Mad Multiplication Flashcards to Go, Math Drills, Pop Math, Flash to Pass, and Math Magic are among the math games. The students in the Comparison group used common methods for practicing multiplication, including math games, fact triangles, and number sequences. Every day, for ten minutes, every pupil would practice. After nine weeks, students were given a 100-multiplication exam with a time limit of ten minutes to complete. The MLI students provided more convincing evidence for the project by getting more of these questions right [32].

In order to create GoMath!, Alexander et al. employed the RR&D methodology. Applications for mobile devices. "Go Play Ball" and "Go Road Trip" are two math applications that encourage families to work together every day to solve problems and take part in everyday activities, raising mathematical awareness in the process. With Go Play Ball, users can keep track of their softball or baseball games and see graphs and charts showing how they're doing compared to their favourite professional players. During the first three to four weeks of baseball season, six families from Boston utilised Go Play Ball. The goal of the nine-game math set Go Road Trip is to spark mathematical conversation on lengthy road trips with the family. While driving, seven families with children in middle school used the app to see how it worked. The experiment was a success since the participants could use the mobile platform whenever and whenever they liked, while engaging in entertaining activities that also promoted socialization [33].

Students with cognitive disabilities, ranging in age from twelve to fifteen, were the subjects of a four-week research conducted by Malley et al. in a Maryland metropolitan district's special education classroom. The purpose of this study was to investigate whether or not the following variables were associated with improved mathematical fluency when students used iPads:

Questionnaire about student demographics.

Use and access to technology.

Achievement in basic mathematics.

fluency in basic mathematics.

Intervention honesty.

Societal credibility.

Integration of technology.

Findings indicated that iPad was an effective instrument for learning that bolstered instructors' pedagogical practices and piqued students' enthusiasm in schoolwork [34].

Thirdly, a digital setting

The impact of a Virtual Reality (VR) setting on children diagnosed with Dyscalculia was studied. A research was conducted in Sao Paulo, Brazil, with 26 dyscalculic youngsters. The children were all in second grade of primary school and had an average

age of 8 years. A child's

The students were randomly assigned to one of two groups. One group used networked computers and games designed for dyscalculia; the other group used reinforcement using more conventional teaching methods. The experimental group's children participated in two weekly one-hour sessions in a virtual environment for a total of five weeks. Virtual environments not only helped students enhance their mathematical abilities, but they also kept students engaged since computers are more fun and engaging than traditional teaching tools like notebooks and blackboards, according to the study's findings [35].

Students' ability to solve algorithmic problems in dynamic contexts was the focus of a research. A total of forty-six first graders (ranging in age from fifteen to sixteen) from a Vocational Educational School on the Greek island of Corfu took part in the research. Equal numbers of students were assigned to two groups: one received traditional hand-written evaluations (the "Control Group"), while the other participated in an interactive virtual evaluation (the "Interactive Evaluate Group"). Based on the study's findings, pupils can better understand basic algorithmic principles when given the opportunity to visualise specific algorithmic challenges. In addition, the majority of students who participated in the Interactive Evaluate Group reported positive emotions during the process and expressed a desire to take the exam again in the near future [36].

On average, the 37 students with math learning disabilities from Utrecht's two special education schools were 10.5 years old in 2008, when the study was conducted by Peltenburg et al. The CITO Monitoring Test for Mathematics, created by Janssen, Scheltens, and Kramer in 2005, was utilised in this study. It consists of seven subtraction problems ranging from 1 to 100. Additionally, a Flash ICT assessment environment was created specifically for this research, utilising digital imaging of the problems, computer speech, and other technologies. In the information and communication technology version, students have access to a virtual manipulative and a dynamic visual tool to aid in problem solving. Results from comparing the two formats revealed that, when given the seven items in the ICT version of the exam, participants were more likely to get the questions right [37].

Intellectual property

The web-based adaptive learning environment for mathematics, ActiveMath, was created using a variety of AI approaches. It offers several components and interactive learning aids. Interactive activities, personal information about the student, instructional tactics, and a complicated architectural framework make up this system.

methods of education and other features and offerings. OMDoc, an expansion of the OpenMath standard for mathematical symbols and expressions, and semantic XML are utilised by ActiveMath for the purpose of content encoding in mathematical texts.

Distance learning, homework, and teacher-assisted learning are all possible uses for this tutoring system. ActiveMath enables the user to study in their own surroundings at any time they want, and it is designed to adapt to each student's technical equipment, environmental variables, and cognitive demands [38–40].

For the purpose of helping students learn to solve algebraic equations, Anthony et al. (2008) presented a model system that relies on intelligent tutoring systems. The system's creators were inspired by the notion that using handwriting as input rather than typing may yield much superior outcomes. The FFES, or Freehand Formula Entry System, is the recognizer that is utilised. Researchers used data collected from more than 40 algebra students in middle and high school to train the recognizer, making ensuring it could adapt to diverse sorts of writing. Researchers found that pupils were presented mathematical problems via handwriting were significantly more efficient and made less mistakes than those who typed them. In a survey of 46 pupils, more than 80% indicated a preference for handwriting [41].

CONCLUSION

The researchers set out to look at studies that are typical of the previous 20 years that have used information and communication technologies to develop diagnostic tools and intervention programmes for dyscalculia. The reliability and usability of diagnostic and evaluation tools are constantly improving. The majority of the people in need can have access to intervention tools, which demonstrate a variation in software employed. These research found that students' cognitive abilities improved significantly more rapidly when exposed to ICTs compared to when they were taught in a more traditional classroom setting, and that students benefited from a more accessible and engaging learning environment overall. By fusing amusement with the development of numerical and mathematical abilities, ICTs have the potential to be effective and useful tools for instructors. While more study is undoubtedly required before ICTs may be integrated into the educational process, the studies that have been conducted thus far provide promising directions for future research.

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