SOFIA UNIVERSITY “ST. KLIMENT OHRIDSKI”

Faculty of Educational Sciences and the Arts

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SUMMARY

DOCTORAL DISSERTATION

“TEACHING STRATEGIES FOR CHILDREN WITH DYSLEXIA AND DYSCALCULIA”

For awarding a doctoral degree in professional field

Pedagogy (Special Education)

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Introduction

The current educational climate reveals a troubling trend where many students grapple with meeting the requirements of their academic programs, often due to underlying specific learning disorders like dyslexia. This disorder severely impacts their reading and language processing abilities, placing them at a disadvantage compared to their peers (Paraskevopoulos, 1985). Dyslexia is part of a broader spectrum of learning disabilities that includes issues like dyscalculia, both characterized by challenges that align closely with normal functional ranges, making their early detection and prevention difficult (Michalogiannis & Izenaki 2000). These disabilities result from a complex blend of cognitive, linguistic, and neurological factors, significantly affecting academic performance across subjects, including mathematics where dyslexia's impact is markedly detrimental due to difficulties in symbol recognition and code-switching.

In the educational and psychological research, dyslexia and dyscalculia are traditionally categorized separately due to their distinct impacts on language and mathematical skills, respectively. However, some researchers, such as Miles in 1992, argue that these conditions share overlapping cognitive impairments, particularly in areas of memory and basic developmental skills (Miles, 1992). This overlap suggests that interventions could be designed to address these commonalities rather than treating the disorders as completely distinct. Such a unified approach could lead to more comprehensive and effective educational strategies that cater to a broader range of learning disabilities, enhancing overall academic achievement.

The study in focus intends to merge the consideration of dyslexia and developmental dyscalculia under a single umbrella of investigation, aiming to develop strategies that address the wide array of challenges these students face, particularly in mathematics. By not differentiating further between these conditions, the research aims to create a holistic understanding and intervention method that addresses the intertwined cognitive and academic challenges. This approach is expected to significantly improve educational outcomes by fostering a learning environment where students with these learning disabilities can achieve substantial advancements in their mathematical abilities and overall academic performance.

OBJECTIVES OF THE RESEARCH

This research aims to address these complex educational challenges by:

1. Assessing learning difficulties in mathematics.
2. Designing a comprehensive pedagogical and therapeutic intervention to improve mathematical learning among primary school children.
3. Investigating the effectiveness of targeted teaching strategies that integrate memory development and numerical skills enhancement.

The significance of this research lies in its potential to refine diagnostic and intervention methodologies within the educational framework, thereby enhancing the academic trajectory of students with learning difficulties. By focusing on the specific area of mathematics and dyslexia, this study seeks to provide a systematic approach to identifying and addressing learning disabilities, which could serve as a model for similar challenges in other academic subjects.

RESEARCH HYPOTHESES

The research hypotheses, based on the objectives of the study, are as follows:

Hypothesis 1: Assessment of Numerical Performance: The use of numerical educational assessment tools in elementary schools significantly improves the numerical performance of students compared to traditional assessment methods. This hypothesis can be evaluated by comparing the results of numerical performance assessments before and after the implementation of the specially designed tools.

Hypothesis 2: Memory Instructional Intervention for Dyslexia and Arithmetic: Implementing a specific instructional intervention program designed to cultivate memory abilities that aid dyslexia and enhance basic arithmetic skills in elementary students with learning disabilities results in improved memory related to dyslexia and better arithmetic performance compared to traditional educational programs. This hypothesis can be tested by collecting and analyzing performance data before and after the program's implementation.

RESEARCH QUESTIONS

1. They differentiate the criteria for the arithmetic we constructed them student performance, to the extent that it can be detected those students whose performance is significantly below their average their peers?
2. They show - and to what extent - developmental deficits in level cognitive-psycho-linguistic development, the students who were found to are they lagging behind in their numerical performance?
3. They present - and to what extent - insufficient development at a level memory ability, the students who have a low performance in arithmetic?
4. Is the memory capacity of the students improved - and to what extent?" after the implementation of the didactic-therapeutic intervention program where did we build?
5. Students' performance in arithmetic improves after implementation of the intervention program we constructed?
6. The speed of filling in increases - and to a greater extent - of repeated evaluation criteria of numerical performance, after the monitoring the intervention program?
7. The numerical performance of students improves after its implementation intervention program and in which individual areas of the basic numerical skills is this improvement more important?
8. The general learning ability improves - and to a greater extent -students' readiness in mathematics, after attending the intervention program?

PART A: THEORETICAL BACKROUND

Chapter 1: INTRODUCTION TO DYSLEXIA

1.1 Important definitions of dyslexia

Dyslexia is a complex and multifaceted challenge that has evolved from being primarily considered a medical issue to a broader learning and cognitive concern. Various definitions of dyslexia have emerged over time, leading to disagreements among scholars and hindering the development of a universally accepted definition and effective intervention strategies (Porpodas, 1997).

Medical perspectives have explored causes such as minimal brain dysfunction, delayed central nervous system maturation, and hereditary predisposition (Avlidou & Doikou, 2002). Educators and psychologists emphasize the gap between a child's potential and their school performance, while experimental psychology researchers focus on reading difficulties within a psycholinguistic framework (Snowling, 1987).

Different definitions of dyslexia exist, with organizations like the British Dyslexia Society and the American Dyslexia Society describing it as a complex neurological condition affecting various aspects of learning, including reading, spelling, and writing (Stasinos, 1999).

Neurological studies using advanced imaging methods have identified brain areas involved in dyslexia, including the posterior temporal lobe, midbrain, and thalamus. Memory deficits, including phonological memory and working memory, are common in individuals with dyslexia, affecting reading and language processing (Anastasiou, 2011). Psychosocial challenges, such as frustration, low self-esteem, and social isolation, are prevalent among individuals with dyslexia, emphasizing the importance of addressing emotional well-being alongside educational needs (Polychroni, Hatzichristou, Bibou, 2006). Visual perception and processing difficulties, along with eye movement problems during reading, are also associated with dyslexia.

1.2 Levels of language functioning and dyslexia

Dyslexia is a complex learning disorder that affects various aspects of language and cognitive processing. It is often described as having four primary levels of impairment: phonological, morphological-syntactic, semantic, and reading comprehension.

Phonological Level: At this level, dyslexia manifests as a significant deficit in the child's ability to integrate their phonological system. This leads to difficulties in encoding phonological patterns, articulating sounds, and comprehending syllable and phoneme structures within words. Phonemes, which are essential units in phonetics, become challenging for dyslexic individuals to distinguish, resulting in difficulties in acquiring reading skills (Babiniotis, 1980).

Morphological-Syntactic Level: Dyslexia also affects the morphological and syntactic aspects of language. Dyslexic individuals struggle to connect the form of inflected words with their meanings in spoken language. Similarly, they find it difficult to link the written form of a word with its corresponding meaning, making it challenging to master spelling and apply syntactic rules accurately. Complex sentence construction and the understanding of deep and surface structures become problematic (Vogel A., 1977).

Semantic Level: Dyslexia affects the ability to connect the auditory and visual representations of words or sentences with their meanings, particularly when dealing with abstract concepts. This results in difficulties in understanding and using vocabulary effectively, especially in the context of more abstract or general content (Wiing, & Semel, 1975).

Reading Comprehension: Dyslexia profoundly impacts reading and text comprehension. Dyslexic individuals exhibit laborious, syllabic reading with a lack of attention to punctuation. Their reading is characterized by errors such as phonological perception difficulties, letter confusion, incorrect pronunciation, word deletions, additions, substitutions, and difficulties in understanding text. Eye movement problems and irregular breathing patterns further contribute to reading challenges (Kourakis, 1997).
Writing: Dyslexic individuals encounter writing and spelling difficulties, leading to illegible and slow writing. Common problems include imperfect word alignment, phonological decoding challenges, difficulties in visual word recognition, and frequent spelling mistakes, including letter substitutions, deletions, additions, and transpositions. Dyslexic individuals may also exhibit confusion between similar letters and difficulties in writing polysyllabic words (Pierangelo & Giuliani , 2006).
Speech: In oral language, dyslexic individuals may experience issues such as pauses between words, limited vocabulary for their age, articulation difficulties, monotonous tone, and the use of specific words and expressions.
Mathematics: Dyslexia extends to mathematical difficulties, including challenges in measurement, approximation, comparison of numbers, recalling simple numerical facts, mental arithmetic, understanding mathematical concepts, and processing geometric shapes and graphic representations.
Daily Activities: Beyond academic challenges, dyslexic individuals may face difficulties in daily life, including emotional instability, social adaptability issues, low self-esteem, and a tendency to withdraw from social interactions. They may exhibit aggression, procrastination, and negative behaviours when faced with emotionally challenging situations (Stampoltzis & Polychronopoulou, 2009).

1.2 Types of Dyslexia

Dyslexia, a condition affecting the processing of written language, can be categorized into two major types: acquired dyslexia and specific (or developmental) dyslexia.

- **Acquired Dyslexia:**

Acquired dyslexia refers to the difficulty or inability of an individual to process written words due to brain injury, particularly in the left lateral temporal region. Geschwind distinguished three types of acquired dyslexia (Geschwind & Kaplan, 1962):

a) The first is characterized by a severe inability to understand spoken and written language and a difficulty in producing spelled writing.
b) The second, and less common type, is characterized by a clear inability to read and write.
c) The third type is characterized by an inability to read but not so much to write. Of these three types, the last one is the one that resembles, in some way, specific dyslexia (Porpodas, 1993).

Different types of acquired dyslexia include deep **dyslexia** (involving visual errors, derivational errors, semantic errors, and difficulty with abstract words), **surface dyslexia** (affecting smooth spelling but reading fake words well), **phonological dyslexia** (difficulty with unfamiliar words and an inability to read fake words), **direct dyslexia** (able to read but not understand the meaning of words), **and wordform or letter-by-letter dyslexia** (reading word by word rather than as a whole).

- **Specific (Developmental) Dyslexia:**

Specific or developmental dyslexia is characterized by difficulties in learning written language (reading and spelling) despite normal mental abilities, sensory function, mental health, and a supportive environment. There are two main types of specific dyslexia:

a) **Visual Dyslexia:** This is the most common form, and it is believed to be associated with deficits in visual perception, discrimination, and memory. Individuals with visual dyslexia struggle to distinguish complex patterns, have difficulty reading words as a whole, and often process words letter by letter (Porpodas, 1993).
b) **Auditory Dyslexia**: This type is characterized by difficulties in representing separate sounds of spoken language, blending sounds, and naming objects. Auditory dyslexics may struggle to write dictated texts correctly due to difficulty hearing and distinguishing sounds.

CHAPTER 2:

I. DESIGN SPECIFICATIONS OF EDUCATION FOR STUDENTS WITH DYSLEXIA

2.1 Teaching methods

Effective educational interventions for students with dyslexia should be grounded in a solid understanding of the underlying causes of their learning disability. These interventions should also be informed by theories of typical language development in children (Snowling & Hulme, 2011). Several historical approaches to supporting and educating students with dyslexia have laid the foundation for contemporary teaching methods:

a) **Hinshelwood's Approach (1917):** Hinshelwood's work can be considered the precursor to "multi-sensory teaching." Unlike contemporary understanding, Hinshelwood initially believed that different sensory channels supported each other and did not assume a visual brain center deficit.
b) **Orton's Approach (1937):** Orton introduced the concept of a multi-sensory, synthetic, alphabetic approach. This method involves combining visual, auditory, and kinaesthetic linguistic stimuli and breaking down language into smaller units before forming more complex wholes.
c) **Fernald's Approach (1943):** Fernald emphasized the importance of creating a positive and supportive learning environment for children with dyslexia. Her approach aimed to redefine the classroom climate to help children distance themselves from negative experiences.
d) **Norrie's Approach (1959):** Norrie's method involved synthetic vocal exercises with colour cues to aid students in recalling specific spoken sounds from memory.
e) **Bannatyne's Method (1966):** Bannatyne's method focused on arranging sounds within words, which proved effective for many children with reading difficulties. It prioritized teaching letter-sound associations to enable correct decoding and spelling.

These historical approaches paved the way for modern teaching strategies. Research suggests that catering to students' preferred learning styles can enhance their performance, goal achievement, and attitudes toward schoolwork (Exley, 2003; Stampoltzis et al., 2010).

One particularly effective method for teaching students with dyslexia is the multi-sensory teaching method. This approach engages visual, auditory, and kinaesthetic learning pathways simultaneously in various tasks during lessons. It recognizes that students often learn through a combination of sensory channels, rather than relying solely on one type of learning. Multisensory teaching has the potential to integrate all students into the learning process, enhancing motivation and memory consolidation.

2.2 Multisensory teaching method Multi-sensory teaching, which engages visual, auditory, and kinesthetic pathways, is proven particularly effective for students with dyslexia and in language learning, as it involves simultaneous activation of multiple sensory channels (Coffield, et al., 2004). This method not only counters older theories that advocated for distinct learning types but also capitalizes on the brain's plasticity to enhance memory consolidation and synaptic connections. Multi-sensory approaches align with Gardner's theory of multiple intelligences (Gardner, 1993), promoting individualized learning experiences that boost motivation and engagement by catering to diverse learning profiles. This teaching style, which is student-centered, allows learners to control their learning process, making education more accessible and effective, especially for those with learning difficulties, thereby improving their phonological, spelling, and syntactic skills.

2.3 ICT in the treatment of dyslexia

In the broader context of addressing dyslexia, modern Information and Communication Technology (ICT) applications play a significant role, acknowledged for their immense educational potential. They are reshaping the educational landscape and proving to be highly effective, particularly in primary education. Computers, as powerful learning tools, offer a wide array of applications that contribute to a deeper understanding of subjects.

ICT, especially when combined with suitable software, holds great promise for students with dyslexia. These individuals often exhibit an affinity for modern electronic technology, making computers and their applications essential tools for skill development and knowledge acquisition.

Here are some specific applications and programs that have been found effective in addressing dyslexia:

a) **Text Editor**: Text editing software provides a valuable tool for dyslexic students to practice and complete language tasks. It alleviates the stress of handwriting by enabling students to produce well-written work with automatic spelling error detection, relieving them from the pressure of strict grammar rules.
b) **File Creation:** Creating and organizing files can help develop classification skills, contributing to the development of perceptual abilities and systematic arrangement of relationships between objects and events, as suggested by psychologists like Vygotsky and Bruner.
c) **Accounting Sheets:** Working with accounting sheets aids dyslexic students in understanding mathematical concepts and problem-solving activities. Special programs that simulate financial transactions and allow students to draw geometric shapes can enhance spatial orientation and quantitative reasoning.
d) **Special Hardware and Software:** Dedicated hardware and software designed for dyslexic individuals, such as electronic pocket dictionaries and organizers, are available to provide support.
e) **Assistive Technology:** Various assistive technologies, such as portable scanners that audibly pronounce scanned words and speech recognition software, assist dyslexic individuals in reading and writing tasks
f) **Programming Languages**: Programming languages like Java and HTML5 allow the creation of customized digital materials tailored to the needs and abilities of dyslexic students. These materials can include educational games aimed at enhancing perceptual abilities like memory, observation, and shape/colour recognition (Diamandopoulos, 2014).

2.4 Intervention and treatment of dyslexia

Teaching interventions to address learning difficulties involve the use of carefully selected materials tailored to each student's abilities. Numerous systematic intervention programs have been developed, primarily in Western countries, leading to extensive research on program effectiveness and the identification of key characteristics that contribute to their success (Brooks, 2005; Torgesen, 2009; Wanzek & Vaughn, 2007). Here are key features of effective interventions for learning disabilities distilled from relevant studies:

a) **Multisensory Methods:** Effective interventions often incorporate multisensory techniques (Singleton, 2009), engaging multiple senses to enhance learning.
b) **Phonological Awareness**: Emphasis is placed on teaching phonological awareness as part of a comprehensive program (Brooks, 2005), as it is a crucial foundation for reading.
c) **Structured Programs**: Structured programs with clearly defined teaching units are designed for consistent, sequential instruction (Gersten et al., 2009; Rose, 2009), ensuring fidelity to the program.

d) **Intensive and Frequent Sessions**: Intensive and regular intervention sessions, following the principle of "little and often," are recommended, especially for students with severe difficulties (Torgesen et al., 2001).
e) **Small Group Interventions:** Small group interventions can be as effective as individualized ones (Torgesen et al., 1999).
f) **Clear and Sequential Teaching**: Interventions involve clear, step-by-step instruction that allows students to experience small successes and receive frequent feedback (NRP, 2000).
g) **Early Intervention**: Early intervention is crucial to address learning difficulties effectively (Wanzek & Vaughn, 2007).
h) **Matching Skill and Task Difficulty:** Interventions should align with the skill level of the student, gradually increasing in complexity as skills improve (Burns, VanDer Heyden & Boice, 2008).
i) **Psychosocial Support:** Effective interventions address both learning and psychosocial aspects, including self-esteem, social skills, and motivation (Vaughn, Sinagub & Kim, 2004).
j) **Progress Monitoring**: Regular monitoring of student progress is essential to assess the effectiveness of the intervention.

It's worth noting that not all students respond equally to intervention programs. Approximately 3% of students may not respond to high-quality interventions due to various factors, including the severity of difficulties, risk factors, educational history, cognitive deficits, and behavioral issues (Torgesen, 2009).

The traditional approach to addressing learning difficulties involves individualized educational programs tailored to each student's specific needs. These programs are designed following a comprehensive diagnostic assessment, considering the student's cognitive, learning, and psychosocial potential, and are implemented in both school and home settings. The goals, methods, materials, and evaluation processes of these individualized programs are clearly outlined and regularly reviewed to track progress.

a) **Reading Comprehension and Dyslexia:** Effective programs addressing comprehension difficulties focus on mastering basic reading skills, strengthening vocabulary, and enhancing higher-level cognitive and metacognitive skills. Vocabulary development is critical, involving various strategies like repetition, exposure to words in context, and multimedia (McCormick, 2003). Teaching the meaning, usage, and relationships of words is emphasized.
b) **Vocabulary Development and Comprehension Strategies:** Effective comprehension interventions encompass metacognitive strategies, such as self-questioning and self-regulation. Cognitive strategies like summarization, question generation, and text structure analysis are essential for improving comprehension (Trabasso & Bouchard, 2002).
c) **Writing and Spelling:** Interventions for writing address pre-writing, writing, and post-writing stages. Pre-writing involves idea generation and planning, while writing emphasizes structuring texts and enriching vocabulary. Post-writing includes revising and self-evaluation.
d) **Spelling:** Spelling interventions focus on mnemonic techniques, multisensory learning, and technology use to enhance memory and word recognition. They also emphasize personalized, intensive training with frequent practice and review (Wanzek, Vaughn, Wexler, Swanson, Edmonds & Kim, 2006).
e) **Comprehension of Written Language:** Students with learning difficulties, including dyslexia, often struggle with text comprehension. Effective interventions aim to improve their overall understanding of texts by developing skills such as main idea

identification, attention, and metacognitive strategies (Panteliadou & Botsas, 2007; Panteliadou & Patsiodimou, 2007).

In conclusion, interventions for learning difficulties are multifaceted and tailored to individual needs, encompassing a range of strategies and approaches to address specific challenges in reading, comprehension, writing, and spelling. These interventions are characterized by their structured nature, early initiation, and consistent progress monitoring.

2.5 Strategies for improving non-language difficulties

To address non-linguistic parameters associated with dyslexia, various strategies are essential to improve memory, sequencing, visual perception, discrimination, and spatial orientation. These strategies can significantly support students with dyslexia in their learning journey. Here are some key strategies for each of these areas:

Memory Improvement Strategies

a) Group Information: Encourage students to group information into meaningful units or categories. This helps in organizing and recalling information effectively.
b) Rhymes and Songs: Utilize rhymes or songs to link information together. This can make memorization more engaging and memorable.
c) Outlines and Summaries: Teach students how to create outlines and write summaries to condense and retain essential information.
d) Memory Games: Engage students in memory games that involve categorizing objects or concepts into related categories. This strengthens memory skills.

Sequencing Enhancement Strategies

a) Reasoning Practice: Encourage students to express their reasoning about what has occurred before and what will happen next based on images or sentences. This can improve their sequencing abilities.
b) Visual Timelines: Use visual timelines or sequences to help students visualize and understand the order of events or processes.

Visual Perception and Discrimination Strategies

a) Find Similarities and Differences: Incorporate activities that require students to identify similarities and differences between objects, shapes, or patterns.
b) Puzzles: Provide puzzles that challenge students' visual perception and spatial reasoning.
c) Shadow Matching: Engage students in shadow matching activities where they match objects to their corresponding shadows.
d) Descriptive Games: Have students describe objects to their peers, who must guess the object based on the description. This enhances visual discrimination skills.

Spatial Orientation Improvement Strategies

a) Drawing Exercises: Conduct exercises such as drawing letters or shapes on the classroom floor to improve spatial awareness.
b) Symmetry Activities: Engage students in symmetry exercises to enhance their understanding of spatial relationships.
c) Mazes: Include maze-solving activities that require students to navigate through spatial challenges.
d) Clock Reading: Teach students to read and interpret clocks, which can help them with time orientation.
e) Dictation and Spatial Awareness Exercises: Incorporate dictation exercises that focus on spatial elements and teach students to navigate and describe spaces (Kasseris, 2002, Mati-Zisi, 2004, Stathis, 1994).

2.5.1 The Role of the Teacher

Teachers play a crucial role in supporting students with dyslexia in the classroom. They can:

a) **Foster a Supportive Environment:** Be empathetic, show understanding, and create a supportive classroom environment where students feel valued.
b) **Minimize Distractions**: Help students with dyslexia stay focused by minimizing distractions, such as seating arrangements away from windows.
c) **Allow Extra Time**: Recognize that dyslexic students may need additional time for tasks and assignments.
d) **Provide Encouragement**: Offer positive encouragement on both personal and class levels to boost students' confidence.
e) **Assign Appropriate Tasks**: Assign tasks that match students' abilities to build their self-esteem.
f) **Utilize Multisensory Approaches**: Employ multisensory teaching methods, including visual aids, to cater to different learning styles.
g) **Clear and Accurate Notes**: Provide well-structured and accurate notes summarizing the main points of the lesson.
h) **Supportive Feedback**: Give constructive and non-critical feedback during oral examinations, and ensure classmates treat dyslexic students with respect.
i) **Regular Progress Updates**: Keep parents informed about students' progress (Bourcier, 2015).

2.4.2 Surveys on Teachers' Knowledge and Perceptions

Several surveys have explored teachers' knowledge and perceptions regarding dyslexia. Research indicates that while some teachers feel confident in managing dyslexic students, many express insecurities due to a lack of training. There is a growing consensus that teachers need specialized training to effectively support students with dyslexia in the classroom.

In conclusion, strategies to address non-linguistic parameters related to dyslexia are essential for supporting students in memory, sequencing, visual perception, discrimination, and spatial orientation. Teachers play a vital role in creating an inclusive and supportive learning environment, but there is a need for comprehensive training to equip educators with the necessary knowledge and skills to effectively assist dyslexic students (Thompson, 2013)

II. CHILDREN'S TEACHING STRATEGIES WITH DYSCALCULIA

2.1 Dyscalculia Overview – Definitions

Dyscalculia is a specific learning difficulty in mathematics, with two main types: developmental dyscalculia and acquired dyscalculia. Developmental dyscalculia emerges during a child's development, while acquired dyscalculia occurs due to brain damage or disease. Research indicates that dyscalculia affects approximately 3.5% to 6.5% of students, irrespective of gender, intelligence, or environmental factors. It falls under the category of Specific Learning Disabilities, which encompass language, reading, writing, logical thinking, and mathematical skill difficulties, often attributed to central nervous system dysfunction.

The term "dyscalculia" was introduced by R. Cohn in 1961, marking the start of systematic research in this area. Earlier references to children with mathematical difficulties existed, but Cohn's work initiated comprehensive study. Dyscalculia has been defined as a structural disorder of mathematical abilities, a condition marked by difficulties in using or learning

mathematics, and a condition that adversely affects numeracy skills acquisition. The debate continues regarding whether dyscalculia is a distinct and autonomous learning difficulty, with some arguing for its independence and others suggesting potential connections to language disorders.
Research by Rourke and Jordan, among others, supports the existence of dyscalculia as a unique condition separate from reading and writing disorders.

2.2 Characteristics of Dyscalculia

Based on research conducted by Johnson & Myklebust in 1967 and subsequent studies, individuals with dyscalculia exhibit several general characteristics, both related to mathematical knowledge and more general cognitive traits:

General Characteristics

- Defective visual-spatial perception and organization.
- Good listening skills and early speech.
- High reading level in terms of decoding written symbols, with limited comprehension of text.
- Disturbed body image.
- Difficulties in visual-motor coordination, which can lead to dysgraphia.
- Lack of social empathy, i.e., difficulty in assessing social situations and perceiving others' emotions.
- Higher performance on verbal aspects of tests compared to non-verbal components.

Mathematical Skill-Related Characteristics

- Difficulty in forming one-to-one correspondences.
- Challenges in connecting number symbols with their corresponding quantities.
- Difficulty in linking auditory and visual symbols of numbers.
- Struggles in understanding the order and absolute magnitude of numbers.
- Difficulty comprehending part-whole relationships.
- Trouble grasping the concept of conservation of quantity.
- Challenges in executing mathematical operations.
- Difficulty understanding and distinguishing symbols for mathematical operations.
- Trouble comprehending the meaning of specific positions and sequences of numerical digits (place value).
- Issues with retaining and applying algorithms.
- Difficulty in measuring sizes, quantities, and volumes.
- Challenges in reading maps and graphs.
- Problems in developing appropriate problem-solving strategies.

Additionally, research by R. Newman in 1997 (see Newman, 2021) highlighted further characteristics, including:

- Normal or above-average language development, with good verbal memory for written words.
- Weaknesses in memory for faces and confusion in recalling names.
- Particular difficulties with financial planning and handling money.
- Potential difficulties in understanding musical concepts and reading musical notation.

- Challenges in muscle coordination, impacting performance in activities such as sports and dance.
- Difficulties in monitoring and recording variations in results during sports activities and games.

Furthermore, Sears (1986) listed 22 features of dyscalculia, including:

- Inverted, malformed, rotated, or extra-large written symbols.
- Difficulty transitioning between mathematical processes or thoughts.
- Confusion and substitution of visually similar numbers.
- Difficulty arranging numbers in arithmetic operations.
- Inability to perceive distances between numbers correctly.
- Challenges in arranging numbers or objects in a row.
- Difficulty ordering numbers based on relative sizes.
- Failure to read or write the correct value of multi-digit numbers.
- Difficulty applying multiple successive steps in mathematical procedures.
- Inadequate memory for simple mathematical operations.
- Difficulty perceiving objects in groups or sets.
- Difficulty in reading maps and line grids.
- Confusion in mathematical processes.
- Issues with one-to-one matching.
- Failure to recognize and understand symbols of mathematical operations.
- Difficulty in associating auditory and visual symbols or visual and verbal names.
- Difficulty copying numbers, geometric shapes, etc., from models.
- Difficulty reproducing numbers, geometric shapes, etc., from memory.
- Difficulty understanding direction, weight, distance, time, or measurement.
- Difficulty transitioning from the concrete to semi-abstract and abstract levels.
- Difficulty understanding and responding verbally or in writing to problems.
- Inability to choose the appropriate course of action to solve a problem.

2.3 Diagnosis of Dyscalculia

Diagnosing dyscalculia is a complex process, as it presents with various characteristics in different individuals due to numerous subcategories. Therefore, creating a universal diagnostic test for all forms and types of dyscalculia is challenging. It is crucial to have a detailed and clear diagnosis for each child to tailor interventions to their specific needs. Teachers play a vital role in detecting and diagnosing dyscalculia since they interact with students daily and are familiar with their difficulties.

Some signs of dyscalculia that teachers can observe, as suggested by Michaelson (2007), include:

- Underdeveloped problem-solving strategies for their age.
- Numerical and computational errors due to poor working memory.
- Difficulty recalling basic numerical facts from long-term memory.
- Slow processing of basic math skills.

- Inability to recognize the commutative property of addition and multiplication.
- Frequent errors, especially those that appear careless.
- Problems with visual and spatial functions.

While these signs can raise suspicion, they may not exclusively diagnose dyscalculia, as students facing math difficulties can exhibit similar behaviours. Emerson and Batbie (2014), experienced special educators, provide guidance on recognizing dyscalculic students' deficiencies, weaknesses, and individual characteristics. They emphasize the importance of understanding each child's unique needs to provide targeted support. Teachers can assess numeracy through standardized assessments tailored to students' age-specific math skills (Gross-Tzur & Shalev, 2001). *Dyscalculia can be diagnosed based on two scenarios:*

a) **Discrepancy between intellectual ability and math performance**: If a student's math performance is significantly below what is expected for their intellectual level.
b) **Significant difference in numerical abilities compared to age peers**: Typically, a two-year gap or more in numerical skills.

However, these general criteria may not offer a precise diagnosis, as other learning difficulties could influence math performance. Therefore, performance on weighted tests assessing numerical skills provides a more reliable diagnosis (Griva, 2012).

Several weighted tests have been used in recent research to assess numerical skills, including:

a) **Stanford-Binet Intelligence Scale IV (SB-IV) - Quantitative Reasoning subtest**: Measures mathematical reasoning, application of basic procedures, and understanding of mathematical concepts and symbols.
b) **Woodcock-Johnson Test of Academic Achievement – Revised (WJ-R) - Calculation subtest, Applied Problems, and Mathematics Reasoning subtest:** Assesses mathematical skills, accuracy, speed, and comprehension of mathematical concepts.
c) **Arithmetic Battery**: Tests number comprehension, production, and calculations.
d) **Wechsler Individual Achievement Test - Mathematics Reasoning subtest**: Evaluates basic numerical skills and higher-level abilities, such as interpreting graphs and telling time.

In Greece, the Centres for Differential Diagnosis, Diagnosis, and Support (KE.D.DY.Y.) under the Ministry of Education are responsible for diagnosing learning difficulties. Diagnosis involves a comprehensive assessment, including the Wechsler Intelligence Scale for Children (WISC-III), which examines mental indicators and school performance. A significant discrepancy between mental indicators and low math performance, along with empirical observations, leads to a diagnosis of dyscalculia.

However, Greece lacks a specialized weighted test for dyscalculia diagnosis, making it challenging to gather statistics or percentages for dyscalculia cases. This complicates the distinction between dyscalculic students and those with math difficulties, including dyslexic students.

CHAPTER 3: TEACHING STRATEGIES

3.1. General ways of dealing with learning difficulties in mathematics

Dealing effectively with learning difficulties in mathematics requires adherence to certain key principles, as compiled by Agaliotis (2000):

- **Reliable Educational Assessment**: Begin with a thorough educational assessment to understand the child's specific needs accurately. Teaching objectives should be based on assessment data to target the child's areas of difficulty. Failure to do so may lead to inappropriate strategies that reinforce errors.
- **Active Participation**: Encourage the active participation of the child in the program. Cooperation and interest in learning are critical to success. Positive reinforcement and setting achievable yet challenging goals can motivate active engagement.
- **Respect for Sequence**: Ensure that mathematical concepts and skills progress through practical, figurative, and symbolic levels. While progression through these stages may not always be lengthy, it is crucial for understanding.
- **Teaching Images, Rules, and Properties**: Pay special attention to teaching general principles, as children with learning difficulties in mathematics often struggle with memory. Emphasize principles that have broad applications.
- **Continuous Monitoring and Feedback:** Regularly monitor the child's progress and provide immediate feedback. Close monitoring and corrective feedback contribute significantly to improvement.
- **Adaptation to Learning Style**: Recognize the diversity in learning characteristics among students with learning difficulties. Adapt teaching methods and activities to cater to individual learning styles.

- **Automation of Procedures**: Encourage the automation of mathematical procedures and data usage. Automation allows students to focus on higher-order problems, enhances accuracy, and boosts self-confidence.
- **Familiarity with Mathematical Language**: Ensure students become proficient in the language of mathematics. Mastery of mathematical vocabulary should be a distinct teaching goal, emphasizing conceptual understanding.
- **Teaching Learning Strategies**: Address weaknesses in study and learning strategies. Teach strategies to enhance mnemonic abilities, organized learning approaches, and problem-solving skills.
- **Teaching Problem Solvin**g: Treat problem solving as an independent learning goal, as it involves complex thinking processes. This is particularly important for children with learning difficulties.
- **Generalization of Learning**: Support the application of acquired knowledge in various contexts beyond initial learning.
- **Promote Positive Attitude**: Foster a positive attitude towards mathematics, as attitudes and beliefs significantly impact learning outcomes. Boost self-esteem and self-image through involvement in goal-setting, avoiding repeated failures, and highlighting the teacher's faith in the student's abilities.

These principles serve as a comprehensive framework for addressing learning difficulties in mathematics and ensuring that interventions are effective and tailored to individual needs.

3.2 The role of the teacher

The role of the teacher in addressing learning disabilities in mathematics, including dyscalculia, is paramount, as it primarily falls within the realm of education and pedagogy (Agaliotis, 2000). The teacher plays a crucial role in identifying students who may be struggling with mathematics and ensuring they receive appropriate support. Some key behaviors and responsibilities of the teacher include:

- **Observation of Student Behaviors:** Teachers should be vigilant in observing certain behaviors that may indicate learning difficulties in mathematics. These behaviors include avoiding reading and writing, misreading written information, struggling with abstract concepts, difficulty with mathematical symbols, and problems with concentration, among others (Argyris, 2010).
- **Educational Evaluation:** A critical aspect of the teacher's role is conducting educational assessments, which should include a qualitative analysis of a child's

mistakes. These assessments help in identifying specific areas of difficulty and shaping the support program accordingly.

- **Respecting the Hierarchical Nature of Mathematics**: Teachers should recognize the hierarchical structure of mathematical concepts and respect the special elements within mathematics. This understanding aids in designing effective teaching strategies.
- **Adaptation to Individual Learning Styles:** Each student has a unique learning style, and teachers should be ready and willing to adapt their teaching methods to suit these individual styles. Flexibility in teaching approaches is essential.
- **Prioritizing Understanding:** Teachers should prioritize helping students understand and master mathematical knowledge rather than rote memorization. Comprehension should precede automation of procedures.
- **Supporting Positive Attitudes**: Fostering a positive attitude towards mathematics is crucial. Teachers can boost self-esteem and self-image by involving students in setting program objectives, avoiding repeated failures, and demonstrating belief in the students' abilities.

Incorporating students with dyscalculia into the classroom requires a teacher to be well-prepared and informed. Michaelson (2007) suggests various strategies for effectively integrating these students, including improving reading skills, enhancing math problem-solving skills, and employing general instructional design strategies. These strategies encompass techniques such as using coloured overlays to reduce glare, breaking down multi-stage problems into manageable steps, providing visual aids, and offering supplementary notes. Furthermore, continuous teacher training is essential, ensuring that educators are equipped with the necessary knowledge, attitudes, and behaviours to address the specific challenges they encounter in their teaching roles. Pedagogical training should enable teachers to make informed decisions in the classroom (Agaliotis, 2000). Lastly, play is a vital part of a child's learning and development. It can be leveraged to help children, including those with dyscalculia, improve their mathematical skills. Games that focus on number sense, counting, calculations, place value, and multiplication can be particularly effective (Emerson and Babtie, 2010).

3.3 Ways to deal with Dyscalculia through play

Play is a fundamental aspect of a child's daily life, serving as a powerful medium for expression, learning, experimentation, and self-discovery (Emerson & Babtie, 2010). It is through play that children explore their emotions, develop essential skills, and gradually gain insights into themselves and the world around them. Beginning from birth, play is the natural mode of learning and development for children. Consequently, well-designed games can be a valuable tool, particularly for enhancing various mathematical skills in children with dyscalculia. Here are some key areas of mathematical development that can be addressed through play:

Number Sense and Counting

Games in this category aim to introduce number sense, the structure of the counting system, and the concept that numbers can be used to compare quantities. Children learn to:

a) Recite numbers in order.
b) Understand one-to-one correspondence, where numbers synchronize with objects counted.
c) Recognize that the last number in a counting sequence represents the quantity of objects.
d) Comprehend ordinal numbers to indicate position (e.g., first, second, third).
e) Develop estimating skills, crucial for making reasonable calculations.
f) Games often involve verbal counting, which encourages accurate and fluent counting. Reading and writing numbers are also integrated into these activities.

Calculations

For children to perform addition, subtraction, multiplication, and division, they should possess strong counting skills. To facilitate these operations, they should be familiar with essential numerical facts such as doubles of numbers, pairs that make up 10 (e.g., $2 + 8 = 10$), and powers of 10. Further numerical understanding can be acquired through reasoning and spatial models of dot patterns, which help develop pattern recognition and comprehension of relative sizes for numbers 1 to 9. These models illustrate that various quantities are composed of smaller components, enhancing the structural understanding of numbers.

Place Value and Institutional Value

Children should be capable of recognizing and generating numbers beyond 10. They must understand that numbers are organized in hundreds, tens, and ones, and grasp the relationships between these values. Understanding that smaller units can be exchanged for larger ones (e.g., exchanging 10 units for one ten) is vital for comprehending the "institutional value" system. While concrete items like money can aid in this understanding, grasping the abstract concept is essential.

Multiplication and Division

Proficiency in basic number facts is beneficial, particularly for multiplication and division. Children should have a solid grasp of multiplication tables, particularly those related to 10 and

5, from which they can derive other tables. Developing a sense of multiplication and division is crucial. Children should understand how these operations relate to each other and their concrete representations.

3.3 Computer treatment of Dyscalculia

In today's digital age, computers have become an integral part of our daily lives, influencing education and learning significantly. Education needs to adapt to these technological advancements to benefit both teachers and students. Children's natural affinity for computers should be harnessed to engage them in the learning process. While computers have made their way into education, there's a lack of specialized software for addressing dyscalculia. Many existing resources are costly and language-dependent, limiting accessibility.

Fortunately, some free and accessible online resources like http://www.number-sense.co.uk/ and http://www.coolmath4kids.com/0-cool-math-games.html offer engaging math games for children. One noteworthy software program, Number Race, developed by Anna Wilson, is available for installation on personal computers and shows promise in addressing dyscalculia. Technology, particularly computers, can play a vital role in addressing learning challenges in today's world.

Active student participation is crucial in teaching, especially for students with dyscalculia. Teachers should adapt their methods to accommodate individual learning styles. Dyscalculic children often benefit from verbal explanations of mathematical concepts and the use of manipulative materials like real objects and counters. Transitioning from concrete to written symbols and applying math concepts to real-world situations helps students understand the utility of mathematical processes (Wilson, 2000).

PART B: RESEARCH APPROACH

CHAPTER 4. RESEARCH METHODOLOGIE

This experimental research has two primary objectives: the development of assessment criteria to identify students with specific learning difficulties and the planning and implementation of a didactic-therapeutic intervention in primary schools to enhance and exercise of memory and observability with mathematical exercises through playful activities in these students. All research stages took place within the school environment.

The games are team-based, and the rules for the board games are described on the packaging of the games. Each group of children should choose a different board game each time, so all children get to play with all the games. Games that are not board games and require physical activity can be played in the school hallways, outside the classroom. The courtyard is usually not suitable for such activities as the many simultaneous uses easily distract the children's attention. Game Sessions were scheduled daily for the Second teaching hour of the program.

The research plan operated under the assumption that students with math learning difficulties might have underlying deficits in cognitive development, particularly related to memory capacity. Therefore, the program was designed to introduce new intervention teaching techniques within the school context.

The 3rd grade of primary school was chosen for this study due to its critical role in mathematical development. Students for the experimental and control groups were selected based on a diagnostic approach using a numeracy performance test aligned with the curriculum. Students demonstrating significantly lower performance than their peers were chosen for the research.

Approval from the Ministry of Education was secured for conducting the research in public schools in the Thessaly Region, Greece. The selection of this region allowed for a Greek sample comparison between students with math difficulties and the control group. Schools in the region were chosen based on criteria like proximity, absence of competing interventions, and availability of suitable classroom space.

Parental consent was obtained as the program occurred outside regular school hours. Parents were provided with detailed information about the program's purpose, structure, and potential benefits. The intervention spanned seven weeks, with two teaching hours per day, except on Wednesdays, within the extended school hours. Classrooms were prepared to create a conducive learning environment, and constant communication was maintained with school directors, teachers, and parents to foster a positive atmosphere within the school community.

4.1 Configuration of the room for the needs of the program

Finding an available room within the 3rd Primary School building was challenging, but a suitable space was secured. Configuring the room was a critical factor for successful teaching. The arrangement of desks and classroom furniture was carefully planned to accommodate the number of children, teaching needs, and available space. Stability in the arrangement was maintained throughout the program to provide a conducive and attractive learning environment for the students (Figure 1).

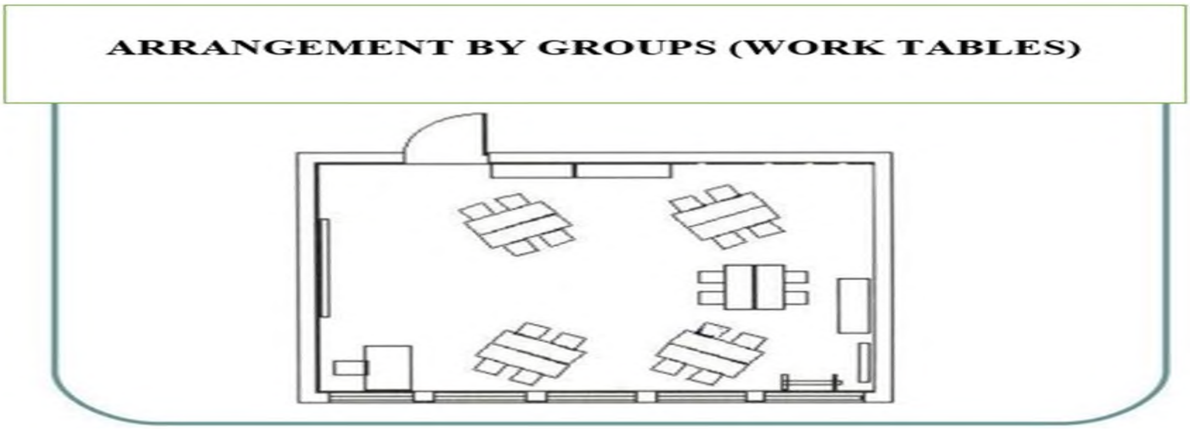


Figure 1. Spatial plan of the hall, where the Program was implemented didactic-therapeutic intervention.

4.1.1 Materials for the implementation of the intervention

For the application and implementation of the program in the classroom, various materials were utilized, including:

- Cardboards measuring 9 x 9 cm, featuring single-digit numbers, double digits, geometric shapes, numerical symbols, etc.
- Cardboards measuring 17 x 9 cm, displaying combinations of addition and subtraction operations ranging from 1 to 20 and from 20 to 100, with the missing operation result (either sum or difference).
- Cardboards measuring 25 x 9 cm, containing combinations of addition and subtraction operations up to 100, with one of the operands (addend or subtrahend) missing.
- An old-style large abacus.
- Individual counters, one for each group of four children, placed on each desk cluster.
- Plastic numerator cubes provided in boxes for each child, allowing them to manipulate sets of ten dozen cubes of different colors and create various combinations.
- A magnetic board with numbers and symbols.
- A traditional blackboard with different colored chalk.
- Ten number boards with a value of 100 (10 × 10).
- One hundred number boards with a value of 10 (10 × 1).
- One hundred numerator cubes with a value of 1 (1 × 10).
- Four magnetic tables and magnetic numbers.
- 9 Board games

These materials were essential for conducting the program effectively and facilitating the learning process in the classroom.

4.2 MEANS OF DATA COLLECTION

To collect research data, we employed two main methods: assessments of students' numerical performance and measurements of their psychometric characteristics related to cognitive and psycholinguistic development.

Numerical Performance Assessment

We evaluated students' mathematical performance using three improvised group-administered criteria, as there were no established standardized tests suitable for our research objectives. These criteria were administered to all 3rd-grade students (N=121) from the 2nd, 3rd, and 4th Primary Schools of Thessaly Region in collaboration with their teachers. The first criterion was administered before the intervention, the second after the intervention, and the third about a month after the intervention's completion. Each criterion consisted of nine distinct parts, covering various aspects of arithmetic skills such as number lines, addition, subtraction, problem-solving, and more. The total score for each criterion ranged from 0-284 points for the first two criteria and 0-236 points for the third criterion.

Psychometric Assessments

For the psychometric assessments, we selected a subset of students (N=25) based on their performance in the first numerical performance evaluation. We conducted these assessments to gain insights into their developmental characteristics.

We used the Euromedica Center Learning Disability Diagnosis, a multi-thematic preliminary psychodiagnostic instrument, to construct a developmental profile for each child. This test included scales for measuring various skills, including direct memory of sequences, both acoustic and visual, through the Number Memory, Image Memory (with semantic visual material), and Shape Memory (with non-visual material) scales. To measure intelligence, we employed the Raven test, a well-known non-verbal intelligence assessment administered in groups, which provided an independent measure of each child's cognitive abilities.

To assess working memory function, we administered the Memory scale of the WISC-III (Digit Span), which measures working memory in a relatively short amount of time. Additionally, we selectively administered the Arithmetic scale from WISC-III to evaluate numerical calculation abilities and "freedom from distraction."

4.3 APPLICATION OF THE RESEARCH

4.3.1 Target Group Selection - Assessment of mathematical achievement

Our research began with the careful selection of the target group, focusing on enhancing working memory and arithmetic performance in primary school students. We concentrated on 3rd-grade mathematics, particularly basic addition and subtraction skills, which are vital for developing number sense in this age group (aged 9 and older). We identified potential participants by administering an arithmetic test to all 3rd-grade students. Those scoring below 140, based on one standard deviation below the mean of the total sample of 121 students, were considered for the Experimental Group, consisting of 15 students who received specialized remedial teaching. The Control Group comprised 10 students who received regular classroom instruction only.

Individual psychometric assessments were conducted for the 25 students who initially scored below 140, revealing weaknesses in memory capacity and cognitive-psycho-linguistic development. The intervention program lasted six weeks, involving two teaching hours per day, four days a week, totalling 64 teaching hours. The first hour focused on memory exercises, including auditory and visual memory tasks, while the second hour involved playful activities aligned with program goals.

The intervention program aimed to achieve the following objectives:

Memory Enhancement

a) Improve the ability to recall and repeat sequences of numbers, both aurally and visually.
b) Enhance memory for mathematical operations and symbols.
c) Strengthen the memory for sequences of numbers, dots, and arithmetic results.
d) Develop the ability to remember representations, symbols, and actions aurally and visually.

These memory activities were repeated regularly, typically for the first 5-10 minutes of each teaching hour. The exercises required concentration and encouraged competition among students, leading to improved memory performance and self-image.

Table 1. Summary table of teaching objectives and actions required for its implementation

A/A	Type of material to memorization	Input diode information	Interference another one performance	Way reproduction performances
1	Semantic	Acoustics	No	Following
2	Semantic	Optics	No	Following
3	Semantic	Acoustics + Optics	No	Following
4	No important	Acoustics + Optics	No	Random order
5	No important	Optics	No	Following
6	No important	Optics	No	Random order
7	Semantic	Acoustics	Yes	Following
8	Semantic	Optics	Yes	Following

Arithmetic

a) P. knows the sequence of numbers and can count from 1 to 20 and vice versa, understands the value of numbers from 1 to 20.
b) P. understands the concepts more – less.
c) P. to be able to add and subtract single digit numbers from memory.
d) Can add and subtract two- and one-digit numbers from memory, which themselves or their sum do not exceed 20.
e) Can count from 20 to 100 and vice versa, understands value of numbers from 20 to 100 and passing to another next or previous ten.

Table 2. Summary table of teaching objectives and teaching hours that are required to implement the numeracy intervention.

A/A	TEACHING OBJECTIVES	Didactic hours
1	P. counts from 0 to 20 and understands the value of numbers and quantity they express	2 hours
2	P. counts down from 20 to 0	2 hours
3	P. understands the meaning of more than... with numbers up to 20	2 hours
4	P. understands the meaning of less than... with numbers up to 20	2 hours
5	P. does additions from 0 to 20 with an emphasis on memory execution	3 hours
6	P. does subtractions from 0 to 20 with an emphasis on memory execution	3 hours
7	P. makes additions from 20 to 100 with an emphasis on memory implementation	4 hours
8	P. makes subtractions from 20 to 100 with an emphasis on memory implementation	4 hours
9	P. solves problems with additions or more than.. assembling the cf data in memory	3 hours
10	P. solves problems with subtractions or less than... assembling the cf data in memory	3 hours
11	P. solves more complex problems, with additions, subtractions, more or less than..., structuring the data in memory	4 hours
	Total program hours of direct instruction ***Total indirect teaching program hours (playful activities)*** ***Total program hours:***	***32 hours*** ***32 hours*** ***64 hours***

Our program design emphasized engaging both hemispheres through memory function exercises and teaching metamemory techniques. These techniques aimed to automate actions, reduce working memory load, and facilitate arithmetic operations and problem-solving. The approach involved intentional teaching actions, focusing on fundamental arithmetic concepts and skills while directly supporting children's working memory. This approach addressed challenges faced by children with limited memory capacity, helping them apply the correct techniques for arithmetic operations and problem-solving.

The selected activities served two purposes: reintroducing children to mathematics learning, addressing challenges in acquiring basic mathematical concepts, and tailoring activities to their developmental stage and specific needs. Notably, due to children's fatigue and negative attitudes toward written work, we minimized the use of written exercises. Although children actively participated in classroom activities, they often exhibited reluctance to complete individual exercise booklets. Additionally, when provided with exercise sheets, a significant number of children failed to return completed work the following day (Courtesy & Conway, 1998; Goldman et al., 1998).

4.4 SAMPLE DESCRIPTION

The total sample for our research, as previously mentioned, comprised 121 male and female students from the 3rd grade in the 2nd, 3rd, and 4th primary schools of the Thessaly Region, across five different departments. For the purposes of our research, we divided this student population into four distinct groups. Subsequently, when presenting findings and engaging in discussions, we will refer to these groups as follows:

N=121, Total Survey Sample: This group includes 3rd-grade students from the 2nd, 3rd, and 4th primary schools in the Thessaly Region.

Individual Groups

a) N=15, Experimental Group: Comprised of students who scored less than or equal to 140 units on the 1st numerical performance criterion.
b) N=10, Control Group: Comprised of students who also scored less than or equal to 140 points on the 1st numeracy criterion.
c) N=25, Experimental Group and Control Group (N15+N10): Includes all students who scored less than or equal to 140 units on the 1st numerical performance criterion.
d) N=96, Students who scored above 140 on the first arithmetic performance test, excluding those in the Experimental Group and Control Group (N25- (N15+N10).

Data from the research were analyzed using the statistical software package SPSS 8.0, and Microsoft Office Excel '97 was used for creating graphs.

Table 3 Frequency distribution of the students in the sample (N=I21) and the individual groups, in terms of the gender.

Gender	Experimental group N15 F	%	Control team N 10 F	%	N125- (N15+N10) N=96 F	%	Total sample N=121 F	%
Boys	7	46,7	5	55	57,3	50,0	67	55,4
Girls	8	53,3	5	41	42,7	50,0	54	44,6
Total	15	100,0	10	96	100,0	100,0	**121**	100,0

The total sample (N=121) included 67 boys and 54 girls. The experimental group, which underwent the intervention program (Table 3), consisted of 15 children, comprising 7 boys and 8 girls. The control group had 10 children, evenly split between 5 boys and 5 girls.

Chronological ages of students in both groups (N=25) ranged from 99 to 111 months, with a mean age of approximately 104.12 months (8 years and 8 months).

To ensure experimental equivalence, both groups were initially matched in terms of their 1st arithmetic performance criterion scores. Subsequent cognitive and psycho-linguistic evaluations using the Raven intelligence test, WISC-III memory scales, and the Thessaly Test showed no statistically significant differences between the two groups.

CHAPTER 5. FOUNDINGS

Basic research data

Answering the key research questions

Summary presentation of the main findings of the research

5.1 Basic research data

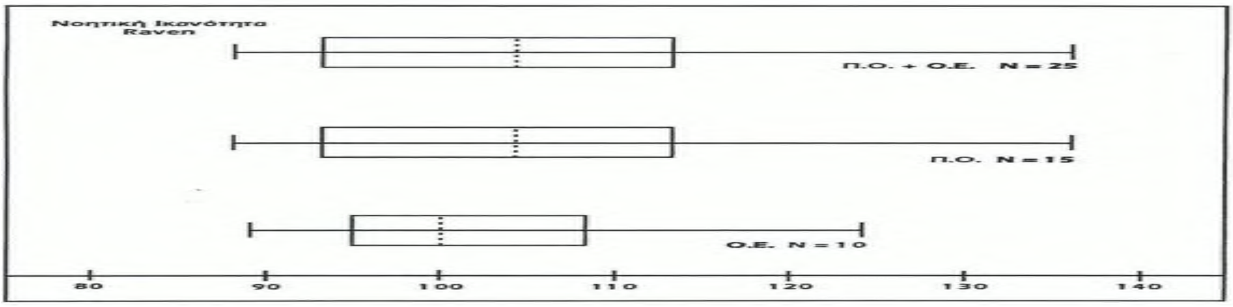
Table 4. Detailed presentation of research data for Experimental students Group (N=15) and the Control Group (N=10), before the Intervention

A/A	Gender	1st performance criterion	Memory Number Euromedica	Memory of images Euromedica	Memory Shapes Euromedica	Memory Number wise	Number tic wise	Mentally quotient Raven	Date Age in months
1	Boy	94	7	9	7	7	7	97	100
2	Girl	140	6	4	5	6	8	111	104
3	Girl	58	9	8	9	9	5	136	106
4	Girl	126	5	4	6	5	7	109	101
5	Boy	92	8	4	4	9	8	113	106
6	Girl	30	4	4	8	4	3	93	108
7	Boy	124	11	7	8	10	7	97	107
8	Girl	110	4	6	4	4	5	92	103
9	Boy	140	8	6	8	9	9	132	107
10	Girl	96	5	8	4	5	2	89	104
11	Girl	48	7	4	5	4	1	88	111
12	Boy	32	8	6	4	9	4	111	100
13	Girl	76	5	6	4	2	5	108	104
14	Boy	118	8	7	7	8	7	118	103
15	Boy	136	6	7	4	7	7	117	108
16	Girl	86	7	9	8	5	5	95	104
17	Boy	96	6	8	5	7	7	96	103
18	Girl	136	6	6	7	8	8	108	100
19	Girl	104	7	7	6	7	7	102	105
20	Boy	140	11	10	10	7	7	124	107

21	Boy	64	4	4	5	5	5	89	106
22	Boy	140	6	5	4	7	7	92	101
23	Girl	36	8	9	7	5	5	107	103
24	Boy	48	7	5	4	3	3	98	99
25	Girl	118	9	8	9	7	7	115	103
M	12 Boys 13 Girls	96	7	6	6	6	6	105	104
S		37	2	2	2	2	2	13	3
Mdn		96	7	6	6	7	7	107	104

The above table shows in detail the gender and age of students who made up the experimental group (N=15) and the control group (N=10), which their score in the 1st evaluation criterion of arithmetic performance did not exceed the limit of 140 units, as well as their performance in the baseline assessments, in which there was post-Intervention and repeat measurement.

Figure 1 Box-plot of the mental ability of the students in the sample, in terms of Raven



5.2 Answer to key questions

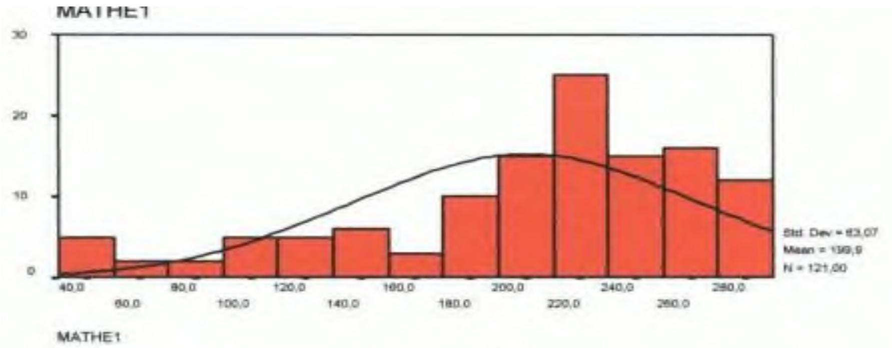
<u>1° RESEARCH QUESTION:</u>

- *1st CRITERION OF NUMERICAL PERFORMANCE (TOTAL RATING RANGE L= 284)*

Table 5 Grouped distribution of the score of the 121 students in the sample (N=121) in the 1st criterion of numerical performance and conversion of initial grades into percentile values, z-scores and IQ values.

Rating- Initial values	*Absolute Frequency f*	*Z values*	*Percentage values*	*T values*
30 – 58	6	-2,52	5	25
60 – 96	7	-1,82	11	32
98 – 124	5	-1,36	15	36
126 – 140	7	-1.04	21	40
142 - 176	5	-0,53	25	45
178 - 186	7	-0,28	31	47
188 - 196	6	-0,12	36	49
198 - 204	6	0,02	41	50
206 - 210	6	0,12	46	51
212	5	0,19	50	52
214 - 216	6	0,24	55	52
218 - 224	7	0,32	60	53
226 - 230	6	0,44	65	54
232 - 238	5	0,57	69	58
240 - 242	7	0,65	75	57
244 - 252	5	0,78	79	58
254 - 262	6	0,93	85	59
264 - 268	7	1,04	90	60
270 - 276	6	1,16	95	62
276 - 282	6	1,28	100	63

Figure 2 Frequency histogram of the score (initial grades) of the students in the sample (N=121) in the 1st criterion of numerical performance.



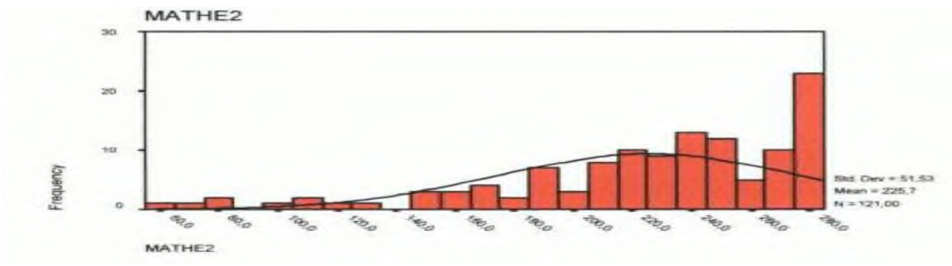
The distribution of scores in the 1st numerical performance criterion is right-skewed, indicating that most students find it easy. During the test, which lasts 45 minutes, students are instructed to tackle questions they are confident about first and not to focus on the sequence of the exercises. The examiner makes sure that the students understand the instructions by keeping them clear and simple. Students are prohibited from copying or cheating, and each test's duration is recorded by the examiner.

- *2nd NUMERICAL PERFORMANCE CRITERION (TOTAL RATING RANGE: L = 284)*

Table 6. Grouped distribution of the score of the 121 students in the sample (N=121) in 2° numerical performance criterion and conversion of initial grades into percentage values, z-values and IQ values.

Rating- Initial values	*Absolute Frequency f*	*Z values*	*Percentage values*	*T values*
64 - 106	6	-2,73	5	23
108 - 152	6	-1,81	10	32
156 - 174	7	-1,19	16	38
176 - 190	6	-0,82	21	42
192 - 202	5	-0,55	25	44
204 - 210	6	-0,36	30	46
212 - 220	7	-0,19	36	48
222 - 224	6	-0,05	41	49
226 - 232	6	0,08	46	51
234 - 236	5	0,18	50	52
240	7	0,27	55	53
242 - 246	8	0,35	62	54
248	3	0,43	65	54
250 - 258	7	0,54	70	55
260 - 268	5	0,74	74	57
270 - 272	7	0,87	80	59
274 - 278	8	0,97	87	60
280-284	16	1,09	100	61

Figure 3. Frequency histogram of the score (initial grades) of the students in the sample (N=121) in the 2nd numerical performance criterion



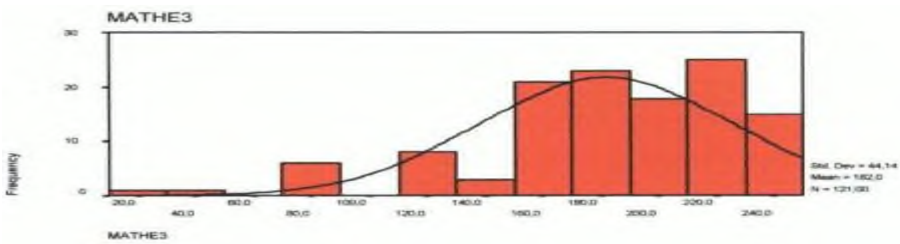
In the 2nd numerical performance criterion, the distribution of student scores is right-skewed, indicating that it's relatively easy for most students. The assessment involves students starting with questions they feel confident about, not necessarily following the order of the booklet, and completing the test within a time frame of 45 minutes. The examiner makes sure that the students understand the instructions.

- *3° CRITERION OF NUMERICAL PERFORMANCE TOTAL RATING RANGE: L= 236*

Table 7. Distribution of the score of the 121 students in the sample (N=121) in the 3rd arithmetic criterion performance and conversion of initial grades into percentile values, z-scores and IQ values.

Rating- Initial values	*Absolute Frequency f*	*Z values*	*Percentage values*	*T values*
28 - 84	6	-2,72	5	23
88 - 120	7	-1,64	10	34
122 - 138	6	-1,21	15	38
148 - 154	5	-0,69	19	44
156 - 160	8	-0,54	26	45
162 - 166	6	-0,40	31	46
168 - 172	6	-0,27	36	47
176 - 180	7	-0,09	41	49
182 - 184	8	0,02	48	50
186 - 188	5	0,11	52	51
190 - 192	3	0,20	55	52
194 - 196	6	0,29	60	53
198 - 202	7	0,40	65	54
204 - 212	6	0,60	70	56
214 - 216	6	0,75	75	58
218 - 222	4	0,90	79	59
224 - 226	8	0,97	85	60
228 - 230	5	1,06	89	61
232 - 236	13	1,19	100	62

Figure 4. Frequency histogram of the score (initial grades) of the students in the sample (N=121) in the 3rd criterion of numerical performance.



The 3rd Numerical Performance Criterion, as described, does not specifically include adaptations for children with dyslexia. The 3rd Numerical Performance Criterion is a group assessment tool for 3rd graders in a typical classroom setting that focuses on assessing collective understanding of basic mathematical concepts rather than individual abilities. Students are advised to tackle exercises they are most confident about first, helping to reduce test anxiety and pacing individually for students with dyslexia. The role of the examiner is limited to ensuring that the students follow the instructions in the booklet, facilitating them by verbally giving the written instructions.

The results clearly show significant variations in students' arithmetic performance across all three evaluation criteria, identifying students with notable difficulties in arithmetic relative to their peers.

<u>2° RESEARCH QUESTION:</u>

Table 8. Developmental quotient of the students of the Experimental Group (N=15) on the 11 quantitative scales of the Euromedica Center.

Students A/A	Language Anal.	Copy Sqm-	Vocabulary-scholar	Memory No.	Memory Fig.	Memory Sqm-	Incl. Proposals	Incl. Words	Distr. Writing	Discrimination of Phthongs	Connection Phthongs
1	10	9	11	7	9	7	10	9	12	10	9
2	10	13	11	6	4	5	4	4	12	4	7
3	10	12	12	9	8	9	6	6	12	9	10
4	11	9	12	5	4	6	10	11	14	5	12
5	13	12	10	8	4	4	10	11	6	8	4
6	4	10	4	4	4	8	4	4	6	5	4
7	8	13	5	11	7	8	6	5	7	8	6
8	8	4	4	4	6	4	6	4	7	10	4
9	9	12	10	8	6	8	5	6	7	8	10
10	4	7	4	5	8	4	4	4	6	4	4
11	7	8	8	7	4	5	4	4	5	6	4
12	10	11	10	8	6	4	7	8	6	7	9
13	9	8	9	5	6	4	10	4	14	8	7
14	6	12	13	8	7	7	8	4	9	7	7
15	9	11	8	6	7	4	10	5	4	9	6
M	*8,53*	*10,07*	*8,73*	*6,73*	*6,00*	*5,80*	*6,93*	*5,93*	*8,53*	*7,20*	*6,87*
s	*2,47*	*2,55*	*3,13*	*1,98*	*1,69*	*1,86*	*2,52*	*2,58*	*3,48*	*2,01*	*2,64*
Mdn	*9,00*	*11,00*	*10,00*	*7,00*	*6,00*	*5,00*	*6,00*	*5,00*	*7,00*	*8,00*	*7,00*

The table presents data on the growth rates of 15 students from P.O. across 11 different scales of the Thessaly Test Difficulty Diagnosis Learning. Notably, all of these students exhibit developmental deficits in multiple skill areas.

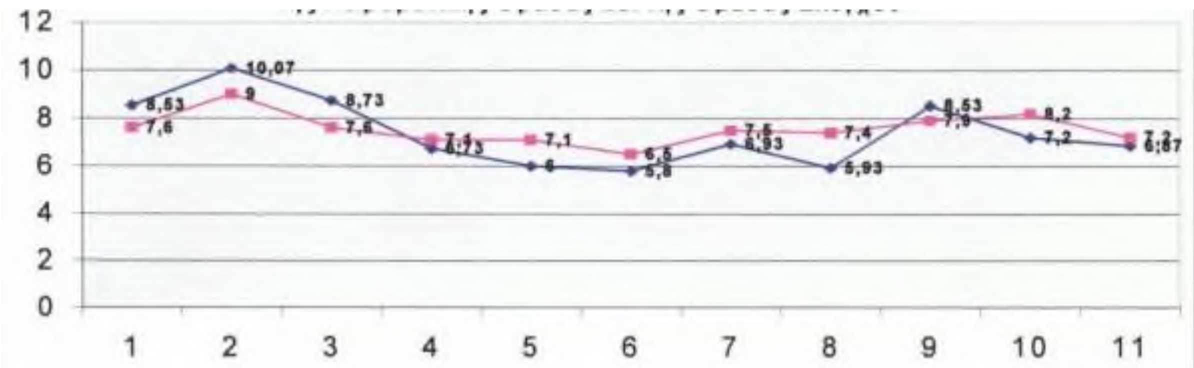
Table 9. Developmental quotient of the students of the Control Group (N=10), on the 11 quantitative scales of Euromedica Center

Students A/A	Language Anal.	Copy Sqm	Vocabulary-scholar	Memory No.	Memory Fig.	Memory Sqm-	Incl. Proposals	Incl. Words	Distr. Writing	Discrimination of Phthongs	Connection Phthongs
1	8	9	7	7	9	8	7	8	6	10	7
2	7	9	8	6	8	5	6	8	10	10	8
3	8	10	9	6	6	7	8	8	9	10	8
4	7	8	7	7	7	6	5	8	8	9	7
5	11	12	10	11	10	10	9	10	10	9	8
6	6	7	6	4	4	5	8	8	6	8	10
7	7	8	5	6	5	4	6	7	7	7	8
8	8	9	8	8	9	7	9	6	5	4	6
9	6	8	7	7	5	4	7	5	7	8	4
10	8	10	9	9	8	9	10	6	11	7	6
M	7,60	9,00	7,60	7,10	7,10	6,50	7,50	7,40	7,90	8,20	7,20
s	1,43	1,41	1,51	1,91	2,02	2,07	1,58	1,43	2,02	1,87	1,62
Mdn	7,50	9,00	7,50	7,00	7,50	6,50	7,50	8,00	7,50	8,50	7,50

The table above shows the developmental quotients of her students in detail O.E. (N=10) on the 11 scales of the Euromedica Center Learning Difficulties Diagnosis. We observe that all students show developmental deficits in various ways areas of competence.

Figure 5. Graphical representation of the Means of the students of the Experimental Group (N=15) and the Control Group (N=10), in terms of developmental quotients on the 11 quantitative scales of Euromedica Center.

Average Growth Quotients in the Euromedica Center of the experimental group and the control group



Memorandum: 1. In blue the means of the Experimental Group 2. Control Group means in pink

Table 10. Means, standard deviations and medians of the performances of the P.O. and O.E. students. (N=25) on the 11 quantitative scales of the Euromedica Center before the intervention.

Students A/A	Language Anal.	Copy Sqm	Vocabulary-scholar	Memory No.	Memory Fig.	Memory Sqm-	Incl. Proposals	Incl. Words	Distr. Writing	Discrimination of Phthongs	Connection Phthongs

M	8,16	9,64	8,28	6,88	6,44	6,08	7,16	6,52	8,28	7,60	7,00
s	2,13	2,20	2,62	1,92	1,87	1,93	2,17	2,28	2,95	1,98	2,25
Mdn	8,00	9,00	8,00	7,00	6,00	6,00	7,00	6,00	7,00	8,00	7,00

The table reveals that among 25 students with performance below one standard deviation from their peers, their individual development abilities, excluding mental ability, typically fall between 6-8 standard deviations, indicating a deficit in growth, albeit only marginally low.

Table 11. Frequency distribution of P. O. and O.E. students. (N=25) in terms of their performance in the categorical scales of the Euromedica Center.

Performance	Common sequences of days-months		Common sequences of numbers		Visual motor coordination		Right left discrimination	
	f	%	f	%	f	%	f	%
sufficient	7	28	5	20	25	100,0	15	60
insufficient	18	72	20	80	0	0	10	40
total	25	100,0	25	100,0	25	100,0	25	100,0

In the table, 72% of the 18 students struggle with common day-month sequences, 80% of the students face difficulties with common number sequences, and 40% have challenges distinguishing right from left.

Table 12. Frequency distribution of P.O. and O.E. students. (N=25) in terms of scale lateralization of Euromedica Center.

Flank	Hand		Eye		Ear		Foot	
	F	%	F	%	F	%	F	%
Right	21	84	14	56	19	76	11	44
Left	0	0	11	44	2	8	13	52
Undifferentiated	4	16	0	0	4	16	1	4
Total	25	100,0	25	100,0	25	100,0	25	100,0

In the table, among the combined group of 25 students from P.O. and O.E., 21 are right-handed, 4 exhibit undifferentiated lateralization, and considerable variability exists in preferences for hand, ear, eye, and foot dominance.

3° RESEARCH QUESTION:

Table 13. Combined absolute and relative frequencies of P.O. and O.E. students. (N=25), as to performance on the 1st criterion of arithmetic performance and standard scores on the memory scales of the WISC-III and the Euromedica Center.

	1st criterion Grading	MEMORY OF NUMBERS WISC-III 1-6	7-8	MEMORY OF NUMBERS EUROMEDICA 4-6	7-8	MEMORY FIG. EUROMEDICA 4-6	7-8	MEMORY FIG. EUROMEDICA 4-6	7-8
2 standard deviations below the mean	20-80	4 16	1 4	3 12	4 16	6 24	1 4	5 20	2 8
1 standard deviation below the mean	80-140	8 32	5 20	8 32	6 24	7 28	7 28	**9 36**	6 24
	Total	12 48	6 24	11 44	10 40	13 52	8 32	**14 56**	8 32

In the table, 72% of the 25 students with arithmetic scores at or below 140 units exhibit a lag in number memory performance on the WISC-III scale. Additionally, 84% struggle with number memory and memory scales in the Thessaly Test images, while 88% show inadequate or marginally low performance on Euromedica Center's Pattern Memory scale.

<u>4° RESEARCH QUESTION:</u>

Table 14. Developmental quotient of the students of the Experimental Group (N=15) in terms of the scales Euromedica Center Number Memory, Picture Memory, and Figure Memory, and standard scores in Memory WISC-III scores, before and after the Intervention.

students	*Number Memory Euromedica*		*Image Memory Euromedica*		*Pattern Memory Euromedica*		*Number Memory WISC-III*	
	before	*after*	*before*	*after*	*before*	*after*	*before*	*after*
1	7	10	9	11	7	10	7	11
2	6	10	4	8	5	9	6	10
3	9	13	8	11	9	11	9	12
4	5	9	4	8	6	10	5	9
5	8	11	4	8	4	6	9	12
6	4	9	4	10	8	10	4	8
7	11	13	7	9	8	10	10	12
8	4	8	6	9	4	8	4	9
9	8	11	6	10	8	11	9	12
10	5	8	8	10	4	8	5	8
11	7	9	4	8	5	8	4	8
12	8	11	6	9	4	8	9	12
13	5	8	6	10	4	8	2	6
14	8	12	7	9	7	9	8	12
15	6	9	7	10	4	8	7	10
M	6,73	10,07	6,00	9,33	5,80	8,93	6,53	10,07
s	1,98	1,71	1,69	1,05	1,86	1,39	2,45	1,98
Mdn	7,00	10,00	6,00	9,00	5,00	9,00	7,00	10,00

The table displays initial grades and growth rates in Euromedica Center's Sequence Memory and Number Memory scales of WISC-III for the Experimental Group (N=15). After the intervention, there is noticeable improvement in their performance.

Figure 6. Graphic representation of the standard grades of the students of the Experimental Group (N=15) in scales Memory of Numbers-Memory of Pictures-Memory of Figures of Euromedica Center and Memory of Numbers of WISC-III, before and after the Intervention .

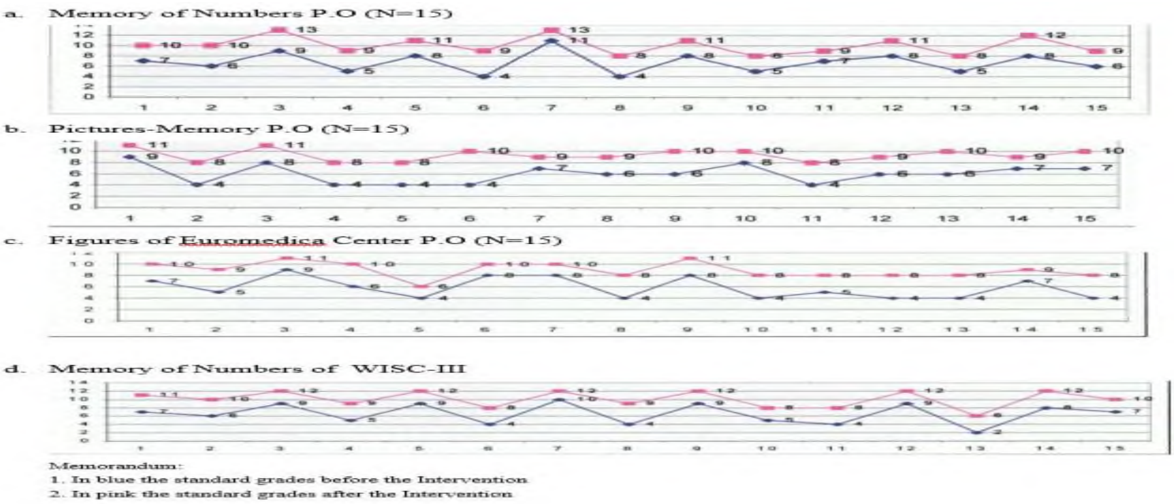
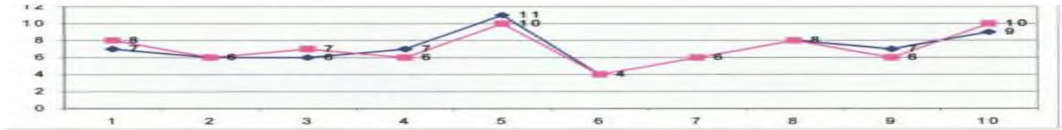


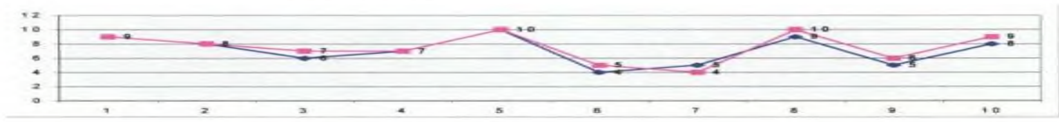
Table 15. Developmental quotient of the students of the Control Group (N=10) in terms of the scales Memory Number-Memory for Pictures- Memory for Figures of the Euromedica Center and standard scores in the Number Memory of WISC-III, before and after the Intervention.

students	Number Memory Euromedica		Image Memory Euromedica		Pattern Memory Euromedica		Number Memory WISC-III	
	before	after	before	after	before	after	before	after
1	7	8	9	9	8	7	8	8
2	6	6	8	8	5	6	4	5
3	6	7	6	7	7	7	7	8
4	7	6	7	7	6	6	6	6
5	11	10	10	10	10	10	9	8
6	4	4	4	5	5	5	1	2
7	6	6	5	4	4	6	5	5
8	8	8	9	10	7	7	8	8
9	7	6	5	6	4	4	6	5
10	9	10	8	9	9	10	9	9
M	7,10	7,10	7,10	7,50	6,50	6,80	6,30	6,40
s	1,91	1,91	2,02	2,07	2,07	1,93	2,50	2,17
Mdn	7,00	7,00	7,50	7,50	6,50	6,50	6,50	7,00

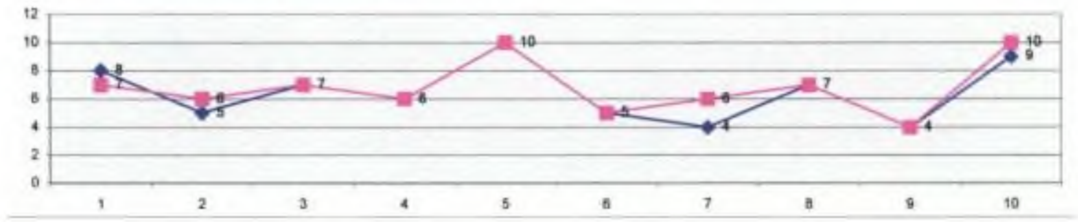
a. Memory of Numbers O.E (N=10)



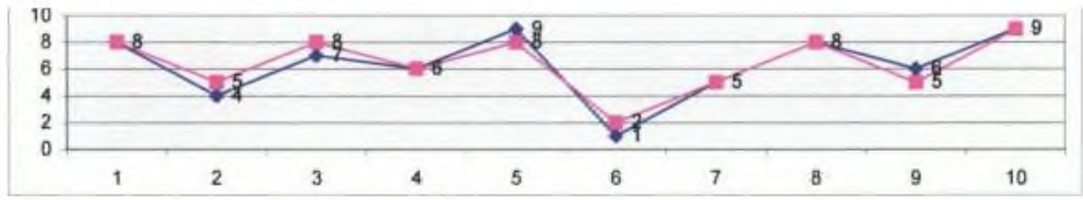
b. Pictures -Memory O.E (N=10)



c. Figures of Euromedica CenterO.E (N=10)



d. Memory of Numbers O.E (N=10)



Memorandum:

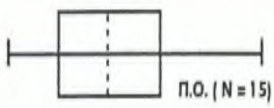
1. In blue the standard grades before the Intervention
2. In pink the standard grades after the Intervention

In summary, the experimental group (N=15) showed significant improvement in mnemonic ability metrics after the intervention, reaching an average-normal level.

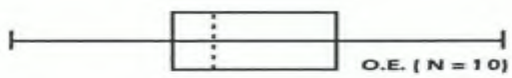
Figure 7. Box-plot of the memory ability of the students of the Experimental Group (N=15) and the Control Group (N=10), regarding Thessaly Test and WISC-III, after the implementation of the intervention program.

a. Memory of Numbers

First case P.O (N=15)

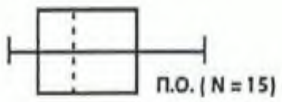


Second case O.E (N=10)

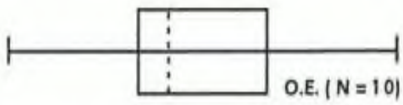


b. Pictures – Memory

First case P.O (N=15)

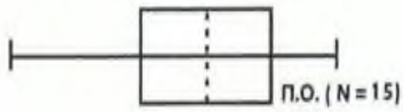


Second case O.E (N=10)

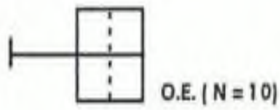


c. Figures of Athena Test

First case P.O (N=15)

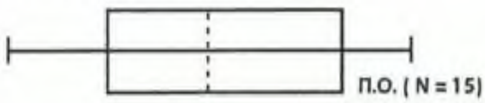


Second case O.E (N=10)

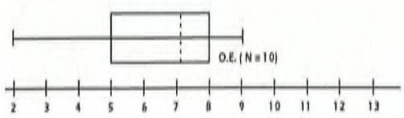


d. Memory of numbers

First case P.O (N=15)



Second case P.O (N=10)

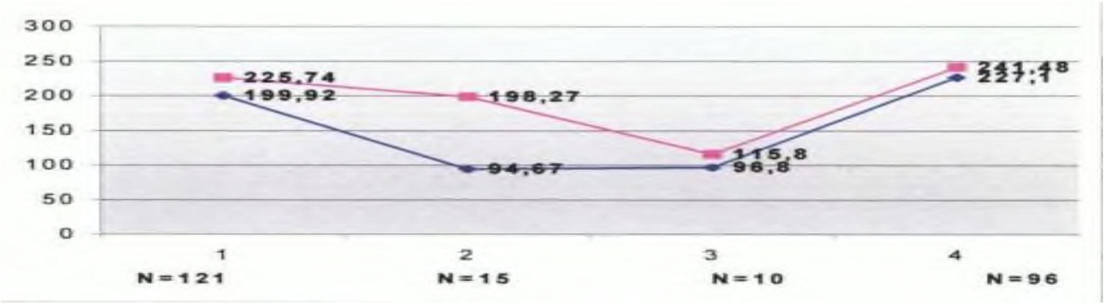


5° RESEARCH QUESTION:

Table 16. Indices of dispersion and central tendency of the scores (initial scores) of the groups of the students of p. 9, regarding the 1st and 2nd evaluation criterion of the numerical performance.

Students' team	1o criterion						2o criterion					
	L	Min	Max	M	S	Mdn	L	Min	Max	M	S	Mdn
N=121	252	30	282	199,92	63,07	214	220	64	284	225,74	51,53	240
N= 15	110	30	140	94,67	38,20	96	146	124	270	198,27	39,76	200
N= 10	104	36	140	96,80	38,07	100	110	64	174	115,80	41,85	107
N= 96	126	156	282	227,10	32,51	225	180	104	284	241,48	36,23	244

Figure 8. Arithmetic performance averages in Criterion 1 and Criterion 2



Memorandum:

1. In blue the averages of the groups' performances in the 1st criterion

2. In pink the averages of the groups' performances in the 2nd criterion

In the table, the average scores in the 2nd criterion surpass those in the 1st criterion, with the Experimental Group showing the most substantial improvement compared to their peers.

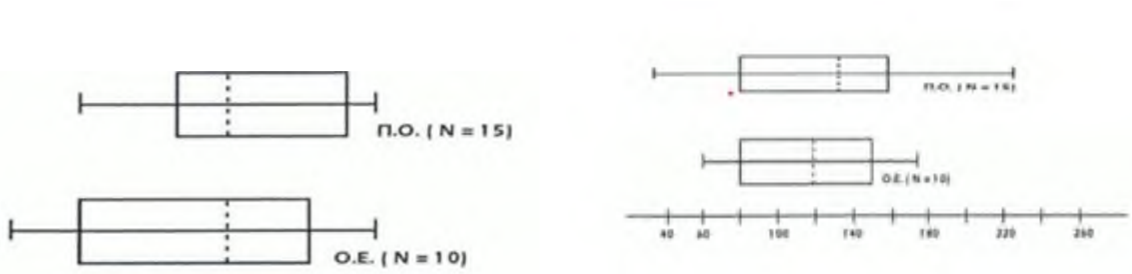
Table 17. Comparison within the groups of the students in table 16, in terms of their score in 1° and 2° criterion for evaluating numerical performance.

Student's team	T- t	Test Sig (2-tailed)	df	Mann- u	Whitney Sig (2-tailed)
N=15 / N=15				4,500	,000
N=10 / N=10				36,500	,307
N=96 / N=96	-2,893	,004	190		
N=121 / N=121	-3,487	,001	230,820		

In the table, there are statistically significant differences in numerical performance between the 1st and 2nd criteria for all groups except the Control Group. Notably, the Experimental Group exhibits the most substantial and statistically significant improvement (U=4.500, p<0.001, two-tailed direction).

Figure 9. Box-plot of the score of the students of the experimental group (N=15) and the control group in the 1st and 2nd numerical performance assessment criteria.

1st CRITERION ARITHMETIC (Before intervention) *2nd CRITERION ARITHMETIC (After intervention)*



6° RESEARCH QUESTION:

Table 18. Indicators of central tendency of the groups of students of the table. 9, as to the time of completion of the 1st and 2nd" numerical performance evaluation criteria (in minutes per hour).

Student's team	min	1o max	Criterion m	s	Dm	min	2o max	Criterion m	s	Dm
N=121	15΄	45΄	35,43	0,78	35	15΄	45΄	30,56	0,78	30
N= 15	26΄	45΄	41,00	6,67	45	22΄	45΄	33,47	7,16	32
N= 10	36΄	45΄	43,00	2,91	44,5	35΄	45΄	40,80	3,68	41
N= 96	15΄	45΄	33,77	8,54	32	15΄	45΄	29,04	8,38	28

Figure 10. Average Completion Times of 1st and 2nd Criterion Numerical Performance, in minutes per hour.

Memorandum:

1. In blue the averages in the 1st evaluation criterion of numerical performance

2. In pink the averages in the 2nd evaluation criterion of numerical performance

Table 19. Comparison within the groups of the students in table 9, in terms of the time to complete the 1st and 2nd numerical performance criterion (in minutes per hour).

Students team	T – test T	Sig(2-tailed)	df	Mann Whitney U	Sig (2-tailed)
N=15 / N=15				49,500	,007
N=10 / N=10				32,000	,158
N=96 / N=96	-3,873	,000	190		
N=121 / N=121	-4,393	,000	240		

In Table 19, the differences in time taken by both the sample (N=121) and individual groups to complete the 1st and 2nd criteria of numerical performance are statistically significant, except for the Control Group, where the difference is not statistically significant (p=0.32).

<u>7° RESEARCH QUESTION:</u>

Table 20 displays dispersion and central tendency indices for the Experimental Group (N=15) and Control Group (N=10) in nine parts of the 1st and 2nd criteria for numerical performance, allowing for performance comparison within each group.

Criterion parts	1° Min	1o Max	1o M	1o s	2o Min	2o Max	2o M	2o s	Mann-Whitney U	Sig (2-tailed)

1 part Grades 0-24	2	24	13,07	5,70	12	24	18,00	3,85	51,500	,011
2 part Grades 0-24	0	24	16,67	6,53	8	24	18,13	4,50	103,500	,705
3 part Grades 0-24	4	22	10,53	5,48	10	24	18,93	4,13	26,500	,000
4 part Grades 0-24	0	24	13,73	9,22	16	24	22,00	3,12	56,500	,013
5 part Grades 0-32	0	28	14,53	8,99	8	32	23,20	8,31	59,500	,026
6 part Grades 0-48	0	40	15,73	14,76	16	48	38,00	11,71	23,000	,000
7 part Grades 0-36	0	18	4,13	6,48	0	36	23,73	9,50	16,000	,000
8 part Grades 0-36	0	24	5,87	8,26	8	24	15,47	6,21	36,500	,001
9 part Grades 0-48	0	12	,80	3,10	0	48	19,47	14,49	13,000	,000

In the table, the Experimental Group shows the most significant performance improvement in mental additions, subtractions (parts 3, 6, 8), and problem-solving (part 9). There's a relatively smaller improvement in operations with three numbers (part 5) and symbol completion tasks, while minimal progress is noted in the mechanical execution of algorithms (part 2).

8° RESEARCH QUESTION:

1. *EVALUATION WITH THE "NUMERICAL" SCALE OF THE WISC-III*

Table 21. Standard scores of the students of the Experimental Group (N=15), in terms of the Arithmetic scale of the WISC-III, before and after the intervention.

Students	Before the intervention		After the intervention	
	Initial grades	Standard grades	Initial grades	Standard grades
1	13	7	14	8
2	14	8	16	11
3	12	5	15	9
4	13	7	15	9
5	14	8	16	11
6	11	3	13	7
7	13	7	16	11
8	12	5	13	7
9	15	9	16	11
10	10	2	13	7
11	5	1	11	3
12	11	4	14	8
13	12	5	14	8
14	13	7	15	9
15	13	7	15	9
M	*12,07*	*5,67*	*14,40*	*8,53*
s	*2,34*	*2,35*	*1,45*	*2,13*
Mdn	*13,00*	*7,00*	*15,00*	*9,00*

Table 22. Standard grades of the students of the Control Group (N=10), in terms of the Arithmetic scale of the WISC-III, before and after the intervention.

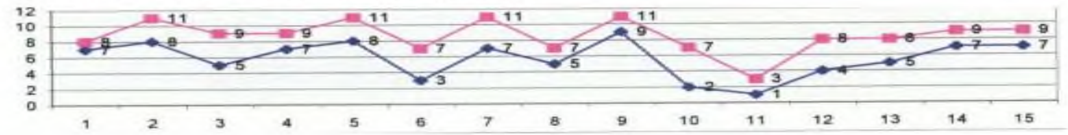
Students	Before the intervention		After the intervention	
	Initial grades	Standard grades	Initial grades	Standard grades

1	12	5	12	5
2	13	7	13	7
3	14	8	14	8
4	13	7	13	7
5	13	7	13	7
6	12	5	12	5
7	13	7	13	7
8	12	5	13	7
9	11	3	12	5
10	13	7	14	8
M	*12,60*	*6,10*	*12,90*	*6,60*
s	*0,84*	*1,52*	*0,74*	*1,17*
Mdn	*13,00*	*7,00*	*13,00*	*7,00*

In the above tables, it can be seen that the students of the experimental group (N=15) show increased performance in numeracy after the intervention, in contrast to the classmates of the control group (N=10).

Figure 11. Graphic representation of the standard grades of the students of the Experimental Group (N-15) and of the Control Group (N=10) on the Wise-Ill Arithmetic scale, before and after the Intervention.

a. WISC III- ARITHMETICAL- P.O (N=15)



b. WISC III- ARITHMETICAL – O.E (N=10)

2. *ASSESSMENT WITH THE "COMMON NUMBER SEQUENCES" SCALE OF THE EUROMEDICA CENTER*

Table 23. Frequency distribution of the students of P.O. (N=15) and O.E. (N=10) in terms of performance them in the categorical subscale of the Euromedica Center "common sequences of numbers", before and after the intervention.

Performance	Experimental Group (N=15)				Control Group (N=10)			
	Before		After		Before		After	
	f	%	f	%	f	%	f	%
Sufficient	3	20	15	100,0	2	20	5	50
Insufficient	12	80	0	0	8	80	5	50
Total	15	100,00	15	100,0	10	100,0	10	100,0

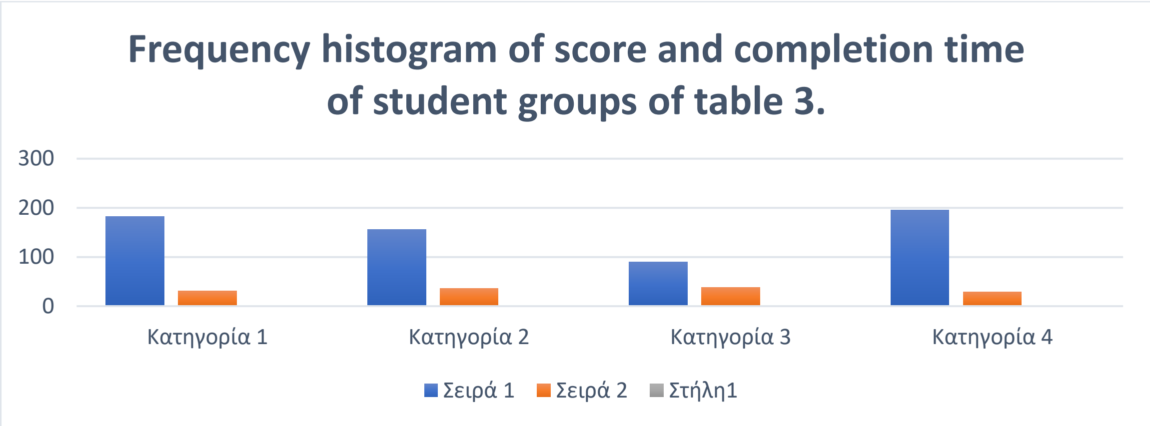
As shown in the table above, the students of the experimental group (N=15), while before the intervention 80% appeared to be insufficient performance on the "common number sequences" subscale of the Thes, after intervention all students show adequate performance.

3. *ASSESSMENT BASED ON PERFORMANCE IN CRITERION 3 ARITHMETIC*

Table 24. Indices of dispersion and central tendency of the score (initial scores) of the groups of students of p. 9, regarding the 3rd numerical performance evaluation criterion (Total Criterion Score Range 0-236).

Students' team	Numerical Performance				Completion time			
	Min	Max	M	s	Min	Max	M	s
N=121	28	236	181,88	44,14	14΄	45΄	30,69	9,57
N= 15	84	194	155,60	32,19	21΄	45΄	36,27	8,89
N= 10	28	154	90,40	39,17	27΄	45΄	38,30	5,33
N= 96	88	236	195,65	31,33	14΄	45΄	29,02	9,35

The table above shows the main dispersion indicators and central tendency of the score of the students in table 1, in the 3rd criterion assessment of numerical performance.



Memorandum:

1. Series 1 : Arithmetic Performance

2. Row 2: Filling Time. 3. 1=N121, 2 = N,5. 3 =N10, 4 =N96

The experimental group of students demonstrated a statistically significant and positive improvement in performance in the 3rd criterion compared to the 1st criterion, while the control group showed no significant improvement, and in fact, the performance declined for the majority of the students in the 3rd criterion.

Table 25. Comparison between the groups of students in table 3, regarding their performance in 3°numerical performance criterion and the exam completion time.

Teams of students	Arithmetic U	Performance Sig – tailed 2	Time U	Completion Sig – tailed 2
N=15 / N=10	14,00	,001	72,500	,889
N=15 / N= 96	256,500	,000	420,500	,010
N=15 / N=121	505,000	,005	610,500	,039

The Experimental Group (N=15) outperforms the Control Group (N=10) significantly (U=14.00, p<0.01) in the 3rd criterion, with similar completion times. However, they lag behind other students, including P.O. and O.E. (N=96), and the total sample (N=121), both in performance and speed in the 3rd criterion.

SUMMARY PRESENTATION OF THE MAIN FINDINGS OF THE RESEARCH.

In the Experimental Group (N=15), significant improvements were observed between the 1st and 2nd measurements across all scales, including memory assessment and numerical performance (p<0.001 for memory capacity and numerical performance, p<0.01 for Wise's Memory of Numbers and Arithmetic scales). Conversely, the Control Group (N=10) showed no statistically significant differences in any of the measurements.

Table 26. Summary and comparison of standard scores on the Thessaly Test and the WISC-III, as well as the scores in the 1st and 2nd criteria of Arithmetic Performance of the students of P.O. (N=15) and the students of O.E. (N=10), in terms of measurements before and after the intervention.

WISC-III					Thessaly Test						Mathematics			
students	memory of numbers		numerical scale		memory of numbers		image memory		shape memory		common sequences of numbers		numerical performance criterion	
N=15	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**1**	**2**
1	7	11	7	8	7	10	9	11	7	10	2	1	94	166
2	6	10	8	11	6	10	4	8	5	9	1	1	140	270
3	9	12	5	9	9	13	8	11	9	11	2	1	58	200
4	5	9	7	9	5	9	4	8	6	10	2	1	126	202
5	9	12	8	11	8	11	4	8	4	6	2	1	92	190
6	4	8	3	7	4	9	4	10	8	10	2	1	30	192
7	10	12	7	11	11	13	7	9	8	10	1	1	124	222
8	4	9	5	7	4	8	6	9	4	8	2	1	110	162
9	9	12	9	11	8	11	6	10	8	11	1	1	140	250
10	5	8	2	7	5	8	8	10	4	8	2	1	96	170
11	4	8	1	3	7	9	4	8	5	8	2	1	48	124
12	9	12	4	8	8	11	6	9	4	8	2	1	32	156
13	2	6	5	8	5	8	6	10	4	8	2	1	76	214
14	8	12	7	9	8	12	7	9	7	9	2	1	118	252
15	7	10	7	9	6	9	7	10	4	8	2	1	136	204
M	6,53	10,07	5,67	8,53	6,73	10,07	6,00	9,33	5,80	8,93	1,80	1,00	94,67	198,27
s	2,45	1,98	2,35	2,13	1,98	1,71	1,69	1,05	1,86	1,39	,41	,00	38,20	39,76
Mdn	7,00	10,00	7,00	9,00	7,00	10,00	6,00	9,00	5,00	9,00	*	*	96,00	200,00
Mann Witney-U Sig-2 tailed	32,000 , 001		37,000 ,001		21,500 ,000		10,000 ,000		22,500 ,000		22,500 ,00		4,500 ,000	

N=10	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	1	2

16	5	8	5	5	7	8	9	9	8	7	2	2	86	84
17	7	5	7	7	6	6	8	8	5	6	2	2	96	82
18	8	8	8	8	6	7	6	7	7	7	2	1	136	170
19	7	6	7	7	7	6	7	7	6	6	1	1	104	108
20	7	8	7	7	11	10	10	10	10	10	2	2	140	148
21	5	2	5	5	4	4	4	5	5	5	2	1	64	106
22	7	5	7	7	6	6	5	4	4	6	1	1	140	152
23	5	8	5	7	8	8	9	10	7	7	2	2	36	64
24	3	5	3	5	7	6	5	6	4	4	2	1	48	70
25	7	9	7	8	9	10	8	9	9	10	2	2	118	174
M.	**6,30**	**6,40**	**6,10**	**6,60**	**7,10**	**7,10**	**7,10**	**7,50**	**6,50**	**6,80**	**1,80**	**1,50**	**96,80**	**115,80**
s	2,50	2,17	1,52	1,17	1,91	1,91	2,02	2,07	2,07	1,93	,42	,53	38,07	41,85
Mdn	*7,00*	*7,00*	*7,00*	*7,00*	*7,00*	*7,00*	*7,50*	*7,50*	*6,50*	*6,60*	*	*	*100,00*	*107,00*
Mann Witney-U		**49,500**		**41,000**		**49,000**		**44,000**		**45,500**		**35,000**		**36,500**
Sig.2-tailed		**,969**		**,460**		**,938**		**,647**		**,730**		**,170**		**,307**

*1= adequate performance, *2=poor performance

1. Discussion of Results:

The research findings reveal that the intervention program had a significant positive impact on the performance of the Experimental Group (N=15) in both arithmetic and memory capacity. The Experimental Group demonstrated statistically significant improvements in arithmetic performance ($p<0.001$) and speed, while the Control Group (N=10) exhibited no significant changes. The program's interactive and playful approach, combined with self-regulation techniques, contributed to the Experimental Group's success.

Moreover, students outside both groups (N=96) also demonstrated enhanced arithmetic performance and speed, possibly due to regular classroom instruction. However, some students in the Experimental Group still faced difficulties, indicating the need for continued support. A third evaluation affirmed the program's enduring benefits. Regarding memory capacity, the program effectively enhanced memory skills for the Experimental Group, bringing their performance within the normal range. These improvements have positive implications for their long-term academic success, as memory plays a crucial role in learning.

Regarding the teaching objectives they incorporate a multifaceted educational approach designed to effectively support students with learning disabilities, particularly those with dyslexia and dyscalculia. The methods used in these objectives are grounded in multi-sensory learning, structured problem-solving, and incremental complexity, which are essential for addressing the specific challenges faced by these students. By engaging multiple senses, these objectives help in making abstract mathematical concepts tangible. For instance, using physical manipulatives like cubes and sticks in early objectives allows students to physically interact with mathematical problems, helping them understand foundational concepts in a concrete manner. This approach is crucial for students with dyscalculia who struggle with number sense, and for those with dyslexia, who may find visual and tactile methods more effective than traditional text-based learning.

As the objectives progress, they build upon each other, introducing more complex mathematical operations and problem-solving techniques in a structured manner. This progression ensures that students master each concept thoroughly before moving to more difficult material, crucial for learners with dyscalculia who require clear and consistent reinforcement to grasp numerical and spatial relationships. The structured problem-solving steps delineated in the later objectives teach students to break down mathematical problems into manageable parts, a strategy that aids in reducing cognitive overload. For dyslexic students, these objectives enhance their ability to organize and process information sequentially, improving their overall mathematical and cognitive skills.

Moreover, these teaching objectives emphasize collaborative and interactive learning environments, verbalization of processes, and the use of visual supports, which further benefit students with learning disabilities. Collaborative activities encourage peer learning and support, which can boost confidence and provide social learning opportunities. The requirement to verbalize thought processes aids dyslexic students in reinforcing their understanding audibly, an essential strategy for those who struggle with reading and writing. Visual supports link mathematical concepts to easily recognizable images, facilitating better retention and understanding. Altogether, these teaching strategies not only make learning more accessible and engaging for students with dyslexia and dyscalculia but also foster a deeper understanding and long-term mastery of mathematical concepts.

2. Conclusions:

This research primarily aimed to understand learning disabilities in a specific school subject and age group. By implementing an innovative intervention program, significant improvements were achieved in memory and basic numerical skills. Future research could investigate the impact of separate interventions for memory and arithmetic in distinct groups. Additionally, adapting the intervention material for different age groups within primary school settings could yield valuable insights.

While recognizing the significance of emotional and self-perception aspects in relation to mathematics, limitations in the current study prevented their exploration. Investigating the connection between self-concept and academic performance at the elementary level may prove valuable. Furthermore, examining family-related parameters and characteristics linked to children's learning difficulties is recommended. The use of more reliable intelligence assessment tools, such as the WISC-III, is advocated over the Raven test. Lastly, achieving a perfect numerical balance between the Experimental and Control Groups posed challenges.

The research appears to successfully address the development of an educational profile and the disclosure of learning strategies for children with dyslexia and dyscalculia. This comprehensive framework utilizes a multi-sensory, structured, and sequential approach to teaching that is well-suited to the needs of children with these specific learning disabilities. By integrating tactile, visual, and auditory learning strategies across a range of mathematical concepts and problem-solving scenarios, the educational profile developed provides a robust basis for effectively supporting students with learning differences. The incremental and cumulative design of the objectives ensures that students build confidence and competence gradually, reinforcing foundational skills before advancing to more complex tasks. This methodical approach helps in creating a supportive learning environment where students with dyslexia and dyscalculia can thrive.

Scientifically, the contribution or innovation of this research lies in its tailored approach that combines several effective educational strategies into a coherent program specifically designed for students with dyslexia and dyscalculia. The innovation is evident in how these strategies are seamlessly integrated to address the multifaceted challenges these students face. Traditionally, educational approaches for such students have been fragmented or not sufficiently tailored to their unique cognitive profiles. This research advances the field by demonstrating how structured, multi-sensory, and interactive learning activities can be systematically employed to significantly improve educational outcomes for students with learning disabilities. It showcases a detailed, step-by-step teaching model that other educators can replicate or adapt, providing a valuable blueprint for effective special education teaching.

Moreover, the research underscores the importance of understanding the neurodiverse needs of students, suggesting that educational strategies must evolve to incorporate an understanding of how these students process information differently. The inclusion of practical, iconic, and symbolic levels of engagement not only aids in understanding and retention but also in the application of knowledge, bridging the gap between theory and practice. By documenting these strategies and their effectiveness in a structured educational framework, the research contributes to the academic literature on special education and offers a replicable model for improving teaching methodologies across diverse learning environments. This dual focus on theoretical innovation and practical application provides a significant contribution to the field of educational strategies for children with specific learning disabilities.

3. Suggestions for Further Implementation within Schools:

In conclusion, this research underscores the need to establish a supportive learning environment that helps children reach their full potential. Schools should proactively identify and address challenges faced by students who struggle with the curriculum, even when the reasons are not immediately clear. This requires personalized remedial assistance based on comprehensive cognitive assessments, with a focus on addressing developmental challenges effectively.

Traditional education often overlooks right-hemisphere learning strategies, especially in mathematics, which are vital for some students. Therefore, there is a pressing need for a more inclusive and adaptable educational system that caters to individual student needs, prevents early academic setbacks, and fosters personal growth. Collaboration among educators, psychologists, and researchers is crucial to unlock each child's full potential.

Key components of this approach include tailored programs, specialized teacher training, time-limited interventions, well-equipped teaching facilities, and a multidisciplinary team for student selection and monitoring. The ultimate goal is to bridge the gap between a student's inherent potential and their actual performance.

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