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(REVIEW ARTICLE)

The use of ICT in the education of students with dyscalculia

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Abstract

Students with learning disabilities are a heterogeneous group due to the variation they present in terms of their skills and their ability to receive and understand knowledge. Thus, the educational approach must be focused on the learning difficulty faced by each student, adopting the appropriate pedagogical methods in a special framework of its overall approach. Learning disabilities are the largest category of educational needs. New technologies and educational technology are now part of the educational process and have radically changed the way and format of teaching. Educational software for people with special learning disabilities has been created to help students with the difficulties they face in specific learning processes.

Keywords: Special Learning Disabilities; Dyscalculia; Education; Educational Software; ICT

1. Introduction

The rapid changes and great technological leaps that have taken place in the last fifty years, with the creation and spread of Information and Communication Technologies (ICT) as a leading event, force a review of the possibility of computers to meet the expectations of modern education (Manola et al., 2023; Vouglanis & Driga, 2023; Vouglanis & Drigas, 2022). The school as a living social institution must constantly transform and adapt modern pedagogical principles and concepts to teaching practices (Matsangouras, 1998). This is necessary for the inclusion for all people with disorders and disabilities (Tsombanoglou et al., 2003).

The application of computers in education is of great importance as it gives students the opportunity to develop a life skill from the beginning of their education and teachers get a greater variety of resources to choose from. Also, the educational needs of students are at the center as the use of computers offers more personalization and a more dynamic curriculum (Bley & Thorton, 2001). The use of ICT in teaching can significantly contribute to the visualization and awareness of the information provided through the learning contents, therefore it is considered that the special functions and special characteristics of ICT will be more efficient and useful in the area of Special Education (Kraidy, 2002; Dillon, 2004). The main exponent of ICT today in the field of education is the computer and the applications and programs that we utilize through the possibilities it provides us, such as educational software.

2. Advantages and benefits of educational software

Considering the computer as an educational tool, we can define educational software as a special category of program that is executed by a computer system and is designed to be used for educational purposes. ICT is linked to several learning theories such as behaviourism, cognitive constructivism and sociocultural approaches. However, educational software mainly used today in the field of Special Education is mostly based on the Cognitive Constructionist approach

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where learning is viewed as an active process in which students actively construct knowledge as they try to understand the world around them. surrounds and use tasks that place the learner in an environment to which they can respond. Therefore, softwares are open-type, hypermedia, modeling, problem solving and simulation, therefore they facilitate learning in the positive sciences (Butterworth & Laurillard, 2010).

The purpose of using digital educational programs is to provide software applied to each learner and which will keep them in an imminent development as the teacher does, consolidate their knowledge and provide greater challenges. To achieve this, digital programs incorporate three basic rules:

- Time rule (to control fluency of performance);
- Constructive rule (to support performance evolution);
- Iterative rule (to support performance extension);
- Digital programs are subject to specific benefits for learners, educators and research (Butterworth & Laurillard, 2010).

The advantages for students-trainees are as follows:

- Digital programs are practice-oriented and allow for repeated unsupervised practice, as they are designed to be easily used by learners themselves, once they learn to use it;
- Age independent;
- Oriented to the individual needs of each individual;
- Essentially as the virtual environment can connect the physical with the abstract in ways that would not be possible in the physical world;
- Private as to use. Digital programs offer time, patience, safety and personal immediate feedback (Butterworth & Laurillard, 2010).

On the other hand, the advantages for educators are as follows:

- Digital programs are customizable and automatically create next goals for learners based on their current performance;
- They are shareable because they incorporate special pedagogical methods in such a way that they can be circulated and tested by other special educators through an online community;
- They are personalized in that a well-designed digital program can provide individualized learning to learners, enabling the special educator to provide undivided attention to another learner'
- Finally, they are motivational because the environment of a digital program encourages the learner for continuous practice more than notebook assignments (Butterworth & Laurillard, 2010).

Finally, there are also the advantages for research:

- The most important thing is the consistency of digital programs in terms of their pedagogical design which is based on clear rules in contrast to human interventions which differ significantly from teacher to teacher;
- They are automated in that programs collect and organize learner data automatically;
- They also present the learner's progress control because they control his performance in accuracy and timed reactions from target to target (Butterworth & Laurillard, 2010).

3. Educational software categories

Software programs are interactive and can illustrate a concept through engaging motion and sound. The structure of an educational software has various forms, a different degree of interaction with the user, while it also varies according to the subject it focuses on. Thus, a categorization of software is made based on teaching and the role of the computer in the classroom (Panagiotakopoulos et al., 2003).

Educational software is generally divided into the following categories or types: tutorials, drill and practice, simulation, problem solving and educational software, educational games (Allsopp et al., 2010). Some software can of course be included in more than one category, while today it is possible to integrate these categories into single educational software programs. Detailed educational software according to the category to which they belong according to Komis (2004) have the following characteristics:

Tutorials: This software is more like an e-book that introduces new ideas and skills through multimedia information, questions and problems. It usually cycles through the information, question and feedback. Ideally, a Teaching software should adapt the teaching material to the particular needs and abilities of the student. This indicates the presence of models of teaching strategies within the software and refers to a special category of educational software referred to as Intelligent Tutoring System (ITS).

Drill and practice: A good software of this type should offer the student unlimited practice, provide continuous feedback, explain how to find the correct answer to a problem, and include a progress tracking subsystem. of the student. It should identify prerequisite knowledge, adapt its exercises and explanations to the needs of each student based on student response, and provide an easy-to-use vocabulary and bibliographic reference system. The ideal case again refers to Experienced Educational Software.

Simulation: This type of software is used to simulate educational activities that are characterized by a certain degree of risk (e.g. Chemistry experiments), have high costs, are difficult or impractical for some reason. Thus, the software creates as realistic as possible a simulation of a real system or phenomenon in a safe, cheap and efficient way through which the student gains experience and knowledge.

Problem Solving: Software of this type provides an environment through which to help the student improve their problem-solving skills and may contain some simulation of a real-world phenomenon. The software must enable the student to create or analyze variations of the problem through changes to the problem data. Include explanatory graphical representations of the student's activities in his effort to solve the problem, support him in understanding algorithmic methods, and discourage him from trial-and-error approaches.

Educational programs and educational games (educational software, educational games): Educational game software takes advantage of the student's enthusiasm, motivation, and attention in the game to convey knowledge, experience, and skills. It lends itself particularly well to cooperative learning. Educational game elements are important to have in other types of educational software as well. It is important that the educational game encourages the achievement of the educational objectives and discourages any other use that is usually associated with the specific multimedia effects of the game.

4. Dyscalculia

One of the most well-known learning difficulties in mathematics, and especially in arithmetic, is dyscalculia. Dyscalculia is defined as a heterogeneous structural disorder with large deviations in the behavior of each individual (Kaufmann, 2008). Developmental dyscalculia is a structural disorder of mathematical abilities that has its roots in a genetic or congenital disorder of certain parts of the brain, parts that constitute the direct anatomical-physiological substrate of the age-appropriate maturation of mathematical abilities-without there being a concurrent impairment of general mental functions (Miles, 1992).

According to another definition, based on recent neurobehavioral and genetic research, dyscalculia is described as a mathematical disorder that reflects a uninuclear deficit (Butterworth et al., 2011). Although various terminologies for dyscalculia are mentioned in the literature, their common component is found in the existence of a fairly severe disorder in learning arithmetic (Butterworth et al., 2011).

It can occur as a developmental disorder or be acquired as a result of damage to the right hemisphere of the brain and occurs in a rate of 5-7%. of the population (Landerl et al., 2004). The contribution of the phenomenon of acquired dyscalculia to the study of brain dysfunctions related to mathematical processes and consequently to learning difficulties in Mathematics is noteworthy (Geary, 2010).

Many researchers believe that dyscalculia in terms of numerical skills is a collection of symptoms of learning difficulties such as:

- Difficulties with spatial relationships (concepts such as up and down);
- Disturbances in motor and visual perception (grouping of objects);
- Speech problems (concepts of "and", "except" or "on");
- Problems with the concepts of direction and time;
- Memory problems (recalling arithmetic operations);
- Problems in symbolism (use of "and" instead of "on");

- Problems in problem solving (Markovitis & Tzouriadou, 1991).

However, neuroscientific research has shown in recent years that the main problem of people with dyscalculia lies in what has been characterized as "number sense" which is defined as the intuitive understanding of numbers, their sizes, the relationships between them, as and how they are affected by actions (Landerl et al., 2004). According to other researchers "number sense" is defined as our ability to quickly understand, approximate and manipulate numerical quantities (Berch, 2005; Wilson et al., 2006).

According to neuroimaging studies of the last decade, the core area where human brain processes involving numbers are performed is located in the intraparietal sulcus. The intense processing that takes place in this part of the brain is associated with the comparison of digits and rows of dots as well as with the enumeration of objects. These fundamental functions are associated with the normal development of numerical skills, while the parietal lobes are largely associated with more complex calculations (Butterworth & Laurillard, 2010; Mórocz et al., 2012; Nieder & Dehaene, 2009).

Neuroscientific research indicates that there is a deficit in the processing of numerical concepts in individuals with dyscalculia, which is found in counting dots and comparing sizes (Butterworth et al., 2011). Also, people with dyscalculia show difficulties in two basic numerical processes: enumerating small series of objects and comparing numbers and their relationship to each other. Based on these findings, neuroscientific research suggests that rehabilitation is aimed at rebuilding fundamental numerical concepts (Zamarian et al., 2009).

As many people with dyscalculia show poor numeracy skills even after elementary school, strengthening the understanding of numbers, especially the connection between mathematical data and the concepts of components, is a very important parameter in the intervention to deal with dyscalculia that make them up. Early specialized educational intervention at this stage can prove to be very effective and reduce the future consequences of dyscalculia (Butterworth et al., 2011).

Of course, it should be noted that neuroscience, although it identifies the specific brain areas whose function needs to be strengthened in people with dyscalculia, suggesting the skills that could be taught, nevertheless does not determine how to learn them (Butterworth et al., 2011). The educational interventions applied to people with dyscalculia for its rehabilitation are designed by pedagogical science on specific cognitive areas indicated by neuroscientific studies. In particular, neuroscientific studies support the view that specific cognitive processes, such as counting dots, are fundamental to understanding numbers and thus arithmetic. This has the consequence of suggesting that educational interventions should ensure that all learners develop the ability to count patterns made up of dots, with the aim of reaching the point where they can understand basic numerical concepts (Butterworth & Laurillard, 2010; Cantlon et al., 2009).

5. Educational Technology & numeracy

Traditional interventions for people with dyscalculia, which take place in classrooms by specialist teachers, include activities with colored bars, with numbers written on pieces of paper that must be arranged correctly and with cards in the form of games (Butterworth et al., 2011).

However, in recent years, a new educational approach has come to be added to the existing ones. This new approach relies more on digital technologies than on the two-way student-teacher relationship in the form of instructions and directions that is already commonly used in classrooms for children with special needs. The development of interactive adapted digital programs aimed at remedial dyscalculia is primarily based on basic numeracy goals, which have been identified based on findings from behavioral and neuroimaging research. These objectives refer to dot pattern recognition, matching collections of dots to collections of digits, dot-to-digit matching games, navigation projects on a number line with the goal of locating a specific number, matching number combinations with homologous sums as well as comparing visual sequences from objects (Butterworth & Laurillard, 2010).

Neuroimaging findings in individuals with dyscalculia have shown reduced activation in the intraparietal sulcus during numerical concept comparison (Mussolin et al., 2010; Price et al., 2007). Therefore, based on the above findings, one key skill that needs to be strengthened in people with dyscalculia is counting dots. Dots 2 track is a program designed to help the learner distinguish the relationship between understanding the numerical concept when represented by dots and when represented as a digit, and its placement within a sequence of numbers. The specific program, adapted to each student individually, develops their ability to count dots (Butterworth & Laurillard, 2010).

The program was based on neuroimaging data demonstrating reduced activation in the intraparietal sulcus during comparison of numerical concepts, which points to the need to enhance the ability to understand and compare numerical quantities (Mussolin et al., 2010; Price et al., 2007). A key skill developed by this program is for learners to match a pattern of dots to the corresponding digit and vice versa. The goal of the program is to test the abstract relationship that exists between the drawings and the name of their numbers, as well as their memorization. Through this practice, they also strengthen their abilities in memorizing numerical data (Butterworth & Laurillard, 2010).

The Adaptive Computer Assisted Instruction system (CAI) program for children with dyscalculia aims to strengthen "number sense". The “number sense” deficit according to neuroscience findings is related to dysfunction in intraparietal brain regions such as the horizontal part of the intraparietal sulcus associated with the processing of numerical quantities (Kaufmann, 2008). This software was based on the view that dyscalculia is due to a basic deficit in "number sense" or the relationship between "number sense" and their representation. The basic principle on which the exercises of the dyscalculia rehabilitation program were based is the comparison of numbers.

'Graphogame Maths' is another digital program influenced by neuroscience. This program targets the inherited system responsible for representing and manipulating sets in the intraparietal sulcus, which is disrupted in children with dyscalculia. The basis of the game is comparing numbers, focusing on comparing visual arrays of objects (Butterworth et al., 2011).

Neuroimaging studies have identified atypical activation in areas of the intraparietal sulcus in individuals with dyscalculia during comparison of number concepts (Mussolin et al., 2010; Price et al., 2007), number symbols (Mussolin et al., 2010) as well as and when performing arithmetic operations (Kucian et al., 2006). To strengthen these areas, the program "Number Bonds" is based on the processing of numerical concepts, making the connection between digits and their meanings. The program is designed to provide internal informational feedback to learners (Butterworth et al., 2011).

"Math Explorer" is multimedia educational software, didactic type for students with Learning Difficulties in mathematics. In research involving students with dyscalculia, using the software increased their ability to solve addition and subtraction math problems, as well as their motivation to learn (Amiripour et al., 2011). It contains four cognitive strategies such as (1) Read, (2) Find, (3) Plan and (4) Calculate, as well as three metacognitive ones such as "Do", "Ask", "Check" the activity. Its educational process includes: (1) Title, (2) Welcome, (3) Teaching objective, (4) Teaching simulation (learning cognitive and metacognitive strategies), (5) Guided practice (solving addition-subtraction), (6) Independent practice (solving and using the strategies) and (7) Eighteen addition and subtraction ability tests, either on the computer or in writing. The software provides three levels of increasing interactive feedback when the student is asked to “Do” the activity as well as positive feedback on each cognitive strategy (Seo & Woo, 2010).

Math Explorer presents one cognitive and metacognitive strategy at a time in two lines of twenty words maximum to help students with ND. It contains a design aid, an explanatory dictionary and attractive animations and graphics (Amiripour et al., 2011). Another popular and easy-to-use digital program based on neuroscience findings for dyscalculia remediation is "Number Race." This program aims to strengthen the system for numerology located in the intraparietal sulcus that can support early numeracy. In people with dyscalculia this system is less accurate and practice is designed to improve and strengthen it. The basic principle on which this program was based is the strengthening of the comparison between numbers and therefore the discrimination of their sizes (Wilson et al., 2006).

First, dot patterns are presented and at the next level they are combined with numbers or operations. The process followed depends on the software automatically adjusting to the degree of difficulty in each student's performance. The software adaptation follows an internal process that tests the student's knowledge in a multidimensional learning domain consisting of three different dimensions of difficulty: number span and spacing, response time, and conceptual complexity (Wilson et al., 2006).

6. Discussion

In conclusion, we stress the importance of all digital technologies in the field of education and in dyscalculia training. These technologies are highly effective and productive and facilitate and improve assessment, intervention, and educational procedures through mobile devices that bring educational activities anywhere [50-51], various ICTs applications that are the main supporters of education [31-47], [52-64], and AI, STEM, and ROBOTICS that raise educational procedures to new performance levels [65-70]. Furthermore, the development and integration of ICTs with theories and models of metacognition, mindfulness, meditation, and the development of emotional intelligence [71-83], accelerates and improves educational practices and results more than those, particularly in children with dyscalculia, treating domain and its practices like assessment and intervention.

7. Conclusions

Educational software has started to be used in education in a digital way to help students with dyslexia learn and access education more easily and effectively. Children with dyscalculia need educational software as, through them, they better understand many concepts, situations and facts. A security is created and thus their training is facilitated. These students show better results in learning when they engage in hands-on activities that appear through educational software.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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