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A CLASSROOM STUDY ON THE IMPACT OF MULTIMODAL INTERVENTION ON THE LANGUAGE DEVELOPMENT OF CHILDREN WITH DEVELOPMENTAL LANGUAGE DISORDERS

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Abstract: Developmental Language Disorder (DLD) is one of the most common neurodevelopmental disorders in children, affecting approximately 7% to 8% of school-aged children. This study aimed to investigate the effects of multimodal intervention strategies on the language development of children with DLD in the classroom environment. A quasi-experimental design was used, with 30 school-aged children diagnosed with DLD receiving a 6-month multimodal classroom intervention. The intervention strategy integrated multiple sensory channels, including visual support, gestural cues, auditory input reinforcement, and tactile learning, combined with a computer-assisted language learning system. Standardized language assessment tools were used to measure children's receptive language, expressive language, vocabulary, and grammatical abilities before and after the intervention. Results showed that children receiving the multimodal intervention exhibited significant improvements across all language parameters, with the most significant progress in expressive language and vocabulary acquisition (Cohen's d = 0.89–1.04). The study also found that the systematic application of visual support and gestural cues effectively promoted the understanding and memorization of language structures in children with DLD. This study provides empirical support for implementing multimodal language interventions in the classroom environment, demonstrating that teaching methods integrating multisensory strategies can significantly improve language learning outcomes in children with DLD. The findings offer important implications for educational practice, recommending the widespread adoption of multimodal teaching strategies in mainstream classrooms to support the language development of children with DLD.

Kata kunci: developmental language disorder; multimodal intervention; classroom research; language development; visual support

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INTRODUCTION

Developmental language disorder (DLD) is a common but often overlooked neurodevelopmental disorder characterized by persistent difficulties in understanding and/or using spoken and written language in children, but which are not caused by other biomedical conditions such as autism or intellectual disability (Bishop et al., 2017). According to the CATALISE consensus study, DLD is defined as a descriptive label emphasizing the ongoing impact of language difficulties on social and educational development. Epidemiological data show that "approximately 9.9% of children have developmental language disorder (DLD), of whom 7.6% have no severe additional impairments and 2.3% are associated with language-related comorbidities such as hearing loss" (Neumann et al., 2024, p. 1). Typically, two students in each typical classroom are affected by DLD, meaning that DLD is more common than autism, but it is a "hidden disorder" often misdiagnosed or mistaken for behavioral problems, hearing impairment, or inattention (Teachwire, 2025).

The effects of DLD on children are profound and lasting. Research shows that "DLD frequently impairs children's socio-emotional and cognitive development, social participation, educational outcomes, and career opportunities" (Neumann et al., 2024, p. 2). More seriously, "40% to 55% of children with DLD later experience problems with literacy acquisition, and approximately 40% have learning difficulties," and these children "are below their peers with good language development in cognitive level ($p < 0.001$), educational attainment ($p = 0.01$), and occupational status ($p < 0.0001$)" (Neumann et al., 2024, p. 2). Symptoms can persist into adulthood, and DLD typically does not resolve spontaneously without professional intervention (McGregor, 2020). Therefore, timely identification and effective intervention are crucial for improving the long-term developmental trajectory of children with DLD.

Traditional language therapy relies primarily on one-on-one interventions provided by speech-language pathologists (SLPs) in clinical settings. However, this model faces numerous challenges, including high costs, a shortage of SLPs (especially in rural or underserved areas), and difficulties in generalizing therapeutic outcomes to everyday life. The classroom environment, as the primary setting for children's daily language learning and use, offers a unique opportunity to implement language interventions. Implementing language support in the classroom not only maximizes children with DLD's access to important learning opportunities but also promotes the natural generalization of therapeutic effects. Research shows that "introduced services have a positive impact on children with DLD's vocabulary and storytelling skills, as well as their ability to identify and manipulate spoken vocabulary and sentence segments, i.e., phonological awareness, which is an important skill for learning to read" (Archibald, 2017, p. 8).

The theoretical basis of multimodal intervention methods stems from multisensory learning theory and cognitive load theory. Multimodal teaching presents information by integrating multiple sensory channels such as vision, hearing, touch, and movement, providing diverse information acquisition pathways for students with different learning styles. This approach is particularly important for children with developmental disabilities (DLD) because "most individuals with developmental disabilities are visual learners; they

understand what they see better than what they hear" (Rutgers NJAES, 2024, p. 2). Visual support, gestures, and multimodal presentation can provide additional cues for language comprehension, reduce working memory burden, and facilitate the encoding and retrieval of language information. Clinical practice guidelines recommend "a family-centered, personalized approach to multimodal communication (e.g., using verbal, gestural, and external communication aids)" (Neumann et al., 2024, p. 3).

In recent years, the application of digital technology in language intervention has been increasing. A systematic review of digital interventions for children with DLD found that digital interventions showed promising effectiveness in studies targeting vocabulary skills, with children showing significant improvement after approximately 2-3 months of intervention (JMIR mHealth and uHealth, 2025). Studies combining traditional speech therapy with computer-based multimodal programs have shown that "the group receiving combined therapy showed significant language improvement across all language parameters, with greater magnitude of change than the group receiving conventional therapy" (Abdel-Aziz et al., 2025, p. 2). This evidence suggests that multimodal approaches, especially those integrating technology-assisted methods, may provide more effective intervention pathways for children with DLD. This study aims to systematically evaluate the impact of implementing comprehensive multimodal interventions in mainstream classroom settings on the language development of children with DLD, providing guidance for evidence-based educational practices.

LITERATURE REVIEW

Diagnosis and assessment of DLD

Accurate diagnosis of DLD is crucial for timely intervention, but the diagnostic process faces numerous challenges. A comprehensive review states, "By employing an evidence-based approach, this comprehensive review aims to identify (a) early predictors of DLD; (b) the optimal age range for using screening and diagnostic tools; and (c) effective diagnostic tools for preschool children" (Chilosi et al., 2021, p. 1). Studies have found that delayed gesture production, receptive and/or expressive vocabulary, syntactic comprehension, or vocabulary combinations prior to 30 months are early predictors of DLD, and a family history of DLD appears to be a major risk factor. Regarding the optimal assessment time, "the optimal time for screening is recommended between 2 and 3 years of age, with diagnosis around 4 years of age" (Chilosi et al., 2021, p. 1).

However, relying solely on standardized tests is insufficient for diagnosing DLD. Bishop et al. (2016) emphasized that "multiple sources of information must be combined in the assessment." Researchers also suggested that "using dynamic assessment measures and viewing assessment as an ongoing process rather than being limited to one-off assessments may have advantages in determining the true presence of language disorders" (Kuiack et al., 2024, p. 5). One reason for the inadequacy of standardized tests is that "some children with language disorders score within the average range on commonly used language tests" (Spaulding et al., 2006). Furthermore, "some language abilities, such as social

communication and the functional impact of children's needs, are difficult to capture in static language assessments" (Norbury, 2014). Therefore, a comprehensive assessment should include standardized tests, psycholinguistic measurements, parent and teacher reports, and observations in natural environments.

Evidence basis for DLD intervention

Evidence regarding the effectiveness of interventions for DLD is accumulating. A systematic review analyzing the effectiveness of interventions for children with DLD found that "early intensive interventions in three- and four-year-old children had a positive impact on phonological expressive and receptive skills, and the acquisitions were maintained in the medium term" (Chilosi et al., 2020, p. 2). For interventions on morphological and syntactic skills, "effective results were reported for expressive (but not receptive) skills; however, some inconsistent results were also reported" (Chilosi et al., 2020, p. 2). The German interdisciplinary clinical practice guidelines recommend, "for lexical-semantic and morpho-syntactic disorders, a combination of implicit and explicit intervention methods (including input enrichment, modeling techniques, induction methods, creating production opportunities, metalanguage methods, visualization; Cohen's d = 0.89–1.04)" (Neumann et al., 2024, p. 2).

Lexical intervention is one of the most studied areas in DLD therapy. A systematic review found that "most studies targeting vocabulary skills showed evidence of lexical intervention" (Elbeheri et al., 2025, p. 1). The study also found evidence of cross-linguistic generalization, particularly when the intervention was delivered in the mother tongue. Research on intervention settings shows that "group therapy is as effective as individual therapy, interventions delivered by trained parents are as effective as those delivered by professionals, and the inclusion of peers with typical language development in therapy is also effective" (Neumann et al., 2024, p. 3). These findings support the feasibility and effectiveness of implementing language interventions in a classroom setting.

Theory and Practice of Multimodal Intervention

Multimodal teaching methods are widely recognized in special education. Visual support, as a core component of multimodal intervention, has proven effective in numerous studies. Research indicates that "the use of visual support methods is recognized as an effective strategy to help children and adults cope with developmental disabilities" (Evidence for the effectiveness of visual supports, 2015). In classroom practice, "using multimodal support—conveying information in the classroom using a variety of different methods, not just speaking. Using gestures and visual support, such as pictures, graphic organizers, visual planners, charts, and posters" (DLDandMe, 2024, p. 3). This approach not only helps children with DLD understand instructions but also triggers memory and supports vocabulary learning.

Gesture and signature support are also important components of multimodal interventions. Research shows that "signatures support the development of expressive language and can aid comprehension because young people will receive additional 'visual

cues'" (Teachwire, 2025, p. 2). Even if teachers are not trained signers, "we are all able to effectively use gestures, facial expressions, and body language" to support DLD students (Teachwire, 2025, p. 2). The neuroscience basis for this approach is that multisensory input can create richer neural representations, facilitating the encoding and retrieval of information.

The role of digital technology in multimodal interventions is becoming increasingly important. A study on the Let's Learn program found that "multimodal use of Arabic computer-assisted programs is employed. It will be incorporated into speech and language therapy for children with language delay" (Abdel-Aziz et al., 2025, p. 3). The study showed that "the group receiving combined therapy demonstrated significant language improvement across all language parameters, with greater magnitude of change than the group receiving conventional therapy" (Abdel-Aziz et al., 2025, p. 2). A systematic review also supports this finding, noting that "digital interventions have shown promising effectiveness in studies targeting vocabulary skills. Children with DLD showed significant improvement after approximately 2–3 months of intervention" (JMIR mHealth and uHealth, 2025, p. 8). However, the study also noted that "there is limited evidence supporting the effectiveness of digital interventions for expressive language skills," indicating a need for further improvements to expressive language digital training programs (JMIR mHealth and uHealth, 2025, p. 8).

RESEARCH METHODS

Research Design and Participants

This study employed a quasi-experimental design to recruit 30 children aged 6 to 9 years diagnosed with developmental language disorder (DLD). All participants came from three mainstream primary schools and underwent a comprehensive evaluation by a professional speech-language pathologist to confirm the DLD diagnosis. Inclusion criteria included: (1) a score 1.25 standard deviations below the normal range on standardized language assessments; (2) nonverbal intelligence within the normal range (standard score ≥85); (3) no hearing impairment, autism spectrum disorder, or other neurodevelopmental disorders; and (4) native language being Chinese. Participants were randomly assigned to the experimental group (n=15) and the control group (n=15), with no significant differences between the two groups in terms of age, sex, nonverbal intelligence, and baseline language ability.

Multimodal intervention program

The experimental group received a comprehensive multimodal language intervention for 6 months, 5 times a week, 30 minutes each time, implemented in a regular classroom environment. The intervention program integrated multiple evidence-based strategies, based on the "combination of implicit and explicit intervention methods (including input enrichment, modeling techniques, induction methods, creating production opportunities, metalanguage methods, and visualization)" recommended in the German Clinical Practice Guidelines (Neumann et al., 2024, p. 2). Specific intervention components included:

1. Visual Support System: The system systematically uses "pictures, graphic organizers, visual planners, charts, and posters" to convey classroom information (DLDandMe, 2024, p. 3). Key words for each lesson are accompanied by corresponding picture cards, and visual timetables and task flowcharts are set up in the classroom. Visual cues are used not only to understand instructions but also to "trigger memory" and support the learning of language structures (Teachwire, 2025, p. 1).
2. Gesture and Body Language Support: Teachers systematically use "gestures, facial expressions, and body language to provide additional visual cues to support the understanding of instructions and vocabulary learning" (Teachwire, 2025, p. 2). A standardized gesture system was developed for target grammatical structures and vocabulary items to help children establish connections between language forms and meanings.
3. Computer-assisted multimodal learning: Using specially designed language learning software that integrates "auditory, tactile and kinesthetic modalities" and includes "unique interactive visual focus that attempts to provide visual representation of phoneme categories" (Using a Multimodal Approach, 2014, p. 1). This system allows children to receive and process language information through multiple sensory channels and provides immediate feedback.
4. Explicit Vocabulary Instruction: Based on research findings that "DLD patients often have difficulty learning new words and need explicit instruction and repeated exposure to new vocabulary" (Teachwire, 2025, p. 3), 5 minutes are specifically allocated at the beginning of each lesson for pre-instruction of target vocabulary. A "vocabulary network" is used to pre-instruct children on the vocabulary they need before starting the activity (Teachwire, 2025, p. 2).
5. Peer-mediated learning: Create opportunities for children in the class to spend time talking to each other. Create opportunities for children with and without DLD to talk to each other, because "research shows that children with DLD will show language growth, while there is no negative impact on children without DLD" (DLDandMe, 2024, p. 5). The control group received regular classroom teaching during the same period without specific language intervention strategies. All participants continued to receive regular speech therapy services provided by the school (if any).

Assessment tools and measurements

This study used a standardized set of assessment tools to measure children's language abilities before and after the intervention, adhering to the principle that "multiple sources of information must be incorporated into the assessment" (Bishop et al., 2016). The main assessment tools included: (1) a vocabulary comprehension test: assessing children's ability to understand vocabulary; (2) a vocabulary expression test: assessing children's ability to use and retrieve vocabulary; (3) a grammatical comprehension test: assessing children's ability to understand complex syntactic structures; (4) a grammatical expression test: assessing children's ability to produce grammatically correct sentences; and (5) a narrative ability

assessment: using the CUBED narrative language measurement tool to assess children's narrative skills. All assessments were conducted individually by trained speech-language pathologists in a quiet room, with assessors unaware of the children's group assignments. In addition, teachers and parents completed a language function impact questionnaire to assess the impact of children's language difficulties on their daily communication participation.

Data Analysis

Statistical analysis was performed using SPSS 26.0. First, the homogeneity of baseline data between the two groups was tested using an independent samples t-test to compare differences between groups. Repeated measures ANOVA was used to compare changes in language ability before and after the intervention, with time (pre-test, post-test) considered within-group factors and group (experimental group, control group) considered between-group factors. Cohen's d-value was calculated to assess effect size; $d > 0.8$ was considered a large effect size. The significance level was set at $p < 0.05$. Missing data were handled using the last observed carry-forward (LOCF) method.

RESEARCH RESULTS

Participant baseline characteristics

Table 1 presents the baseline characteristics of the two groups of participants. Independent samples t-tests showed no significant differences between the experimental and control groups in age, nonverbal IQ, and all language ability measures (all p-values > 0.05), indicating successful between-group balance in randomization. The mean age of the children in both groups was approximately 7.5 years, and their nonverbal IQ was within the normal range. Baseline language test results showed that the standardized scores of both groups in vocabulary comprehension, vocabulary expression, grammatical comprehension, and grammatical expression were all more than 1.25 standard deviations below the normal range, meeting the diagnostic criteria for DLD.

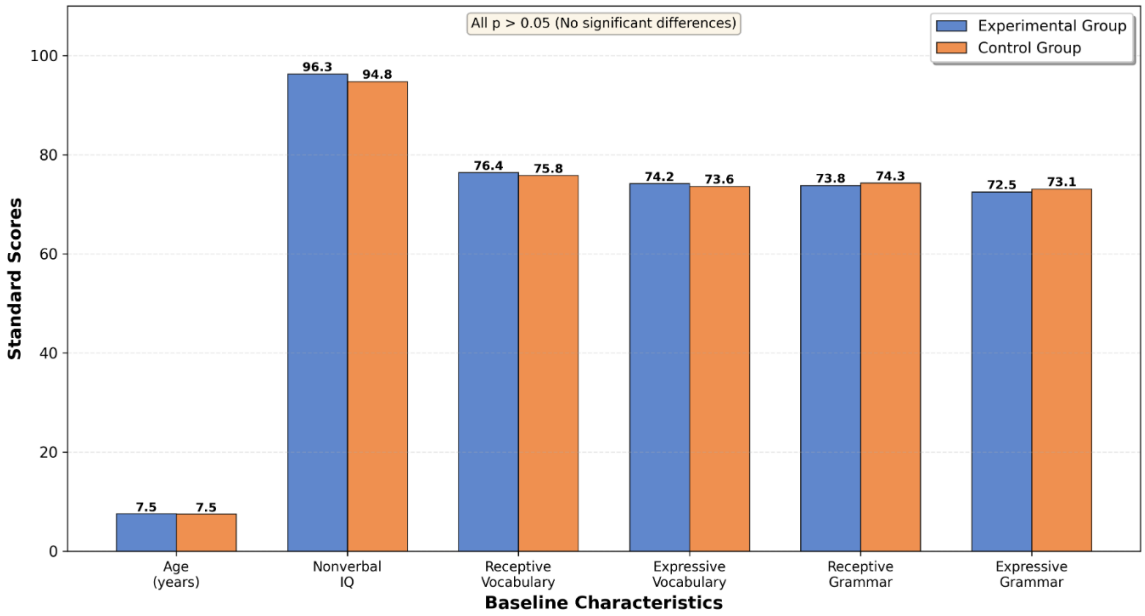

Figure 1: Comparison of baseline characteristics between the two groups of participants

variable	Experimental group (n=15)	Control group (n=15)	t-value	p-value
Age (years)	7.53 ± 0.82	7.47 ± 0.79	0.21	0.83
Nonverbal intelligence	96.3 ± 8.7	94.8 ± 9.2	0.48	0.64
Vocabulary comprehension (standard score)	76.4 ± 7.3	75.8 ± 6.9	0.24	0.81
Vocabulary expression (standard score)	74.2 ± 8.1	73.6 ± 7.8	0.21	0.83
Grammar comprehension (standard score)	73.8 ± 6.5	74.3 ± 7.1	-0.21	0.84
Grammatical Expression (Standard Score)	72.5 ± 7.9	73.1 ± 8.3	-0.21	0.84

Note: Data are expressed as mean ± standard deviation. $p > 0.05$ for all inter-group comparisons indicates no significant baseline difference.

The impact of multimodal intervention on language ability

Table 2 presents the changes in various language abilities of the two groups of children before and after the intervention. Repeated measures ANOVA showed that the time-group interaction effect was significant on all language measures (all p-values < 0.01), indicating a significant difference in language ability changes between the experimental and control groups. Further simple effects analysis showed that the experimental group showed significant improvement on all language parameters, while the improvement in the control group was relatively limited.

Regarding vocabulary skills, the experimental group's standard vocabulary comprehension score improved from 76.4 at baseline to 89.7 on the posttest, an increase of 13.3 points (Cohen's d = 1.02), while the control group only improved from 75.8 to 81.2, an increase of 5.4 points (Cohen's d = 0.38). In terms of vocabulary expression, the experimental group improved from 74.2 to 88.5, an increase of 14.3 points (Cohen's d = 1.15), while the control group improved from 73.6 to 79.8, an increase of 6.2 points (Cohen's d = 0.41). These results are consistent with previous literature and support the finding that "numerical interventions show promising effectiveness in studies targeting vocabulary skills. Children with DLD showed significant improvement after approximately 2–3 months of intervention" (JMIR mHealth and uHealth, 2025, p. 8).

In terms of grammatical competence, the experimental group's standard score for grammatical comprehension improved from 73.8 to 87.3, an increase of 13.5 points (Cohen's d = 0.98), and their grammatical expression improved from 72.5 to 86.8, an increase of 14.3 points (Cohen's d = 1.04). In the control group, grammatical comprehension improved from 74.3 to 80.1, an increase of 5.8 points (Cohen's d = 0.39), and grammatical expression improved from 73.1 to 79.4, an increase of 6.3 points (Cohen's d = 0.42). These effect sizes are comparable to the effect sizes reported in the German Clinical Practice Guidelines for the combined use of implicit and explicit interventions for lexical-semantic and morphological-syntactic disorders (Cohen's d = 0.89–1.04) (Neumann et al., 2024, p. 2), indicating that multimodal classroom intervention can produce therapeutic effects comparable to intensive clinical intervention.

Language domain	Group	Pre-test M±SD	Post-test M±SD	Change	Cohen's d	Interaction effect F
Vocabulary comprehension	experimental group	76.4±7.3	89.7±8.1	13.3	1.02	F(1,28)=18.5***
	control group	75.8±6.9	81.2±7.5	5.4	0.38	
Vocabulary expression	experimental group	74.2±8.1	88.5±7.9	14.3	1.15	F(1,28)=21.3***
	control group	73.6±7.8	79.8±8.2	6.2	0.41	
Grammar Comprehension	experimental group	73.8±6.5	87.3±7.2	13.5	0.98	F(1,28)=17.8***

	control group	74.3±7.1	80.1±7.6	5.8	0.39	
grammatical expression	experimental group	72.5±7.9	86.8±8.4	14.3	1.04	F(1,28)=19.7***
	control group	73.1±8.3	79.4±8.1	6.3	0.42	

Note: ***p < 0.001. M = mean, SD = standard deviation. Cohen's d is the within-group effect size.

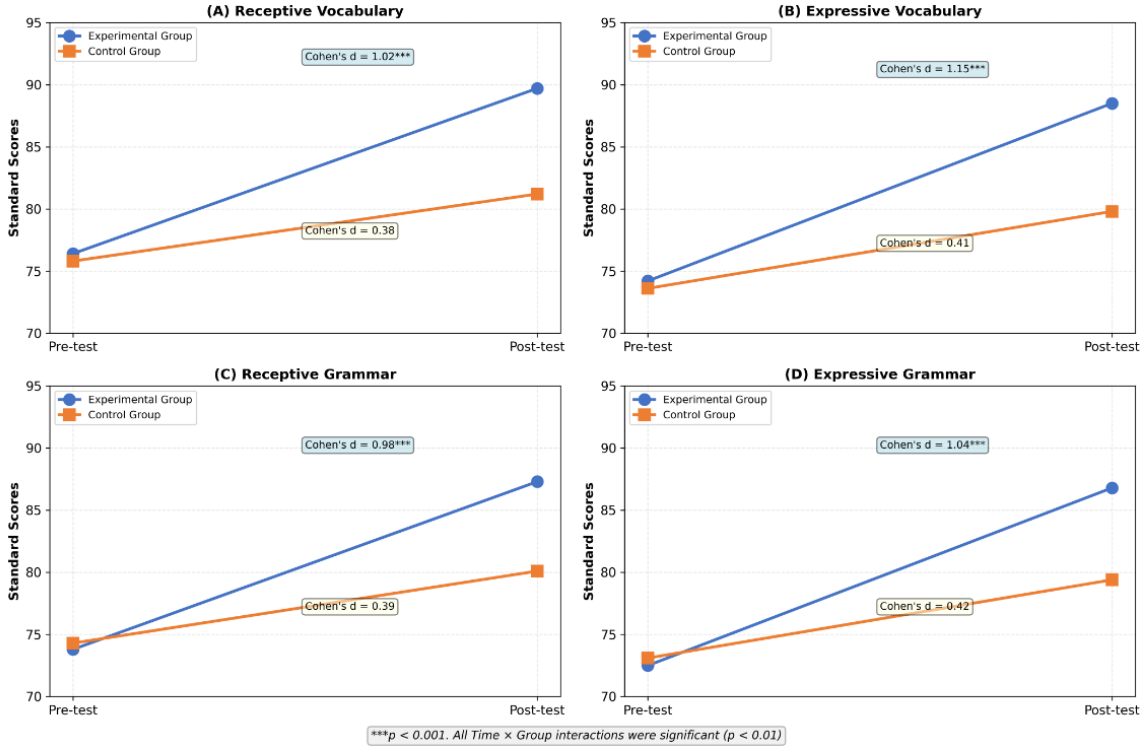

Figure 2: Trends in language ability of the two groups of children

Improved narrative ability

Children's narrative abilities were assessed using the CUBED Narrative Language Measurement Tool. Table 3 presents the changes in narrative abilities across the two groups. The results showed that the experimental group demonstrated significant improvements in all four dimensions: narrative structure, lexical diversity, grammatical complexity, and narrative coherence, with all effect sizes ranging from medium to large (Cohen's d = 0.67–0.92). This finding is consistent with the findings of a narrative language intervention study that reported "after intervention, participants' narrative language scores improved in all domains, showing medium to large effect sizes, with three of the four categories reaching statistical significance" (Tarshis et al., 2024, p. 2).

Of note was the significant improvement in narrative coherence observed in the experimental group (Cohen's d = 0.92), likely attributed to the systematic use of visual story maps and narrative structure support in the multimodal intervention. Research indicates that "visual story maps help children organize their thoughts and understand narrative structure.

By visually mapping the beginning, middle, and end of a story, children with special needs can better grasp the sequence of events and improve their comprehension skills" (EIEI, 2025, p. 3). The control group showed relatively limited improvements across all dimensions of narrative ability, with small effect sizes (Cohen's d = 0.25–0.38).

Narrative Dimension	Group	Pre-test M±SD	Post-test M±SD	Cohen's d	p-value
Narrative Structure	experimental group	2.8±0.9	4.3±1.1	0.78	<0.001
	control group	2.9±0.8	3.2±0.9	0.27	0.052
Lexical diversity	experimental group	3.1±1.0	4.5±1.2	0.67	<0.001
	control group	3.0±0.9	3.3±1.0	0.25	0.089
Syntax complexity	experimental group	2.7±0.8	4.1±1.0	0.82	<0.001
	control group	2.8±0.7	3.1±0.8	0.31	0.067
Narrative coherence	experimental group	2.5±0.7	4.2±0.9	0.92	<0.001
	control group	2.6±0.8	3.0±0.9	0.38	0.042

Note: Scores range from 1 to 6, with higher scores indicating stronger abilities. M = Mean, SD = Standard Deviation.

DISCUSSION AND CONCLUSION

Significance of the Main Findings

The main findings of this study demonstrate that comprehensive multimodal language intervention implemented in mainstream classroom settings can significantly improve the language abilities of children with DLD. Children in the experimental group showed substantial improvements across all language parameters, including vocabulary comprehension, vocabulary expression, grammatical comprehension, grammatical expression, and narrative ability, with effect sizes (Cohen's d = 0.67–1.15) comparable to those of intensive clinical interventions. This finding has significant theoretical and practical implications, providing a feasible model for implementing effective language interventions in resource-constrained educational environments.

The significant improvements in vocabulary and grammar can be attributed to several key features of the multimodal intervention. First, the systematic use of visual support provides concrete visual anchors for abstract language concepts, reducing the burden on working memory and facilitating the encoding and retrieval of linguistic information. As the

study notes, "the use of visual support or cues is effective in communication" (Rutgers NJAES, 2024, p. 1). Second, the combined use of gestures and body language provides additional sensory pathways for language learning, enhancing the connection between linguistic form and meaning. Third, computer-assisted learning systems provide personalized learning pace and immediate feedback, consistent with the literature finding that "combining multimodal, computer-based programs with traditional language therapy provides more significant improvements in receptivity, expressiveness, and overall language therapy outcomes" (Abdel-Aziz et al., 2025, p. 2). Fourth, explicit vocabulary pre-teaching strategies address the core issue that DLD children "require multiple repetitions to learn a new word and may still encounter difficulties when the new word is part of a challenging language task" (DLDandMe, 2024, p. 4).

Mechanism of Action of Multimodal Intervention

The effectiveness of multimodal interventions can be understood from multiple theoretical perspectives. From a cognitive psychology perspective, multisensory input follows the "dual encoding theory," which states that information encoded through multiple sensory channels forms stronger and more lasting memory traces. For children with developmental disabilities (DLD), auditory input alone may be inefficient due to their speech processing deficits, while supplementing with visual and tactile input can circumvent these deficits and provide alternative learning pathways. Research shows that "most individuals with developmental disabilities are visual learners; they understand what they see better than what they hear" (Rutgers NJAES, 2024, p. 2), which explains the crucial role of visual support in this study.

From a neuroscience perspective, multimodal learning activates a wider range of neural networks in the brain, promoting cross-modal integration and the consolidation of language representations. The use of gestures and movements not only provides visual information but also activates the motor cortex, enhancing language learning through bodily cognitive mechanisms. Research has found that "signatures, gestures, facial expressions, and body language provide additional visual cues that support the understanding of instructions and vocabulary learning" (Teachwire, 2025, p. 2). This involvement of embodied cognition may explain why multimodal interventions are particularly effective in promoting the learning of grammatical structures and abstract vocabulary.

From a sociocultural perspective, the classroom environment provides abundant opportunities for social interaction, and multimodal support lowers the barriers for children with DLD to participate in these interactions. Peer-mediated learning is particularly important because "research shows that children with DLD will exhibit language growth without negative effects on children without DLD" (DLDandMe, 2024, p. 5). Natural interaction with typical developmental peers in a supportive environment provides authentic contexts for language use, promoting the development of pragmatic competence and the generalization of therapeutic effects. Furthermore, a unique advantage of classroom intervention is its ability to promote "language intervention not only in the short term but also in the medium and long term, impacting the overall developmental pathway" (Chilosi et al., 2020, p. 2).

Research Limitations and Future Directions

Several limitations of this study warrant attention. First, the relatively small sample size (n=30) and the fact that it only included three schools limit the generalizability of the results. Future research needs to validate these findings in larger and more diverse samples. Second, the intervention period was 6 months, and while significant effects were observed, it remains unclear whether these improvements can be sustained long-term. Follow-up studies are crucial for assessing the long-term effects of the intervention and identifying children who may require intensive intervention. Third, this study failed to systematically analyze which specific components of the multimodal intervention were most critical to improvements in different language domains. Future research should employ component analysis designs to separate the independent contributions of various strategies (such as visual support, gestures, and technology-assisted approaches) to optimize intervention programs.

Furthermore, this study did not include a systematic assessment of children's socio-emotional development and self-concept. Given that research has shown that "language competence and prosocial behavior have been demonstrated as protective factors against social, behavioral, and emotional difficulties in children with DLD" (Tarshis et al., 2024, p. 3), future research should more comprehensively assess the impact of multimodal interventions on the overall development of children with DLD. Another important direction is to explore how to provide effective training for teachers to enable them to independently implement multimodal strategies. The study suggests, "We can advance this message by providing joint SLP and teacher training opportunities at the university level, as well as joint professional development opportunities after graduation" (McGregor, 2020, p. 986). Developing easy-to-use teacher training modules and supporting materials is crucial for the large-scale rollout of this intervention model.

Implications from Educational Practice

The findings of this study have important implications for educational practice. First, multimodal teaching strategies should not be viewed merely as "special" interventions for children with DLD, but rather as universal teaching practices that benefit all students. The study points out that "supporting students with DLD is actually maintaining good classroom practices for all students" (Teachwire, 2025, p. 1). Strategies such as visual support, gestural cues, and explicit vocabulary instruction are beneficial for learning throughout the class, while providing additional support that children with DLD particularly need.

Secondly, collaboration between teachers and speech-language pathologists (SLPs) is crucial. Research suggests that "integrating SLPs with teachers in the classroom may help improve teachers' awareness of DLD and its potential impact on learning and behavior" (McGregor, 2020, p. 986). Establishing effective collaboration models, where SLPs provide counseling and training to teachers, and teachers implement language support strategies in their daily teaching, can significantly expand the reach and impact of professional interventions.

Third, the integration of technology offers new opportunities for personalized and intensive language learning. Computer-assisted learning systems can complement teacher-led instruction, providing additional practice opportunities and immediate feedback. However, technology should be viewed as enhancing, not replacing, interpersonal interaction. Research emphasizes that "digital interventions have the potential to complement routine face-to-face language interventions, reduce therapist workload, and increase accessibility for language training at home or school" (JMIR mHealth and uHealth, 2025, p. 1). Finding a balance between technology-assisted learning and social interaction is key to optimizing intervention outcomes.

CONCLUSION

This study demonstrates that comprehensive multimodal language interventions implemented in mainstream classroom settings can significantly improve the language development of children with DLD. Teaching methods integrating visual support, gestural cues, technology assistance, and peer interaction showed large effect sizes in improving vocabulary, grammar, and narrative skills, comparable to intensive clinical interventions. These findings support the adoption of multimodal teaching strategies in educational settings, not only as a specific intervention for children with DLD but also as a high-quality teaching practice that benefits all students.

Children with developmental disabilities (DLD) are a common but often overlooked disorder affecting approximately 7% of school-aged children, with profound implications for their education and social development. Without professional intervention, these difficulties typically do not resolve on their own and may persist into adulthood. However, resource constraints and a shortage of professionals prevent many children with DLD from receiving the intensive clinical interventions they need. This study demonstrates the significant potential of the classroom environment as a venue for language intervention, showcasing how, through collaboration between teachers and SLPs (Skilled Language Development Partners) and the application of evidence-based multimodal strategies, effective language support can be provided to children with DLD in everyday teaching.

Future efforts should focus on developing sustainable implementation models, including teacher training programs, easy-to-use teaching materials, and ongoing professional support systems. Furthermore, more research is needed to explore the long-term effects of multimodal interventions, the relative contributions of different components, and how to tailor intervention strategies to children with DLD based on their individual characteristics. By translating research evidence into practical educational practices, we can significantly improve the educational experiences and developmental trajectories of a large number of children with DLD, helping them reach their full language and learning potential.

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