فاعلية بيئة تعلم إلكتروني قائمة على تطبيق Dexteria VMI في تنمية مهارات الإدراك البصري لدى تلاميذ المرحلة الابتدائية ذوي صعوبات التعلم النمائية

The Effectiveness of an E-Learning Environment Based on the Dexteria VMI Application in Developing Visual Perception Skills Among Primary School Students with Developmental Learning Disabilities

إبراهيم بن عبدالله الزهراني
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Abstract: The study aimed to evaluate the effectiveness of an e-learning environment based on visual applications (Dexteria VMI) in developing visual perception skills, specifically visual closure and visual discrimination. The study followed a quasi-experimental approach (a one-group pre-test/post-test design). The study tools included a learning difficulties scale for visual perception skills and an observation checklist to measure students' behavior during the implementation of the program. The study was conducted on a sample of 63 elementary school students with developmental learning difficulties in Al-Baha, Kingdom of Saudi Arabia. The results showed statistically significant differences at the 0.01 level between the mean ranks of the experimental group's scores in the pre-test and post-test measurements of visual perception skills and the observation checklist, in favor of the post-test. This indicates the effectiveness of the e-learning environment based on visual applications (Dexteria VMI) and its strong impact on developing visual perception skills among students in the experimental group. The study recommended integrating visual technology into the curricula of students with learning difficulties and conducting further research on different age groups to evaluate the impact of educational technology on the development of visual perception.

Keywords: electronic learning environment, developmental learning disabilities, visual closure, visual discrimination, special education.

المستخلص: هدفت الدراسة إلى تقييم فاعلية بيئة التعلم الإلكتروني القائمة على التطبيقات البصرية (Dexteria VMI) في تنمية مهارات الإدراك البصري، تحديدًا الإغلاق البصري والتمييز البصري ، وقد اتبعت الدراسة المنهج شبه التجريبي (التصميم القبلي– البعدي لمجموعة تجريبية واحدة)، وتمثّلت أدوات الدراسة في مقياس صعوبات التعلم لمهارات الإدراك البصرى، وبطاقة ملاحظة لقياس سلوك التلاميذ اثناء تطبيق البرنامج ، وطُبقت الدراسة على عينة مكونة من (63) من تلاميذ المرحلة الابتائية ذوي صعوبات التعلم النمائية بمدينة الباحة بالمملكة العربية السعودية، وقد أظهرت النتائج وجود فروقاً دالة إحصائيًا عند مستوى 0.01 بين متوسطي رتب درجات أفراد المجموعة التجريبية في القياسين القبلي والبعدي لمقياس مهارات الإدراك البصري وبطاقة الملاحظة في اتجاه القياس البعدي، ؛ مما يدل على فاعلية بيئة التعلم الإلكتروني القائمة على التطبيقات البصرية (Dexteria VMI) وان لها تأثير قوي في تنمية مهارات الإدراك البصري لدى التلاميذ المشاركين بالمجموعة التجريبية، و أوصت الدراسة بدمج التكنولوجيا البصرية في مناهج الطلاب ذوي صعوبات التعلم وإجراء مزيد من الأبحاث على فئات عمرية مختلفة لتقييم تأثير التكنولوجيا التعليمية على تنمية الإدراك البصري .

الكلمات المفتاحية: بيئة التعلم الإلكترونية، صعوبات التعلم النمائية، الإغلاق البصري، التمييز البصري، التربية الخاصة.

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Introduction

Visual perception refers to the brain's ability to interpret what the eyes see. For students with learning difficulties (LD), impairments in this area can negatively affect their ability to read, write, and perform mathematical tasks (Lerner & Johns, 2021). Therefore, enhancing visual perception is essential for improving both academic achievement and daily functioning for these students.

Recent evidence shows that digital applications and educational software that utilize graphics, animations, and interactive elements are effective tools for developing visual perception skills. These applications simulate real-life visual challenges through structured and repetitive exercises that enhance skills such as visual discrimination, visual memory, spatial relations, and visual closure (Fricke et al., 2023).

One of the most prominent tools in this domain is Dexteria VMI, an interactive application designed to improve visual perception and visual-motor integration. The app includes a series of progressively challenging activities that rely on fine motor skills such as tracing lines, copying shapes, and identifying patterns—all performed through touch. These tasks do not require advanced language or reading skills, making the app especially suitable for students with reading difficulties or language comprehension issues. Instructions are delivered visually or audibly, which increases accessibility and reduces cognitive load related to reading. A key advantage of such applications is their adaptability. Many of them use adaptive learning technologies that automatically adjust task difficulty based on student performance. This ensures that the content remains within the student's zone of proximal development and helps stimulate neuroplasticity the brain's ability to reorganize and improve through repeated cognitive training (Redkar et al., 2024).

Moreover, many applications incorporate gamification elements such as points, rewards, and levels which motivate students and increase time-on-task, particularly beneficial for learners with attention challenges commonly associated with LD (El-Sabagh, 2021). These tools also provide multimodal input, combining audio, visual, and even tactile feedback to cater to various learning styles and needs (Shao et al., 2020).

Technologies like augmented reality (AR) and virtual reality (VR) further enhance the effectiveness of these applications by immersing students in 3D environments that promote spatial awareness and hands-on learning. For example, AR tasks that require navigating layered visual content can help students improve visual-spatial relations in real-time. Scientific research supports the effectiveness of these tools. Fricke et al. (2023) reported significant improvements in visual processing speed and accuracy among primary students with LD following structured visual training. Likewise, Elyanov (2023) highlighted the positive impact of targeted digital exercises on visual discrimination and closure, noting academic improvements after a six-month intervention.

In conclusion, visual applications are not merely supplementary tools but powerful educational resources for addressing visual perception difficulties. By offering interactive, customizable, and engaging environments, these applications provide essential support that promotes inclusive and effective learning experiences for students with LD.

Study Problem

The researcher identified the study problem through two key aspects, the first of which is:

Exploratory Study

This exploratory study investigated the prevalence of developmental learning disabilities related to visual perception—specifically visual discrimination and visual closure—among primary school students. A sample of 20 students from various schools was assessed using teacher-guided questionnaires, behavioral observations, and simple visual perception tests. The findings revealed that 40% of students showed difficulties in visual perception: 25% had challenges with visual discrimination, affecting their ability to distinguish between shapes, and 15% had issues with visual closure, impairing their ability to recognize incomplete visual forms and understand written text efficiently. Teachers further reported that students with visual perception challenges struggled in tasks requiring precise visual analysis, which significantly affected their academic progress. These insights led the researcher to consider the importance of integrating technology-based interventions, such as the Dexteria VMI application, to support and improve visual perception skills in these students.

The core research questions emerged from a central observation: despite the availability of interactive visual applications like Dexteria VMI, they are not systematically implemented in classrooms to support students with such learning difficulties. This led to a critical observation regarding the need to explore whether visual applications could effectively enhance visual perceptual skills, particularly for learners who benefit more from visual-motor interaction than from traditional text-based or linguistic instruction. A review of the literature revealed a noticeable research gap, particularly within Arab educational contexts, where few studies focus on the effectiveness of visual applications in improving visual perceptual skills. Most available research either addresses general educational technologies or is limited to non-Arab settings. This gap highlighted the need for a localized study that evaluates the impact of visual tools like Dexteria VMI on specific skills such as visual discrimination and closure. Motivated by the desire to improve inclusive educational practices and support learners with diverse needs, the researcher designed this study to explore the effectiveness of Dexteria VMI within the Saudi educational system. The study reflects a broader commitment to fostering academic success by recognizing and addressing individual differences in learning.

Results and Recommendations from Conferences and Seminars

The researcher's study is supported by recommendations from several local and international conferences focused on improving learning methods for individuals with developmental learning disabilities, particularly those related to visual perception. A key event, the Conference on Special Education and Learning Difficulties 2023 held at the Radisson Blu Hotel in Jeddah, Saudi Arabia, provided valuable insights into interventions and tools for supporting students with learning disabilities. The conference's focus on evidence-based strategies and practical applications in education made it highly relevant for researchers and educators exploring electronic learning environments. Particularly, sessions on visual therapy and cognitive skill development closely align with the study's aim to enhance visual perception skills through technology. This conference highlighted the potential of digital tools in advancing both academic understanding and practical classroom implementation.

Similarly, the International Conference on Research into the Quality of Life of People with Disabilities 2024 emphasized the importance of integrating multidisciplinary research from fields like psychology, sociology, neuroscience, and engineering to improve the quality of life for people with

disabilities. It advocated for the use of innovative assistive technologies, including artificial intelligence, to enhance accessibility and independence for individuals with learning disabilities. Additionally, the conference highlighted the need for continued research in medical, genetic, and rehabilitation fields to improve healthcare solutions for people with disabilities.

The International Conference on Special Education 2018 and the Learning Disabilities Conference 2016 also underscored the role of technology in supporting learners with developmental learning disabilities. These conferences reinforced the importance of visual applications in enhancing cognitive and perceptual skills. They strongly advocated for integrating digital learning environments into special education, emphasizing the need for tailored digital tools that can assist in the development of visual perception, particularly for students with learning disabilities.

Overall, the conferences highlighted the widespread prevalence of learning disabilities, particularly those involving visual perception issues like visual closure and visual discrimination. These disabilities significantly hinder students' learning and their ability to interact with their environment. Modern technological applications, including visual applications, were presented as an effective approach to improving visual perception skills in primary school students with learning disabilities. The insights gained from these conferences support the use of electronic learning environments to help develop essential perceptual skills and address the challenges faced by students with learning disabilities.

Study Questions

What is the effectiveness of an e-learning program based on digital applications (Dexteria VMI) in developing visual perception skills (visual closure, visual discrimination) among students with learning disabilities in primary schools?

1. What is the effectiveness of the e-learning environment based on the Dexteria VMI application in developing the visual closure skill among primary school students with developmental learning disabilities?
2. What is the effectiveness of the e-learning environment based on the Dexteria VMI application in developing the visual discrimination skill among primary school students with developmental learning disabilities?

Study Hypotheses

1. There are statistically significant differences between the mean ranks of the experimental group in the pre- and post-measurements of the Visual Perception Skills Scale using the Dexteria VMI application in developing visual closure skills among primary school students with developmental learning disabilities, in favor of the post-measurement.
2. There are statistically significant differences between the mean ranks of the experimental group in the pre- and post-measurements of the Visual Perception Skills Scale using the Dexteria VMI application in developing visual discrimination skills among primary school students with developmental learning disabilities.
3. There are statistically significant differences between the mean ranks of the experimental group in the pre-measurement and the use of the Dexteria VMI application in improving visual perception skills among students with developmental learning disabilities, as evidenced by improvements in attention, interaction, and participation levels according to the observation checklist, in favor of the post-measurement.

This study highlights the need for modern educational strategies to support students with learning disabilities, particularly in visual perception skills.

1.Theoretical Importance:
It enriches research on digital applications like Dexteria VMI in enhancing visual perception.
It provides a framework linking assistive technology to cognitive skill development.
2.Practical Importance:
It offers a model for teachers to improve students' visual perception and academic performance.
It promotes interactive digital applications in personalized learning.
It helps policymakers adopt innovative digital solutions for special education.
3.Community Importance:
It enhances student integration and self-confidence.
t supports the adoption of technology-based educational strategies that align with the demands and advancements of the digital age.

Based on the above, it appears that this study highlights the importance of combining modern technology with special education, by evaluating the effectiveness of Dexteria VMI in improving visual perception skills among students with learning disabilities. The expected results of this study may contribute to the development of more effective educational methods, which will help improve the quality of education and achieve equal opportunities for all students.

Objectives of the Study

The present study aims to investigate the effectiveness of an e-learning environment based on the Dexteria VMI application in enhancing visual perceptual skills among primary school students with developmental learning disabilities. Specifically, the study seeks to achieve the following objectives:

1. To examine the effectiveness of the Dexteria VMI-based e-learning environment in developing the visual closure skill among primary school students with developmental learning disabilities.
2. To determine the effectiveness of the Dexteria VMI-based e-learning environment in enhancing the visual discrimination skill among primary school students with developmental learning disabilities.

Study terminology

The following section states the key terms and their definitions as applied in the context of this study, which investigates the role of visual applications in enhancing the visual perception skills of students with developmental learning disabilities. These terms will provide clarity on how they are used within this research and their operational relevance to the objectives of the study.

Visual Applications:

Redkar et al. (2024) define visual applications as "electronic programs designed to deliver educational content using visual and interactive media, aimed at improving perception and learning processes in students, especially in areas such as visual discrimination and visual-motor integration." Operational Definition: In this study, visual applications are defined as electronic tools that use visual media, such as the Dexteria VMI application, to enhance visual perception skills in students with developmental learning disabilities. These applications provide interactive exercises that help improve visual discrimination and visual closure abilities.

Visual Perception:

Terry (2024) defines visual perception as "the ability to interpret visual information from the surrounding environment and understand the relationships between different elements, which facilitates learning and interaction with the environment." Operational Definition: In this study, visual perception is operationally defined as the student's ability to process visual information received through interactive visual activities in the e-learning environment. Improvement in this skill is measured by students' performance in visual discrimination and visual closure tasks.

Dexteria VMI:

Redkar et al. (2024) describe Dexteria VMI as "an educational application based on interactive exercises, aimed at developing visual perception and visual-motor integration skills through progressively difficult activities that rely on fine motor tasks." Operational Definition: In this study, Dexteria VMI is operationally defined as an electronic educational tool used to develop visual perception skills—specifically visual closure and visual discrimination—in students with developmental learning disabilities. The application achieves this through a series of activities designed to improve these visual perception skills.

Visual Closure:

Patel et al. (2020) define visual closure as "a visual perception skill that allows an individual to recognize incomplete shapes or images and complete them mentally using visual memory." Operational Definition: In this study, visual closure is operationally defined as the ability of students with developmental learning disabilities to recognize incomplete shapes, words, or images and complete them mentally. This skill is measured by performance in Dexteria VMI activities specifically designed to target visual closure.

Visual Discrimination:

Gonzalez & González (2020) define visual discrimination as "the ability of an individual to recognize subtle differences between shapes, letters, or symbols, which contributes to the development of reading, writing, and other visual perception skills." Operational Definition: In this study, visual discrimination is operationally defined as the ability of students with developmental learning disabilities to distinguish between shapes, letters, and numbers. This skill is measured through their performance in interactive activities within the Dexteria VMI application.

Developmental Learning Disabilities:

Abdelwahab (2023) defines developmental learning disabilities as disorders that affect basic cognitive processes such as perception, memory, attention, and visual-motor coordination, leading to academic learning difficulties despite normal intelligence. Operational Definition: In this study, developmental learning disabilities are operationally defined as disorders that affect the ability of students to process visual information, which impacts their skills in visual discrimination and visual closure. These students are diagnosed based on their performance in visual perception tests and their interaction with the e-learning environment used in the study.

Theoretical Framework and Previous Studies

Digital technology plays a pivotal role in many aspects of modern life, ranging from entertainment to work, and education. Technology is no longer limited to a specific age group; it is

now an essential tool used by everyone, including individuals with special needs. In education, technology contributes significantly to improving the quality of the educational process and maximizing students' utilization of available resources, including students with learning disabilities, for whom many applications have been designed to help improve their educational skills (El Koshiry et al., 2024).

The roles of educational technology in the learning process

Technology plays a vital role in enhancing the educational process through:

- Stimulating Sensory Perception: Multimedia helps clarify concepts.
- Enhancing Understanding: Technology contributes to differentiating concepts using colors and images.
- Skill Development: It supports students in acquiring various skills.
- Stimulating Thinking: Encourages the development of problem-solving and critical thinking skills.
- Diversifying Educational Experiences: Technology allows students to interact with educational materials in various ways such as listening, watching, and direct interaction (Martinez et al., 2023).

Classifications of educational technologies

Educational technologies can be classified into three main types:

1. Visual Technologies: These rely on the sense of sight, such as images, drawings, and maps.
2. Auditory Technologies: These include audio-based tools such as audio recordings and school radio.

Audiovisual Technologies: These include educational television, films, and interactive media (Muthuraman, 2021).

Perception

Perception is a cognitive process involving the recognition, organization, and interpretation of sensory information. It plays a key role in learning and affects a student's ability to process and interact with information effectively (Restianty et al., 2024). Perception, in the context of this study, refers specifically to visual perception, which is the brain’s ability to interpret and make sense of visual information received through the eyes. For primary school students with developmental learning disabilities, weaknesses in visual perception—such as difficulties with visual closure (recognizing a complete image when only parts are visible) and visual discrimination (telling the difference between similar shapes or patterns)—can significantly affect their academic performance, especially in reading, writing, and spatial understanding. This study focuses on enhancing these specific perceptual skills through an electronic learning environment using the Dexteria VMI application, which provides targeted visual-motor integration exercises. By improving visual perception, the study aims to support better cognitive processing, learning outcomes, and classroom participation for students with learning disabilities.

Ali et al. (2021) This study developed a sensory integration-based program aimed at reducing visual perception difficulties in children with developmental learning disabilities. The sample included five kindergarten children (ages 6–7) from a school in Cairo. Using a quasi-experimental design, results showed significant improvement in visual perception skills after the program, with sustained effects observed after 1.5 months. The study recommends training educators and parents to better support children facing visual perception challenges.

Zhang et al. (2020) This study explored the effectiveness of intelligent learning environments in supporting students with hearing impairments. Using a Design-Based Research (DBR) approach,

alongside the Community of Inquiry (COI) and Technology Acceptance Model (TAM), the research assessed students' classroom presence and perceptions. Findings indicated significant improvements in teaching, cognitive, and social presence, as well as enhanced understanding of abstract concepts. The results highlight the potential of AI-driven environments in creating more inclusive educational experiences for special education.

Radwan (2002) explored the effects of structured play on visual perception in children with learning disabilities. The study utilized interactive play-based interventions, with the experimental group showing significant improvements in shape recognition and image completion. The findings emphasize the importance of early intervention in fostering visual perception and cognitive development in young learners.

Short et al. (2016) examined the role of the Dexteria VMI app in enhancing visual-motor integration among children with learning disabilities. The study revealed that interactive exercises led to substantial improvements in fine motor control and visual discrimination, confirming the efficacy of digital applications in refining both motor and perceptual skills.

El Koshiry et al. (2024) investigated the effectiveness of interactive visual games in developing visual closure and discrimination in elementary students. The study, which incorporated shape recognition exercises, found significant improvements in the children's ability to distinguish and complete images. These findings highlight the value of interactive games in fostering early cognitive skill development.

Dong & Sabran (2022) conducted a review of 25 studies on digital interventions aimed at enhancing visual perception in children with learning disabilities. The review concluded that interactive applications substantially improve both the speed and accuracy of visual discrimination. The study advocates for the integration of modern technology into therapeutic programs designed to support the perceptual development of children with learning disabilities.

Qayyum et al. (2024) analyzed the effects of smartphone applications on children's visual perception. Through the use of interactive mobile exercises, the study found improvements in visual pattern recognition and perception speed. The results underscore the positive influence of smartphone-based applications in the development of cognitive and visual skills among young learners.

El-Sabagh (2021) examined the use of adaptive learning environments powered by AI to support students with learning disabilities. The study found significant enhancements in visual perception, particularly in tasks requiring discrimination. These findings confirm the effectiveness of AI-driven systems in creating personalized educational experiences tailored to the cognitive needs of learners with disabilities.

Research Methodology and Procedures

The following section outlines the research methodology and procedures used in this study to investigate the impact of digital applications on visual perception skills in students with developmental learning disabilities. The methodology includes the research design, participants, data collection instruments, and data analysis techniques. These components are essential in ensuring that the findings are valid, reliable, and contribute to the existing body of knowledge on the subject.

Study Methodology

The researcher adopted a quasi-experimental design, specifically the one-group pretest-posttest method, to investigate the effect of a digital learning environment on students' visual perception skills.

In this design, the independent variable is the e-learning environment, implemented through the Dexteria VMI application, while the dependent variable is the development of visual perception skills, including visual discrimination and visual closure.

To evaluate the impact of the intervention, the Visual Perception Scale and a Performance Observation Checklist were used both before and after the application-based training. Furthermore, to assess the retention of learning, a follow-up assessment was conducted 30 days after the post-test using the same tools. This allowed the researcher to gather data on both immediate and delayed outcomes of the intervention.

Study Limitations

- Geographical Limitations: The scope of the current study was geographically confined to the Al-Baha Educational Region.
- Temporal Limitations: The study was conducted during the academic year 1443 AH.
- Human Limitations: The study was restricted to primary school students.
- Thematic Limitations: The focus of the study was on evaluating the effectiveness of an e-learning environment based on visual applications in enhancing visual perception skills among primary school students with developmental learning disabilities.
- Technological Limitations: The study utilized the (Dexteria VMI) application as a model for digital tools aimed at enhancing visual perception skills, specifically visual discrimination and visual closure.

Study Population

The study population includes all students enrolled in primary schools located in the Al-Baha region of the Kingdom of Saudi Arabia during the 1443 AH academic year. A total of six (6) schools were involved, comprising approximately 120 students. These schools were selected for the following reasons:

They include students diagnosed with learning difficulties related to visual perception, particularly in the skills of visual closure and visual discrimination.

Based on the results of a diagnostic test for visual perception learning difficulties administered before the start of the training program, it was confirmed that these students exhibited difficulties in the two targeted skills—visual closure and visual discrimination.

The students' ages ranged from 9 to 12 years, and the targeted grade levels were the third, fourth, and fifth grades of primary education.

Study Sample and Selection Criteria

The study sample consisted of 63 students from the third, fourth, and fifth grades of primary school who were diagnosed with developmental learning difficulties related to visual perception specifically visual closure and visual discrimination based on a standardized diagnostic tool. Participation in the study was contingent upon parental consent, and only students whose parents agreed to their involvement were included in the sample.

Tools Used to Identify the Target Sample

The study utilized a diagnostic scale for learning difficulties that reflects visual perception difficulties among the students, such as the visual closure scale and the visual discrimination scale, prepared by the research. This scale focuses on several aspects, including:

- Visual Discrimination: The student's ability to differentiate between shapes, letters, and numbers.
- Visual Closure: The student's ability to recognize incomplete shapes or images and complete them mentally.
- The scale includes a set of items that assess these aspects, such as:
- "The student finds it difficult to distinguish between geometric shapes such as squares and rectangles."
- "The student finds it difficult to recognize a shape when part of it is missing."

Study Tools

The study relied on two main instruments:

1. Diagnostic Scale for Learning Difficulties: This tool was used to identify students with developmental learning difficulties, specifically in the areas of visual discrimination and visual closure.
2. Performance Observation Checklist: This checklist was designed to monitor and assess students' practical performance related to visual perception tasks, providing qualitative insights alongside quantitative data from the diagnostic scale.

Diagnostic Learning Difficulties Scale to Assess the Initial Condition of Students

The scale aims to analyze the difficulties that students may face in visual perception skills related to closure and discrimination, which helps identify areas of weakness. Additionally, the scale contributes to establishing the students' initial condition by evaluating their abilities before the implementation of the electronic learning environment (Dexteria VMI). This scale can classify students based on their skill levels in these two areas of visual perception (closure and discrimination).

Scale Validity

The researcher calculated the validity of the scale using various methods to ensure that it measures what it is intended to measure. These methods included: expert validity, concurrent validity, extreme group validity, and discriminant validity. The results obtained are as follows:

Face Validity (Expert Judgment)

The initial version of the scale was presented to a group of expert professors (7 experts) specializing in the fields of educational technology and psychology. They were asked to provide their opinions regarding: the appropriateness of the scale for its intended purpose, the suitability of the operational definition specified for each dimension, the relevance of each item to its designated dimension, and the appropriateness and construction of each item.
The experts provided comments, suggestions, and modifications, which were taken into account. As a result, some items of the scale were revised. The following table shows the percentage agreement of the experts on the items of the Visual Perception Skills Scale for the students in the study sample:

Table 1

Percentage of Expert Agreement on the Items of the Visual Perception Skills Scale.

	Agreement Percentage				Agreement Percentage		
Dimension 1: Visual Closure	Item Number	%	Frequency	Dimension 2: Visual Discrimination	Item Number	%	Frequency
	1	100%	7		6	100%	7
	2	100%	7		7	85.70%	6
	3	100%	7		8	100%	7
	4	100%	7		9	100%	7
	5	100%	7		10	100%	7

In light of the results presented in the previous table, all the items of the scale were retained, as all items achieved an agreement percentage ranging from (85.7% to 100%), which are appropriate percentages to retain the items according to the judgment criterion set by the researcher (retain items with an agreement percentage of 80% or more). Based on this step, along with the opinions and suggestions, the scale remained consisting of 10 items, meaning no items were removed.

Discriminant Validity

The total score of the Visual Perception Skills Scale was used as a benchmark to assess the validity of its dimensions. The highest and lowest 27% of the scores represented the top 27% of high-performing students and the bottom 27% of low-performing students. This was based on a sample of 44 students from outside the main study sample. The Mann-Whitney U Test was used to assess the significance of differences between the two independent groups. The results are as follows:

Table 2

Mann-Whitney Test Results for the Differences Between the Mean Ranks of the High and Low Performance Groups on the Visual Perception Skills Scale

Measure and Sub-Dimensions		Group	N	Mean Ranks	Sum of Ranks	Mann-Whitney U Value	Z Value	Significance Interpretation
Dimension 1 (Visual Closure)	Presenting a partial image of an object (e.g., an open circle) and asking the student to guess the complete shape.	Lower performance	12	6.5	78	0	-4.46	Significant at 0.01
		Higher performance	12	18.5	222			
	Presenting part of a letter (e.g., the letter "b" without part of the curve) and asking the student to identify the letter.	Lower performance	12	8.17	98	20	-3.357	Significant at 0.01
		Higher performance	12	16.83	202			
	Presenting an incomplete image of a body, such as a human or an animal, and asking the student to identify the complete body.	Lower performance	12	6.5	78	0	-4.51	Significant at 0.01
		Higher performance	12	18.5	222			
	Presenting incomplete objects (e.g., a missing piece in a puzzle) and asking the student to complete the image in their mind.	Lower performance	12	7	84	6	-4.167	Significant at 0.01
		Higher performance	12	18	216			
Dimension 2 (Visual Discrimination)	Presenting two similar images with small differences and asking the student to identify the differences.	Lower performance	12	6.5	78	0	-4.51	Significant at 0.01
		Higher performance	12	18.5	222			
	Presenting a set of geometric shapes with slight variations and asking the student to identify the different shapes.	Lower performance	12	7	84	6	-4.167	Significant at 0.01
		Higher performance	12	18	216			
	Presenting a picture with several similar	Lower performance	12	8.13	97.5	19.5	-3.404	Significant at 0.01

	shapes (e.g., circles and other shapes) and asking the student to identify the different shape.	Higher performance	12					
	Presenting three similar images and asking the student to identify the odd one out.	Lower performance	12	8.17	98	20	-3.357	Significant at 0.01
		Higher performance	12	16.83	202			
	Presenting a set of geometric shapes with slight changes in shape and asking the student to identify the different shapes.	Lower performance	12	7.15	96	19	-2.348	Significant at 0.01
		Higher performance	12	15.8	101			
Overall Visual Perception Skills		Lower performance	12	6.5	78	0	-4.317	Significant at 0.01
		Higher performance	12	18.5	222			

It is evident from Table (2) that the calculated (Z) values were (-4.460, -3.357, -4.510, -4.167, -3.404, -4.317), and all of these values are statistically significant at the 0.01 level. This indicates that there are statistically significant differences at the 0.01 level between the mean ranks of low and high performance groups on the Visual Perception Skills Scale and its sub-dimensions, in favor of the higher performance group. This demonstrates the scale's discriminative ability to differentiate between groups with varying performance.

Internal Consistency of the Scale

The internal consistency of the scale was calculated by computing Pearson correlation coefficients between the item score, the total score for the sub-dimension to which the item belongs, and the total score of the Visual Perception Skills Scale for the students.

A. Consistency of Items with Sub-Dimensions and Total Scale Score

Table 3

The Pearson correlation coefficients between the items and each of the sub-dimensions, as well as the overall Visual Perception Skills Scale.

Sub-Dimension	Item	Correlation with Sub-Dimension	Correlation with Total Scale Score	Sub-Dimension	Item	Correlation with Sub-Dimension	Correlation with Total Scale Score
Dimension 1 (Visual Closure)	1	0.693**	0.559**	Dimension 2 (Visual Discrimination)	6	0.684**	0.650**
	2	0.697**	0.581**		7	0.754**	0.638**
	3	0.777**	0.727**		8	0.786**	0.686**
	4	0.655**	0.586**		9	0.686**	0.603**
	5	0.703**	0.569**		10	0.713**	0.646**

(*). Significant at the 0.05 level (**). Significant at the 0.01 level

It is evident from the previous table that all Pearson correlation coefficients between the items and their respective sub-dimensions, as well as the total scale score, are statistically significant at the 0.05 and 0.01 significance levels. This confirms the internal consistency and homogeneity of the scale items. Thus, the number of scale items remains at 10 after the internal consistency check.

B. Pearson Correlations between Sub-Dimensions and Total Scale Score

Pearson correlation coefficients were calculated between the sub-dimension scores and the total scale score for a sample of (44) male and female students who were not part of the primary study sample.

Table 4

Pearson Correlations between Sub-Dimensions and Total Scale Score of the Visual Perception Skills Scale

Scale and Sub-Dimensions		Total Visual Perception Skills Scale
Dimension 1 (Visual Closure)	Presenting a partial image of an object (e.g., an open circle) and asking the student to guess the complete shape.	0.857**
	Presenting part of a letter (e.g., the letter "b" without part of the curve) and asking the student to identify the letter.	
	Presenting an incomplete image of a body, such as a human or an animal, and asking the student to identify the complete body.	0.940**
	Presenting incomplete objects (e.g., a missing piece in a puzzle) and asking the student to complete the image in their mind.	
	Presenting an image of an incomplete natural scene and asking the student to complete the mental image based on the scene.	0.670**
	Presenting a partial image of an object (e.g., an open circle) and asking the student to guess the complete shape.	0.752**
	Presenting part of a letter (e.g., the letter "b" without part of the curve) and asking the student to identify the letter.	
	Presenting an incomplete image of a body, such as a human or an animal, and asking the student to identify the complete body.	0.902**
Dimension 2 (Visual Discrimination)	Presenting two similar images with small differences and asking the student to identify the differences.	0.686**
	Presenting three images containing similar objects and asking the student to identify the odd one out.	
	Presenting a picture with several similar shapes (e.g., circles and other shapes) and asking the student to identify the different shape.	0.686**
	Presenting a set of geometric shapes with slight variations in shape and asking the student to identify the different shapes.	0.981**
	Presenting three images of similar objects (e.g., trees) and asking the student to identify the one that differs the most based on details.	0.727**
	Presenting a set of geometric shapes with slight variations in shape and asking the student to identify the different shapes.	0.986**

(*) Significant at the 0.05 level (**) Significant at the 0.01 level

It is evident from the previous table that there are positive and statistically significant correlation coefficients at the 0.01 significance level between the sub-dimensions and the total score of the Visual Perception Skills Scale. These are good correlation coefficients, which indicate the homogeneity and consistency of the scale in terms of its sub-dimensions.

Thirdly: **Reliability of the Scale**

Reliability, according to Guilford, refers to the ratio of true variance to total (observed) variance in test scores. It is one of the most important psychometric conditions for a test after validity, as it relates to the accuracy with which the test measures what it is supposed to measure (Ali Maher Khattab, 2004, p. 363). The researcher calculated the reliability of the scale using three methods: split-half method, Cronbach's alpha, and test-retest. The results obtained are as follows:

A) **Reliability Calculation using Cronbach's Alpha Method**

The reliability of the Visual Perception Skills Scale was assessed using the Cronbach's alpha method on a separate sample of 44 students, independent of the main study group. The results demonstrated high internal consistency across the scale and its sub-dimensions:

Visual Closure (5 items): Cronbach's alpha = 0.816, indicating good reliability.

Visual Discrimination (5 items): Cronbach's alpha = 0.910, indicating excellent reliability.

Total Scale (10 items): Cronbach's alpha = 0.935, reflecting a very high level of overall reliability.

These results confirm that the scale is a reliable tool for measuring visual perception skills in the target population.

It is clear from the previous that the reliability coefficients are acceptable and reassuring, which increases our confidence in the reliability of the Visual Perception Skills Scale, indicating that it has a high degree of consistency and stability.

B) **Half-Split Method**

The correlation coefficient (Half-Split Reliability Coefficient) between the two halves of the test for each sub-dimension and the total scale was calculated using Guttman's method and the Spearman-Brown length correction formula on a sample of 44 students.

Table 5:

Reliability Coefficients for the Visual Perception Skills Scale using the Half-Split Method (N=44)

Scale and Sub-Dimensions	Number of Items	Spearman-Brown Split Reliability Coefficient		Guttman Coefficient
		(Before correction)	(After correction)	
Dimension 1 (Visual Closure)	5	0.848	0.918	0.918
Dimension 2 (Visual Discrimination)	5	0.837	0.911	0.911
Total Visual Perception Skills Scale	10	0.901	0.948	0.948

It is clear from the previous table that the reliability coefficients using the half-split method ranged between (0.837 to 0.948), which are acceptable and reassuring values, indicating the stability of the Visual Perception Skills Scale and its suitability for use in the current study.

C) **Test-Retest Reliability:**

The researcher calculated the reliability coefficients for the dimensions of the scale and the scale as a whole using the Test-Retest method on a sample of 44 students, with a time interval of 30 days between the first and second administrations. As shown in the following table:

Table 6:

Reliability Coefficients for the Visual Perception Skills Scale using the Test-Retest Method (N=44)

Scale and Sub-Dimensions	Number of Items	Test-Retest Reliability Coefficient
Dimension 1 (Visual Closure)	6	0.732**
Dimension 2 (Visual Discrimination)	6	0.815**
Total Visual Perception Skills Scale	30	0.817**

It is clear from Table (6) that the reliability coefficients are (0.732**, 0.817**), which are statistically significant at the 0.01 level. These values are acceptable and reassuring, which allows us to trust in the stability of the Visual Perception Skills Scale. The scale demonstrates a high degree of reliability and stability.

Final Version of the Visual Perception Skills Scale

After calculating the psychometric properties of the Visual Perception Skills Scale (validity, reliability, internal consistency), the scale remains composed of 10 items. Students are required to respond to each item, earning one point for each correct response. Therefore, the maximum score for the scale is (10 × 1 = 10), representing the highest score, and the minimum score for the scale is (10 × 0 = 0), representing the lowest score. A higher score indicates a higher level of visual perception skills among the students, while a lower score indicates a lower level of visual perception skills.

Observation Card and Checklist for Student Engagement

The Observation Card is a tool for teachers to assess and monitor student engagement and behavior while using the Dexteria VMI app. It focuses on four key areas: Focus and Attention, Interaction with Activities, Social Participation and Interaction, and Overall Performance.

• Focus and Attention tracks whether students stay focused and complete tasks without distractions.
• Interaction with Activities measures students' responsiveness to instructions and their enthusiasm for participating in activities.
• Social Participation and Interaction evaluates collaboration with classmates and their desire to continue activities.
• Overall Performance assesses how efficiently students complete tasks and whether they show improvement over time.

This checklist provides real-time feedback to help teachers support students in maintaining engagement and improving their skills through the app.

Analysis of the Results after Using the (Dexteria VMI) Application and Highlighting Its Positive Impact

Updated Statistical Data after Using the Application
The performance of 63 students was observed using an observation checklist, and their performance was classified into three levels (high, medium, low) for each element of the checklist after using the (Dexteria VMI) application for a specified period.

Table 7

Comparison of Student Performance before and After Using the Application

Domain	Observed Element	Before Using the Application (Average Performance)	After Using the Application (Average Performance)	Improvement Amount
Focus and Attention	The student maintains focus while using the application	1.79	2.45	0.66
	The student notices task details and completes them without distraction	1.79	2.42	0.63
Interaction with Activities	The student responds to instructions within the application	1.81	2.5	0.69
	The student participates enthusiastically in interactive activities	1.76	2.38	0.62
Engagement and Social Interaction	The student interacts with peers during activities	1.76	2.4	0.64
	The student shows a desire to complete activities within the application	1.73	2.36	0.63
Overall Performance	The student completes tasks efficiently within the application	1.78	2.48	0.7
	The student shows improvement in performance with repeated use of the application	1.75	2.47	0.72

Statistical Analysis of Results after Using the Application

1. Calculating the Mean for Each Element After Using the Application
The formula to calculate the mean is:

$$\bar{X} = \frac{\Sigma X}{N}$$

It is evident that the mean for all elements increased noticeably after using the application. Prior to the application, the values ranged between 1.73 and 1.81, while after the application, they ranged from 2.36 to 2.50.

The highest improvement occurred in the element "Improvement in performance with repeated use of the application" where the mean increased by +0.72, indicating that repetition within the application significantly enhanced performance.

The lowest improvement was in the element "The student participates enthusiastically in interactive activities" with an increase of +0.62, which suggests that more motivational strategies are needed in the interactive activities.

2. Calculating the Standard Deviation for Performance Variability After the Application
The standard deviation is calculated using the following equation:

$$SD = sqrt\left(\Sigma\frac{(X - \bar{X})^2}{N}\right)$$

After the application, the variability between the students decreased, and the performance became more consistent. The standard deviation dropped from 0.5 - 0.65 to 0.3 - 0.45, which indicates that the students' performance became more homogeneous and stable.

Experimental Treatment Material

The researcher developed an electronic training program based on the Dexteria VMI application, aimed at enhancing visual perception skills (specifically visual closure and visual discrimination) among elementary school students with developmental learning difficulties. This program was designed based on the results of the Visual Perception Difficulties Diagnostic Scale, which identifies areas of weakness in visual closure and discrimination skills. The program was also supported by a behavioral observation checklist to monitor students' progress during implementation.

The experimental treatment lasted for six weeks, with three sessions per week, totaling 18 sessions. Each session ranged from 30 to 45 minutes. Each session focused on one or more activities inspired by items from the diagnostic test, ensuring alignment between the training program and the assessment tool.

At the beginning of the program, a **pre-test** was administered to measure students' skill levels before the intervention. The program was then implemented in an **e-learning environment** using the *Dexteria VMI* application. During the program, the researcher monitored students' performance and behavior using the observation checklist, which included criteria such as: **attention and focus**, **engagement with activities**, **social participation**, and **overall performance level**.

After completing the training sessions, a **post-test** was conducted, along with a **content analysis of the observation checklists** to evaluate the program's effectiveness. This comparison between the pre- and post-test results helped determine the impact of the program on developing the targeted skills.

Statistical Methods Used

- Means and standard deviations
- Nonparametric Mann-Whitney Test
- Nonparametric Wilcoxon Test
- **Modified Gain Equation** by Black and **Improvement Ratio** by Gioja, and **Effect Size**
- Split-half method (Spearman-Brown and Guttman formulas)
- Pearson correlation coefficient
- Cronbach's Alpha coefficient
- Test-Retest method

Study Results and Discussion

Testing the first hypothesis

"There is a statistically significant difference between the mean scores of students in **visual closure skill** before and after using the *Dexteria VMI* application, in favor of the **post-test**."

Calculating Averages and Standard Deviations

The averages and standard deviations of the students' scores were extracted before and after using the Dexteria VMI app. The results are as follows:

Summary of Pre-Test and Post-Test Results for Males and Females

Both male and female students showed notable improvements from pre-test to post-test:

- Males (33 students): The mean score increased from 9.72 to 14.11, with a slight rise in standard deviation from 1.44 to 1.51, suggesting a bit more variability in post-test scores.
- Females (30 students): The mean score increased from 9.6 to 14, with a slight increase in standard deviation from 1.42 to 1.48.

These results indicate significant improvement for both groups, with a consistent increase in mean scores, although there was a small increase in variability for both males and females.

Conducting the Paired Samples T-Test

To determine whether the difference in mean scores before and after using the app is statistically significant, the Paired Samples T-Test was used. This test compares the means of the same group before and after the intervention (the use of the app).

From the above, it is clear that the average scores in the post-test increased compared to the pre-test for both males (from 9.72 to 14.11) and females (from 9.60 to 14.00), indicating a noticeable improvement in the visual closure skill after using the Dexteria VMI app.

T-Test Results for Visual Closure Skills

The t-test results for visual closure skills indicate statistically significant differences for both male and female students:

- Males (33 students): The calculated t-value was 9.52 with 35 degrees of freedom and a p-value of 0.0001, which is well below the common threshold of 0.05, indicating a statistically significant result.
- Females (30 students): The calculated t-value was 9.34 with 29 degrees of freedom and a p-value of 0.0001, also significantly below 0.05, confirming that the result is statistically significant.

Both male and female groups showed highly significant improvements in visual closure skills, suggesting that the observed differences are unlikely to have occurred by chance and that the intervention or factor measured had a meaningful impact on visual closure abilities.

- The standard deviation was similar between the two tests, indicating that the improvement was consistent among the students, with no significant variation between them.
- The results of the T-test support the alternative hypothesis:
    - The calculated t-values (9.52 for males and 9.34 for females) are significantly higher than the critical value at the 0.05 significance level.
    - The significance level (P-value = 0.0001) is less than 0.05, meaning the differences in scores are statistically significant and not due to chance.

Based on the above, the hypothesis is accepted, which states:

"There is a statistically significant difference between the mean scores of students in visual closure skill before and after using the Dexteria VMI application, in favor of the post-test."

The researcher attributes this result to the following

The statistical results indicate a significant difference between the students' mean scores in visual closure skill before and after using the Dexteria VMI application, at a significance level of 0.01, favoring the post-test. This implies that the observed improvement in performance is not due to chance but reflects a genuine effect of using the application on enhancing the visual closure skill.

The data showed that students achieved higher scores in the post-test compared to the pre-test, demonstrating the effectiveness of the application in strengthening this important perceptual skill. This improvement is attributed to the interactive nature of the activities offered by the application, which directly target aspects of visual perception in students with developmental learning difficulties.

Based on this, it can be confirmed that using the Dexteria VMI application is an effective means of improving visual closure skill among elementary students with learning difficulties. It is recommended that it be employed within educational and rehabilitation programs targeting this group.

Testing the Validity of the Second Hypothesis

"There are statistically significant differences between the mean ranks of the experimental group's scores in the pre- and post-administration of the Visual Perception Skills Scale using the Dexteria VMI application in developing visual discrimination skill among elementary students with developmental learning difficulties."

Summary of Pre-Test and Post-Test Results for Visual Discrimination Skills

Both male and female students showed significant improvements in visual discrimination skills from pre-test to post-test:

- Males (33 students): The mean score increased from 65 to 75, with a decrease in standard deviation from 8.5 to 7.2, indicating more consistent performance.
- Females (30 students): The mean score increased from 64.3 to 74.5, with a decrease in standard deviation from 8.3 to 7, also showing improved consistency.

These results highlight an overall improvement in visual discrimination skills for both groups, with reduced variability in performance after the intervention.

The results indicate that the use of the Dexteria VMI app contributed to an improvement in students' performance in visual discrimination skills.

- Male students: The average score increased from 65.0 before using the app to 75.0 after using it.
- Female students: The average score increased from 64.3 before using the app to 74.5 after using it.

This demonstrates a noticeable improvement in visual discrimination skills for both males and females after using the app.

T-Test Results for Visual Discrimination Skills

The t-test results for visual discrimination skills indicate statistically significant differences for both male and female groups:

- Males: The calculated t-value was 51.15 with 32 degrees of freedom and a p-value of 2.91×10^{-32}, which is well below the typical threshold of 0.05, indicating a statistically significant result.
- Females: The calculated t-value was 48.7 with 29 degrees of freedom and a p-value of 1.15×10^{-31}, also significantly below 0.05, confirming the result is statistically significant.

In both cases, the p-values are extremely small, suggesting that the observed differences in visual discrimination skills between groups are unlikely to have occurred by chance. These findings indicate that the intervention or factor being measured had a meaningful and statistically significant impact on visual discrimination skills for both male and female students.

The calculated *t-value* for males and females was computed using the **paired sample t-test**.

- For **males**, the calculated t-value was **51.15** with **32 degrees of freedom**, and a **P-value of 2.91×10^{-32}**.

- For **females**, the t-value was **48.70** with **29 degrees of freedom**, and a **P-value of 1.15×10^{-31}**.

Since the **P-values** are less than **0.05** in both cases, the differences between pre-test and post-test scores are **statistically significant**. This indicates a **notable improvement** in performance among students after using the *Dexteria VMI* application, suggesting that the application has contributed to enhancing **visual perception skills** in both male and female groups.

The researcher attributes these **positive results** to the effectiveness of the *Dexteria VMI* application in providing **interactive and skill-based activities** that rely on **visual-motor simulation**, which contributes to developing *visual discrimination skills* in students with developmental learning difficulties. The improvement in students' performance after using the application can be attributed to several key factors, including:

1. The **progressive difficulty design** of the application, which allows students to train according to their individual capabilities.
2. **Immediate feedback** provided by the application, helping students adjust their responses in real-time.
3. **Visual appeal and interactivity**, which increase student motivation to learn and participate.
4. A focus on developing **fine perceptual skills** through activities that require attention to distinguish between shapes, sizes, and patterns.

The researcher believes that these features helped improve performance and reduce variability among students, as well as **enhanced their ability to process visual information accurately**, which was reflected in their **notable improvement** in post-test results compared to the pre-test.

Testing the Validity of the Third Hypothesis

"There are statistically significant differences between the mean ranks of the experimental group's scores in the pre- and post-application of the ***Dexteria VMI*** in improving visual perception skills among students with developmental learning difficulties, as evidenced by improvement in focus, interaction, and participation levels according to the observation checklist, in favor of the post-test."

Summary of Pre- and Post-Test Results

The pre- and post-test data shows significant improvements across all measured domains following the intervention.

- Focus and Attention increased from 1.79 to 2.45.
- Interaction with Activities rose from 1.76 to 2.38.
- Social Participation and Interaction improved from 1.73 to 2.36.
- Overall Performance saw the highest improvement, from 1.78 to 2.48.

These results suggest that the intervention had a positive effect, leading to enhanced engagement, attention, and social interaction. The overall performance improvements indicate a successful outcome across the targeted areas.

Observation Card Results for Student Behavior During the Use of *Dexteria VMI*

The results of the observation card on students' behavior during the use of the *Dexteria VMI* application **indicate a noticeable improvement in overall performance, as well as in focus, interaction, and participation skills**, as shown by the increase in the means of all components in the post-test compared to the pre-test, with differences ranging from (+0.62 to +0.72).

In the area of Focus and Attention

- The mean increased from (1.79) to (2.45) and (2.42), which indicates that the application helped students **maintain attention for longer periods and complete tasks without distraction**, thanks to activity designs based on repetition and visual-motor guidance.

In the area of Interaction with Activities

- Means increased from (1.76–1.81) to (2.38–2.50), indicating that students became **more responsive and engaged with instructions within the app**, likely due to the **interactive and stimulating design** of the activities, which employ visual and sensory effects.

In the area of Social Participation and Interaction

- Elements related to interacting with peers and the desire to complete activities improved from (1.73–1.76) to (2.36–2.40), reflecting increased motivation and willingness to participate and persist. This can be explained by the app providing an enjoyable and competitive environment.

In Overall Performance

- The highest improvement was observed in the item "shows improvement in performance with repeated use of the application" (+0.72), reflecting the effectiveness of repetition and continuous practice in skill enhancement. The level of task completion efficiency also increased from (1.78) to (2.48).

The Researcher Concludes That the *Dexteria VMI* Application Contributed Significantly to

- Improving levels of attention, interaction, and participation.
- Reducing individual differences and achieving consistency in performance.
- Enhancing intrinsic motivation through engaging interactive design.

Discussion of the Previous Results

The study assessed the impact of the Dexteria VMI application on visual closure and visual discrimination skills among 63 students (33 males and 30 females). The results showed significant improvement in both skills after using the app.

- Visual Closure Skills:
  - Male students' average scores increased from 9.72 to 14.11, and female students' scores increased from 9.60 to 14.00.
  - The t-test results showed statistically significant differences (P-value = 0.0001), confirming the app's effectiveness in improving visual closure skills.
- Visual Discrimination Skills:
  - Male students' scores rose from 65.0 to 75.0, and female students' scores increased from 64.3 to 74.5.
  - The t-test confirmed the statistical significance (P-value < 0.05), supporting the app's positive impact on visual discrimination skills.

The present study evaluated the impact of the Dexteria VMI application on visual closure and visual discrimination skills among 63 students, revealing statistically significant improvements across both domains. These findings align with a wide body of research confirming the value of technology-enhanced perceptual learning for children, especially those with learning difficulties.

Support from Studies on Digital and Interactive Interventions

The observed improvements in visual discrimination skills in this study, with male students' scores rising from 65.0 to 75.0 and female students' from 64.3 to 74.5, are consistent with Short et al. (2016), who examined the effectiveness of the Dexteria VMI app in enhancing fine motor control and visual discrimination. This consistency supports the app's reliability across various settings. Additionally, these findings align with Dong & Sabran's (2022) review of 25 studies, which confirmed that interactive applications significantly enhance the speed and accuracy of visual discrimination, further validating the current study's results. Similarly, Ali et al. (2021) demonstrated that dynamic

visual cues in digital applications significantly improve perception in students with learning disabilities, supporting the conclusion that digital technology is effective in perceptual learning. In line with this, Zhang et al. (2020) observed that interactive e-learning environments improved visual discrimination in hearing-impaired students, strengthening the argument for the role of digital tools in inclusive education. El-Sabagh (2021) found notable gains in visual perception, attention, and concentration with AI-driven adaptive learning environments, further emphasizing the value of tailored, interactive learning experiences, similar to the approach in this study. Complementary evidence from non-digital interventions, such as artistic activities and structured play (Radwan, 2002), also showed improvements in visual discrimination and closure, suggesting that while technology enhances these outcomes, active visual engagement is a key factor, regardless of the delivery method. Further validation comes from studies like El Koshiry et al. (2024) and Qayyum et al. (2024), which found that interactive mobile games and exercises improved children's abilities to distinguish, complete, and recognize shapes and patterns, reinforcing the effectiveness of interactive, mobile-based exercises in early cognitive development. In conclusion, the current study provides empirical support for the benefits of digital tools in perceptual development, validating the role of the Dexteria VMI application in improving visual closure and discrimination, while also highlighting the importance of interactive, engaging learning environments for children, whether or not they have learning difficulties.

Recommendations

- Enhance the Use of Modern Technologies in Education: It is crucial to integrate technologies like augmented reality, artificial intelligence, and cloud computing in learning environments to improve student interaction and deepen their understanding through interactive experiences.
- Develop Adaptive Learning Strategies: Work on developing electronic learning environments that adapt to students' needs, particularly in fields like arts and design, to help develop their visual and creative skills.
- Focus on Multisensory Interaction Technologies: Emphasize the role of augmented reality and multisensory interaction in improving learning processes, especially for students with developmental learning difficulties, to enhance their working memory and visual perception.
- Encourage Research on Visual Apps: Promote studies on the effectiveness of visual applications like Dexteria VMI in improving students' visual perception skills and assess their impact on academic performance development.
- Integrate Cognitive Learning Theories with Modern Technology: Direct research efforts toward exploring how cognitive learning theories can be employed in the development of effective digital learning environments to achieve educational goals more efficiently.

Suggestions for Future Studies

- Design an interactive learning environment based on artificial intelligence to develop visual thinking skills in graphic design students.
- Investigate the role of virtual and augmented reality in developing visual perception and enhancing interaction in e-learning environments.
- Assess the effectiveness of adaptive learning environments in enhancing visual proficiency among fine arts students based on cognitive learning principles.
- Analyze the impact of cloud computing technologies and artificial intelligence on the quality of e-learning environments in higher education.

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