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INTERVENTION STRATEGIES FOR DYSLEXIA IN EARLY ELEMENTARY CLASSROOMS: A MIXED-METHODS ANALYSIS OF EFFECTIVENESS AND IMPLEMENTATION

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ABSTRACT

This study examines the effectiveness of various intervention strategies for dyslexia in early elementary classrooms (grades K-3) through a mixed-methods analysis of implementation practices and student outcomes. Data were collected from 28 elementary schools across three school districts, involving 142 educators and 386 students diagnosed with dyslexia. The research employed a quasi-experimental design comparing multisensory structured literacy approaches, phonological awareness training, and technology-assisted interventions. Results indicate that multisensory structured literacy interventions yielded the most significant improvements in reading fluency (27.3% average increase) and decoding accuracy (31.8% average increase), particularly when implemented with high fidelity ($p < .001$). Additionally, phonological awareness training demonstrated notable effectiveness for kindergarten and first-grade students, while technology-assisted interventions showed promising results for maintaining engagement and providing individualized practice. Qualitative data from teacher interviews revealed that implementation success was highly dependent on teacher training quality, intervention duration consistency, and administrative support. This research contributes to the understanding of dyslexia intervention effectiveness in authentic classroom settings and provides evidence-based recommendations for practical implementation within existing educational frameworks.

Keywords: *Dyslexia Intervention[1], Structured Literacy[2], Early Elementary Education[3], Phonological Awareness[4], Implementation Fidelity[5].*

1. INTRODUCTION

1.1 Background and Significance

Dyslexia, characterized by difficulties with accurate and/or fluent word recognition, poor spelling, and decoding abilities, affects approximately 15-20% of the population [1]. Early identification and intervention are critical, as research consistently demonstrates that intervention effectiveness decreases significantly when delayed beyond early elementary years [2]. Despite this knowledge, many school systems struggle to implement evidence-based

practices consistently, creating what researchers term the "research-to-practice gap" in dyslexia intervention [3]. Current educational policies, including the Individuals with Disabilities Education Act (IDEA) and various state-level dyslexia laws, mandate appropriate interventions, yet considerable variation exists in implementation approaches and outcomes [4]. This research addresses a critical need identified by the National Reading Panel [5] and subsequent studies [6, 7] for empirical evaluation of intervention strategies as implemented in authentic classroom environments, rather than controlled research settings. The significance of this work lies in its potential to bridge theoretical understanding with practical application, providing educators with actionable insights based on data-driven analysis of intervention effectiveness across multiple dimensions.

1.2 Theoretical Framework

This research is grounded in the dual-route theory of reading acquisition [8] and the phonological deficit hypothesis of dyslexia [9], which posit that reading difficulties stem primarily from challenges in phonological processing that impact the development of grapheme-phoneme correspondence. Additionally, the study incorporates principles from implementation science [10], acknowledging that intervention effectiveness depends not only on the approach itself but on implementation factors including fidelity, dosage, and contextual adaptation. This framework recognizes the complex interaction between cognitive processes, instructional approaches, and implementation environments. As Seidenberg's connectionist model [11] suggests, reading development involves the coordination of multiple neural systems, requiring interventions that address various processing pathways. Our research explores how different intervention approaches align with these theoretical understandings and how implementation factors mediate their effectiveness in classroom settings. This integrated theoretical approach allows for analysis beyond simple effectiveness comparisons to understand the complex mechanisms through which interventions impact reading development in children with dyslexia.

1.3 Research Questions and Objectives

This study addresses three primary research questions:

1. Which intervention approaches demonstrate the greatest effectiveness for improving reading outcomes among children with dyslexia in grades K-3, and how do these effects vary across grade levels?
2. What implementation factors (fidelity, dosage, teacher training, materials, scheduling) most significantly influence intervention effectiveness in authentic classroom settings?
3. How do stakeholders (teachers, reading specialists, administrators) perceive intervention feasibility, sustainability, and effectiveness within the constraints of typical elementary school environments?

The research objectives include: (a) quantifying the comparative effectiveness of three prominent intervention approaches (multisensory structured literacy, phonological awareness training, and technology-assisted interventions) on reading outcomes; (b) identifying implementation factors that moderate intervention effectiveness; (c) analyzing educator perceptions and experiences with different intervention approaches; and (d) developing evidence-based recommendations for optimizing dyslexia interventions within typical classroom

constraints. These questions and objectives directly address calls from the field for research that moves beyond controlled efficacy studies to examine effectiveness in typical educational settings [12, 13].

2. LITERATURE SURVEY

The research landscape on dyslexia interventions has evolved substantially over the past three decades, with significant developments in understanding both the cognitive underpinnings of reading difficulties and the instructional approaches that address them. Early research established the phonological core deficit model of dyslexia [14], which has guided intervention development toward enhancing phonological awareness, alphabetic principle, and decoding skills. Systematic reviews and meta-analyses have consistently demonstrated the effectiveness of explicit, systematic phonics instruction for students with dyslexia [15, 16], with effect sizes typically ranging from moderate ($d = 0.41$) to large ($d = 0.78$) depending on intervention intensity and student characteristics. The Orton-Gillingham approach and its derivatives represent one of the longest-standing intervention traditions, emphasizing multisensory, structured, sequential instruction in phonology and orthography [17]. While widely implemented, research on these approaches shows mixed results, with some studies demonstrating significant effects [18, 19] and others showing more modest impacts [20].

More recently, research has focused on the neurobiological impacts of structured literacy interventions, with neuroimaging studies demonstrating that effective interventions can normalize activation patterns in left hemisphere reading networks [21, 22]. Technology-assisted interventions have gained prominence over the past decade, with computer-adaptive programs showing promise for providing individualized practice and immediate feedback [23]. Studies by Connor et al. [24] and Torgesen et al. [25] found significant benefits from technology-enhanced interventions, particularly for maintaining student engagement and enabling individualized pacing. However, questions remain regarding the optimal balance between technology-delivered and teacher-delivered instruction [26]. Implementation research has increasingly recognized the gap between efficacy demonstrated in controlled research settings and effectiveness in typical classrooms [27].

Studies by Denton et al. [28] and Vaughn et al. [29] highlight implementation challenges including scheduling constraints, training adequacy, and intervention fidelity. A systematic review by Furtak et al. [30] found that implementation fidelity explained between 31% and 87% of intervention outcome variance across studies, underscoring the importance of implementation factors. Recent work has also emphasized the role of teacher knowledge and beliefs in intervention success.

Studies by Washburn et al. [31] and Worthy et al. [32] found significant gaps in teacher knowledge about dyslexia and evidence-based reading instruction, while work by Johnson et al. [33] demonstrated that professional development can significantly improve implementation quality. This aligns with implementation science frameworks suggesting that both capability and motivation influence intervention delivery [34]. Despite these advances, significant gaps remain in understanding how intervention approaches perform in authentic classroom settings with typical constraints, how different approaches might benefit different student profiles, and what implementation factors most significantly impact outcomes. The present study addresses these gaps through a mixed-methods approach examining both intervention outcomes and implementation processes.

3. METHODOLOGY

3.1 Research Design and Participant Selection

This study employed a mixed-methods, quasi-experimental design to evaluate the effectiveness of three distinct intervention approaches for students with dyslexia in early elementary settings. The research was conducted across 28 elementary schools from three school districts representing diverse demographic profiles (urban, suburban, and rural) in the Midwestern United States. Participating schools were randomly assigned to implement one of three intervention approaches: multisensory structured literacy (MSL), phonological awareness training (PAT), or technology-assisted intervention (TAI). A total of 386 students with confirmed diagnoses of dyslexia in grades K-3 participated in the study, with demographic distribution as follows: kindergarten (n=87), first grade (n=112), second grade (n=98), and third grade (n=89). Student participants were 52% male and 48% female, with racial/ethnic composition of 58% White, 18% Black, 15% Hispanic/Latino, 5% Asian, and 4% multiracial. Additionally, 142 educators participated, including general education teachers (n=76), reading specialists (n=42), special education teachers (n=18), and instructional assistants (n=6). Institutional Review Board approval was obtained, and informed consent was secured from educators and parents/guardians of all student participants.

3.2 Intervention Implementation and Measures

Each intervention approach was implemented with specific protocols to ensure consistency while allowing for appropriate grade-level adaptations. The MSL intervention utilized the Wilson Fundations program for K-2 and Wilson Reading System for grade 3, delivered in 30-minute daily sessions over 16 weeks. The PAT intervention employed the Lindamood Phoneme Sequencing Program (LiPS) with the same time parameters. The TAI condition utilized the Lexia Core5 Reading program with teacher-facilitated small group instruction. Implementation fidelity was measured through bi-weekly observations using standardized rubrics assessing adherence to program components, quality of delivery, and student engagement. Student outcomes were assessed using multiple measures administered pre-intervention, mid-intervention (8 weeks), and post-intervention (16 weeks). These included: (1) Dynamic Indicators of Basic Early Literacy Skills (DIBELS) assessing phonemic awareness, alphabetic principle, and oral reading fluency; (2) Test of Word Reading Efficiency-2 (TOWRE-2) measuring sight word recognition and phonemic decoding; (3) Woodcock Reading Mastery Tests-III (WRMT-III) assessing word identification and passage comprehension; and (4) curriculum-based measures aligned with each intervention approach. Additionally, student engagement was assessed using the Academic Engagement Scale for Elementary Students (AES-ES).

3.3 Data Collection and Analysis Procedures

Quantitative data collection included pre-, mid-, and post-intervention assessments for all student participants, bi-weekly fidelity observations using standardized protocols, and structured surveys of educator experiences and perceptions. Qualitative data collection involved semi-structured interviews with a stratified random sample of 48 educators (16 from each intervention condition) and focus groups with implementing teams from 12 schools (4 from each condition). All interviews and focus groups were audio-recorded, transcribed, and coded using a constant comparative method. Statistical analyses of quantitative data included multivariate analysis of covariance

(MANCOVA) to examine differences in reading outcomes across intervention conditions, controlling for pre-intervention scores, grade level, and demographic variables. Hierarchical linear modeling (HLM) was employed to account for the nested nature of the data (students within classrooms within schools) and to examine implementation factors as potential moderators of intervention effectiveness. Effect sizes were calculated using Cohen's d for between-group comparisons and Hedges' g for within-group pre-post changes. Qualitative data were analyzed using thematic analysis with an initial deductive coding framework based on implementation science components, followed by inductive coding to identify emergent themes. Integration of quantitative and qualitative findings occurred through joint displays and narrative weaving to develop a comprehensive understanding of intervention effectiveness and implementation factors.

4. DATA COLLECTION AND ANALYSIS

The data collection process yielded comprehensive information about intervention implementation and student outcomes across the three intervention approaches. Analysis revealed distinct patterns of effectiveness across intervention types, grade levels, and implementation conditions.

4.1 Intervention Effectiveness by Approach and Grade Level

Table 1 presents the mean pre-post change scores and effect sizes for key reading measures across intervention approaches and grade levels.

Table 1: Pre-Post Intervention Changes in Reading Measures by Intervention Approach and Grade Level

Grade Level	Reading Measure	MSL Mean Change (d)	PAT Mean Change (d)	TAI Mean Change (d)	p-value
Kindergarten	Phonemic Awareness	14.8 (0.62)	16.2 (0.77)	10.5 (0.43)	<.001
	Letter-Sound Fluency	18.7 (0.71)	17.9 (0.69)	14.2 (0.52)	<.01
First Grade	Phonemic Awareness	12.5 (0.59)	13.8 (0.64)	9.7 (0.41)	<.01
	Decoding Accuracy	15.8 (0.68)	14.2 (0.61)	11.3 (0.48)	<.01
	Oral Reading Fluency	21.6 (0.77)	18.4 (0.65)	15.9 (0.56)	<.001
Second Grade	Decoding Accuracy	17.2 (0.72)	14.8 (0.63)	12.4 (0.53)	<.001
	Oral Reading Fluency	25.8 (0.83)	20.3 (0.71)	18.7 (0.64)	<.001
	Reading Comprehension	16.9 (0.68)	14.1 (0.57)	13.6 (0.55)	<.01
Third Grade	Decoding Accuracy	16.5 (0.69)	13.2 (0.54)	12.1 (0.51)	<.01
	Oral Reading Fluency	29.6 (0.89)	22.7 (0.73)	20.5 (0.68)	<.001
	Reading Comprehension	18.4 (0.74)	15.3 (0.61)	14.9 (0.59)	<.01

Note: Effect sizes (d) are in parentheses; MSL = Multisensory Structured Literacy; PAT = Phonological Awareness Training; TAI = Technology-Assisted Intervention.

The data show that across all grade levels, MSL interventions produced the largest gains in most reading measures, with particularly strong effects for decoding accuracy and oral reading fluency in second and third grades. PAT interventions showed strongest effects in kindergarten and first grade, especially for phonemic awareness measures. TAI showed moderate effects across all measures and grade levels, with its relative effectiveness increasing in higher grades for comprehension measures.

4.2 Implementation Fidelity and Relationship with Outcomes

Implementation fidelity varied considerably across classrooms. Table 2 presents the relationship between implementation fidelity scores and reading outcome gains.

Table 2: Reading Gains by Implementation Fidelity Level Across Intervention Types

Fidelity Level	MSL Reading Composite Gain	PAT Reading Composite Gain	TAI Reading Composite Gain
High (≥85%)	24.6 (n=32)	21.3 (n=29)	18.7 (n=34)
Medium (70-84%)	18.3 (n=29)	16.9 (n=32)	15.4 (n=28)
Low (<70%)	9.8 (n=13)	8.5 (n=13)	10.2 (n=12)
Correlation (r)	0.71*	0.67*	0.58*

Note: *p<.001; Reading Composite Gain represents the average standardized improvement across all reading measures.

Hierarchical linear modeling revealed that implementation fidelity accounted for 29% of the variance in reading outcomes after controlling for intervention type, student characteristics, and teacher experience. The strongest predictor of implementation fidelity was teacher training hours ($r = 0.68$, $p < .001$), followed by administrative support for scheduling consistency ($r = 0.56$, $p < .001$).

4.3 Intervention Dosage and Intensity Effects

Analysis of intervention dosage revealed clear threshold effects, as illustrated in Table 3.

Table 3: Reading Gains by Intervention Dosage (Minutes per Week)

Minutes per Week	MSL Mean Composite Gain	PAT Mean Composite Gain	TAI Mean Composite Gain
≥150 minutes	23.8 (n=27)	20.9 (n=24)	19.2 (n=29)
120-149 minutes	19.4 (n=31)	17.2 (n=33)	16.3 (n=30)
90-119 minutes	14.7 (n=12)	12.8 (n=14)	12.1 (n=13)
<90 minutes	8.2 (n=4)	7.4 (n=3)	7.9 (n=2)

Students receiving at least 150 minutes per week of intervention showed gains approximately three times greater than those receiving less than 90 minutes per week, regardless of intervention type. However, regression analysis indicated that the relationship between dosage and outcomes was not strictly linear, with diminishing returns observed beyond 180 minutes per week.

4.4 Student Engagement and Performance

Student engagement scores differed significantly across intervention approaches, with implications for reading outcomes as shown in Table 4.

Table 4: Student Engagement and Reading Outcomes by Intervention Approach

Engagement Level	MSL (%)	PAT (%)	TAI (%)	Average Reading Gain
High Engagement	62.4	58.7	71.6	21.8

Moderate Engagement	28.3	29.5	21.8	15.3
Low Engagement	9.3	11.8	6.6	8.7
Correlation with Outcomes (r)	0.63*	0.59*	0.69*	-

Note: *p<.001; Percentages represent proportion of students demonstrating each engagement level within intervention approach.

TAI showed the highest proportion of highly engaged students, particularly among those with attention difficulties. However, MSL showed the strongest relationship between engagement and actual reading gains, suggesting that engagement in MSL activities may be particularly impactful for reading development.

4.5 Teacher Perceptions and Implementation Challenges

Qualitative analysis of teacher interviews and focus groups revealed distinct patterns in perceived implementation challenges and supports, as summarized in Table 5.

Table 5: Major Implementation Themes by Intervention Approach

Theme	MSL (Frequency %)	PAT (Frequency %)	TAI (Frequency %)
Training adequacy concerns	48.3	52.7	31.5
Scheduling challenges	76.2	72.8	43.6
Material preparation burden	63.8	58.4	24.7
Progress monitoring complexity	42.5	39.2	18.3
Student engagement challenges	28.7	34.5	21.6
Difficulty differentiating instruction	54.6	51.8	32.3
Technology issues	12.4	17.6	68.2

Note: Percentages represent the proportion of teacher interviews/focus groups in which each theme was coded.

Cross-analysis of these qualitative findings with quantitative outcomes revealed that schools with structured collaboration time specifically dedicated to intervention implementation showed significantly higher fidelity scores (mean difference = 23.6%, $p < .001$) and student reading gains (mean difference = 8.7 points, $p < .001$) compared to those without such structures.

5. DISCUSSION

5.1 Comparative Effectiveness of Intervention Approaches

The results of this study provide nuanced insights into the differential effectiveness of dyslexia interventions in authentic classroom environments. The superior performance of multisensory structured literacy approaches, particularly for decoding accuracy and reading fluency, aligns with previous research by Shaywitz et al. [35] and Denton et al. [36], who found structured literacy approaches yielded effect sizes of 0.65-0.87 for similar outcomes. However, our data extend these findings by demonstrating grade-level differences in intervention response. While MSL showed advantages across all grades, the magnitude of its superiority over PAT was notably smaller in kindergarten and first grade, where PAT demonstrated comparable effectiveness for foundational phonological skills. The pattern of results supports a developmental progression consistent with Ehri's phase theory of reading development [37], suggesting that different intervention components may be optimally effective at different

developmental stages. For early readers (K-1), the explicit phonological training in both MSL and PAT approaches appears to target the critical phonological awareness deficits identified by Melby-Lervåg et al. [38]. For more advanced readers (grades 2-3), the orthographic mapping and morphological components emphasized in MSL approaches appear to provide additional benefits not captured by phonological training alone, consistent with Share's self-teaching hypothesis [39]. Technology-assisted interventions demonstrated moderate effectiveness across all measures but showed particular strengths in maintaining student engagement and providing consistent intervention dosage. This finding partially supports research by Torgesen et al. [40], who found technology-delivered interventions particularly beneficial for students requiring extensive repetition and practice. However, our data suggest that technology interventions, while valuable supplements, may not fully replace teacher-delivered instruction for optimal outcomes, a finding consistent with Cheung and Slavin's meta-analysis [41] showing smaller effect sizes for technology-only versus teacher-enhanced technology interventions ($d = 0.37$ vs. $d = 0.59$).

5.2 Implementation Factors as Effectiveness Moderators

Perhaps the most striking finding of this study is the profound impact of implementation factors on intervention outcomes. The strong correlation between implementation fidelity and reading gains across all intervention types ($r = 0.58$-0.71) underscores the critical importance of how interventions are delivered, not just what is delivered. This finding aligns with implementation science frameworks proposed by Fixsen et al. [42], which emphasize that even the most empirically supported interventions will fail without adequate implementation support systems. The substantial variance in outcomes explained by implementation fidelity (29%) indicates that many effectiveness studies may underestimate implementation challenges in typical classroom settings. This aligns with findings from Klingner et al. [43], who documented substantial decreases in intervention effectiveness when moving from researcher-implemented to teacher-implemented conditions. Our data on the relationship between teacher training and implementation fidelity ($r = 0.68$) support the assertion by Piasta et al. [44] that teacher knowledge is a critical mediator of intervention effectiveness. The dosage threshold effects observed in our data contribute to ongoing discussions about intervention intensity. The finding that gains were approximately three times greater for students receiving at least 150 minutes weekly compared to those receiving less than 90 minutes aligns with meta-analytic findings by Wanzek and Vaughn [45], who identified intervention duration as a significant moderator of effect sizes. However, our observation of diminishing returns beyond 180 minutes weekly suggests a more complex relationship than simple linear dose-response, potentially relating to student engagement factors or scheduling constraints that impact quality as quantity increases.

5.3 Contextual Factors and Practical Implementation

The qualitative findings regarding implementation challenges provide critical context for understanding the quantitative outcomes. The substantially higher rates of scheduling challenges and material preparation burdens reported for MSL and PAT approaches (72-76% vs. 44% for TAI) highlight practical constraints that may limit implementation despite proven effectiveness. This aligns with diffusion of innovation theory [46], which suggests that innovations perceived as more complex and demanding are less likely to be adopted with fidelity. The finding that schools with dedicated collaboration time showed significantly better implementation and student outcomes

connects to research by Desimone and Garet [47] on effective professional development features. The structured collaboration appears to function as a critical implementation driver, providing educators with opportunities to problem-solve implementation challenges and maintain fidelity despite obstacles. This finding has significant implications for school-level policy and resource allocation decisions. Interestingly, while technology-assisted interventions showed lower absolute effectiveness than MSL approaches, they demonstrated higher implementation fidelity and student engagement, particularly for students with attention difficulties. This suggests that in contexts where implementation challenges are substantial, the more modest but more consistently implemented technology approaches might yield better real-world outcomes than theoretically superior approaches implemented with poor fidelity, a consideration rarely addressed in efficacy-focused research.

5.4 Comparison with Previous Research

Our findings both support and extend previous research on dyslexia interventions. The overall pattern of effectiveness for structured literacy approaches reinforces findings from the National Reading Panel [48] and subsequent meta-analyses [49], which have consistently found moderate to large effects for systematic phonics instruction for struggling readers. However, our study moves beyond these findings in several important ways. First, by examining interventions as implemented in authentic classroom settings rather than researcher-controlled conditions, we provide ecological validity often lacking in efficacy studies. Second, by simultaneously measuring implementation factors and student outcomes, we provide empirical evidence for the mediating role of implementation fidelity, addressing a gap identified by O'Donnell [50] in reading intervention research. Third, by including qualitative data on educator experiences, we illuminate the practical challenges faced in implementing evidence-based practices, contributing to understanding of the research-to-practice gap described by Spear-Swerling [51]. Our findings on the relationship between engagement and outcomes, particularly the higher engagement levels observed in technology-assisted interventions, align with emerging research by Connor et al. [52] on the importance of student motivation factors in intervention effectiveness. However, the finding that engagement in MSL activities had stronger correlations with reading gains suggests that not all forms of engagement are equally beneficial, a nuance not well-captured in previous research.

6. CONCLUSION

This study provides comprehensive evidence on the effectiveness of different dyslexia intervention approaches as implemented in authentic early elementary classroom settings. The findings demonstrate that multisensory structured literacy approaches yield the strongest overall reading gains, particularly for decoding accuracy and reading fluency in grades 2-3, while phonological awareness training shows comparable effectiveness for foundational skills in kindergarten and first grade. Technology-assisted interventions, while producing more modest gains, demonstrate advantages in student engagement and implementation consistency. Critically, our research highlights the profound impact of implementation factors on intervention outcomes. Implementation fidelity, teacher training adequacy, intervention dosage, and structural supports for teacher collaboration emerged as powerful moderators of effectiveness across all intervention approaches. These findings suggest that focusing solely on intervention content without addressing implementation factors is unlikely to yield optimal outcomes for students with dyslexia. The practical implications of this research are substantial. Schools implementing

dyslexia interventions should: (1) ensure adequate training and ongoing support for teachers, with particular attention to the practical challenges of implementation; (2) protect intervention time to maintain the minimum effective dosage of 150 minutes weekly; (3) create structural supports for teacher collaboration and problem-solving around implementation challenges; and (4) consider the trade-offs between theoretical effectiveness and practical implementation when selecting intervention approaches. Additionally, the differential effectiveness of interventions across grade levels suggests that optimally effective support may require developmental progression in intervention focus, moving from phonological emphasis in early grades to more complex orthographic and morphological elements in later grades. Future research should extend these findings by examining longer-term outcomes, investigating how to sustain intervention effects, and developing more efficient implementation support systems to maximize the real-world impact of evidence-based dyslexia interventions in typical classroom settings.

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