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AI-Assisted Teaching for Children with Childhood Apraxia of Speech: Perceptions of Cognitive and Speech-Motor Support

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Abstract

Childhood Apraxia of Speech (CAS) is a motor speech disorder that can affect speech-motor planning, expressive communication, and participation in learning. This qualitative study explored how special educators, speech-language pathologists, occupational therapists, a cognitive-behavior therapist, and parents perceive the use of artificial intelligence (AI)-assisted tools for children with CAS aged 6–12. Twelve participants from Saudi Arabia, the United Arab Emirates, and Pakistan took part in semi-structured interviews. Data were analyzed thematically, with interpretation informed by Cognitivism, Bloom's Taxonomy, and principles of motor learning represented through Dynamic Temporal and Tactile Cueing (DTTC). Five themes were identified: gradual academic and phonological gains; AI as supplemental support for speech practice rather than a replacement for therapy; increased engagement, motivation, and independence; the need for balanced and supervised use; and demand for more personalized, multilingual, and clinically aligned tools. Participants commonly associated AI-assisted practice with repetition, immediate feedback, phoneme practice, vocabulary recall, and increased willingness to participate. Professional participants were more cautious about claims concerning speech-motor planning and emphasized clinician-led intervention. The findings support a hybrid model in which therapists define goals, AI tools provide structured opportunities for repeated practice, parents reinforce learning at home, and educators connect practice to classroom objectives. Larger longitudinal studies using objective clinical measures are needed to evaluate effectiveness beyond stakeholder perceptions.

Keywords: childhood apraxia of speech, artificial intelligence, special educational needs, speech-motor planning, phonological working memory

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1. Introduction

Childhood Apraxia of Speech (CAS) is a neurological motor speech disorder in which the precision and consistency of movements underlying speech are impaired without primary neuromuscular weakness. The literature has long described difficulties in diagnosis and intervention, and the American Speech-Language-Hearing Association recognizes impaired transitions between sounds and syllables, inconsistent speech errors, and inappropriate prosody among the consensus characteristics associated with CAS (Forrest, 2003; Shriberg et al., 2017; Stringer, 2024). For school-age children, these speech difficulties may interact with vocabulary, literacy, classroom participation, and the ability to communicate academic knowledge.

The educational implications are particularly important where access to specialist services is uneven. Literature cited in the original study indicates continuing challenges in Saudi Arabia and other regional contexts concerning awareness, professional training, inclusive provision, and access to appropriate communication support (Khoja, 2018; Alrudayni, 2025). Children who require intensive and individualized intervention may therefore experience a gap between clinical recommendations and the amount of practice that can realistically be delivered across school, therapy, and home settings.

Digital and AI-assisted tools offer one possible way to extend structured practice. Computer-assisted speech interventions, automatic speech recognition, machine learning, augmentative and alternative communication (AAC), and interactive applications can provide repeated trials, multimodal presentation, immediate feedback, and opportunities for home practice (Furlong et al., 2017; McKechnie et al., 2018; Bhardwaj et al., 2024; Green et al., 2024). Such tools should not be assumed to deliver clinical treatment independently. Rather, their educational value may lie in supporting practice intensity, engagement, communication access, and continuity between professional sessions.

This study focuses on stakeholder perceptions of AI-assisted teaching for children with CAS aged 6–12. It is theoretically informed by Cognitivism, Bloom's Taxonomy, and principles of motor learning represented through DTTC. Together, these perspectives emphasize active processing of information, structured progression of learning goals, repeated practice, feedback, and adaptation to learner performance. The study therefore examines not only whether participants view AI positively, but how they believe it contributes to phonological working memory, speech-motor practice, expressive language, academic participation, and motivation.

The study aimed to: (1) explore perceptions of teachers, parents, and therapists regarding AI-assisted interventions for phonological working memory and speech-motor planning in children with CAS aged 6–12; (2) examine perceived influence on oral vocabulary and expressive language; and (3) describe how AI tools are integrated at home, in school, and alongside traditional therapy. Correspondingly, the research asked how stakeholders perceive AI support for cognitive abilities, communication development, and the practical integration of AI-assisted tools in intervention.

2. Literature Review and Theoretical Framework

2.1. Childhood Apraxia of Speech and educational needs

CAS is characterized by difficulty planning and programming the movement sequences required for speech rather than by weakness of the speech musculature. Earlier literature highlighted diagnostic uncertainty, while later work has refined clinical markers and motor-based intervention approaches (Forrest, 2003; Shriberg et al., 2017). School-age children may require intensive speech therapy together with educational accommodations, communication support, literacy intervention, and opportunities to generalize speech targets beyond clinical sessions. Motor-based approaches such as DTTC and ReST emphasize intensive, individualized practice and carefully structured cueing. AAC may also support communication access where speech intelligibility limits participation (Maas et al., 2014; Rvachew & Matthews, 2017; Hayes et al., 2022).

2.2. AI-assisted speech and language learning

AI-related technologies in speech and language support include automatic speech recognition, machine learning models, adaptive practice systems, digital AAC, and interactive learning applications. Their potential advantages include high-frequency practice, immediate feedback, consistent stimulus presentation, progress recording, and personalization. Computer-assisted intervention literature suggests that digital media can support speech practice when implementation is appropriate and fidelity is maintained (Furlong et al., 2017; McCormack et al., 2017). More recent literature has emphasized the emerging role of AI in communication sciences and disorders, while also noting that clinical judgment, validation, privacy, accessibility, and appropriate training remain essential (Bhardwaj et al., 2024; Green et al., 2024).

2.3. Phonological working memory and speech-motor planning

Phonological working memory temporarily maintains and manipulates sound-based information and contributes to vocabulary learning, sentence processing, and the rehearsal of

speech sequences. Research cited in the study has linked CAS with differences in working-memory performance and speech planning, although the relationship should not be reduced to a single causal mechanism (Nijland et al., 2015; Ortiz et al., 2010). Repetition and structured practice may therefore have educational value by allowing children to rehearse sound sequences, vocabulary, and increasingly complex utterances. AI-assisted systems may increase the number of available practice opportunities, but perceived gains in working memory or motor planning require cautious interpretation unless supported by objective clinical measures.

2.4. Cognitivism and Bloom's Taxonomy

The study uses Cognitivism to frame learning as an active process in which learners organize and connect new information with existing knowledge structures. Bloom's Taxonomy provides a complementary educational framework for sequencing objectives from remembering and understanding toward applying, analyzing, evaluating, and creating. Within AI-assisted learning, these perspectives support the design of tasks that move beyond passive screen exposure toward purposeful rehearsal, discrimination, application, and increasingly independent communication. For children with CAS, multimodal cues and repeated opportunities may support the formation and retrieval of speech and language representations when activities are aligned with individualized goals (Zorluoğlu, 2024).

2.5. DTTC and principles of motor learning

DTTC is a motor-based approach for CAS that dynamically adjusts temporal delay and cueing according to the child's performance. Principles emphasized in the manuscript include repeated trials, modeling, sensory cueing, feedback, and flexible progression. Recent work has reported treatment gains with DTTC in children with CAS, reinforcing the importance of individualized motor practice (Grigos et al., 2024). AI tools cannot reproduce the full clinical reasoning and tactile support of a trained clinician, but they may supplement selected components of practice by presenting consistent models, encouraging repetition, and recording responses.

2.6. Engagement, multimodality, and access

Interactive and "phygital" experiences combine digital elements with physical activity and sensory input. The manuscript discusses augmented reality, movement-based games, tactile activities, and visually responsive environments as examples of how digital systems might increase engagement. Such approaches are theoretically relevant because attention and motivation influence participation in repeated practice. However, evidence for specific phygital

systems in CAS remains limited, and the present study therefore treats these applications as potential educational supports rather than established CAS treatments.

2.7. Challenges and research gap

The literature identifies practical limitations including cost, uneven access, language availability, technological reliability, accent and dialect recognition, professional training, and the clinical validity of automated feedback. These concerns are especially relevant in multilingual contexts such as Saudi Arabia and the UAE and in settings where Arabic- and Urdu-language resources may be limited. The central gap addressed by this study is not a clinical trial of a particular application; it is an exploration of how parents and professionals who work with children with CAS perceive AI-assisted tools, what benefits they observe, and what safeguards and features they believe are necessary.

Figure 1 illustrates the hierarchical structure of DTTC as applied conceptually in this study, showing progression from simultaneous production through direct and delayed imitation toward more spontaneous production, with cueing adjusted according to learner need.

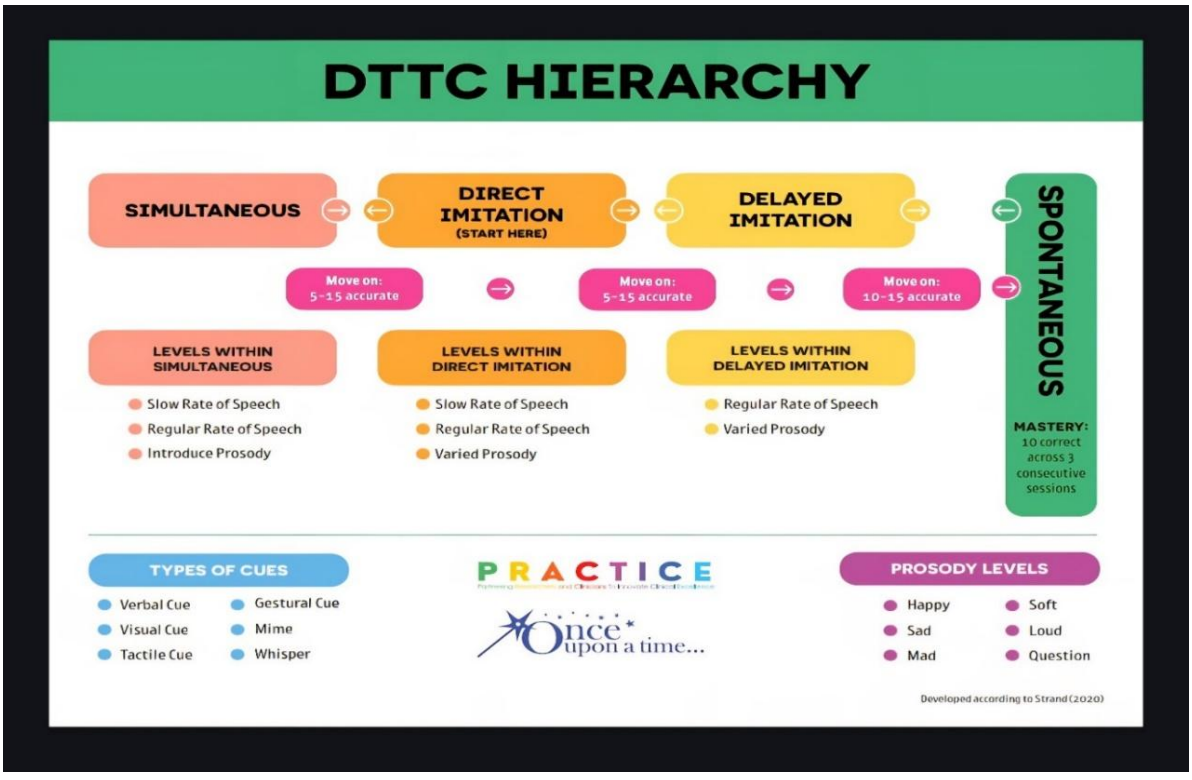

Figure 1. *DTTC hierarchy*

Figure 2 presents the conceptual framework guiding the study, linking Cognitivism, Bloom's Taxonomy, and principles of motor learning/DTTC with stakeholder perceptions of AI-assisted teaching and the speech-motor, phonological working-memory, vocabulary, and expressive-language outcomes examined in the interviews.

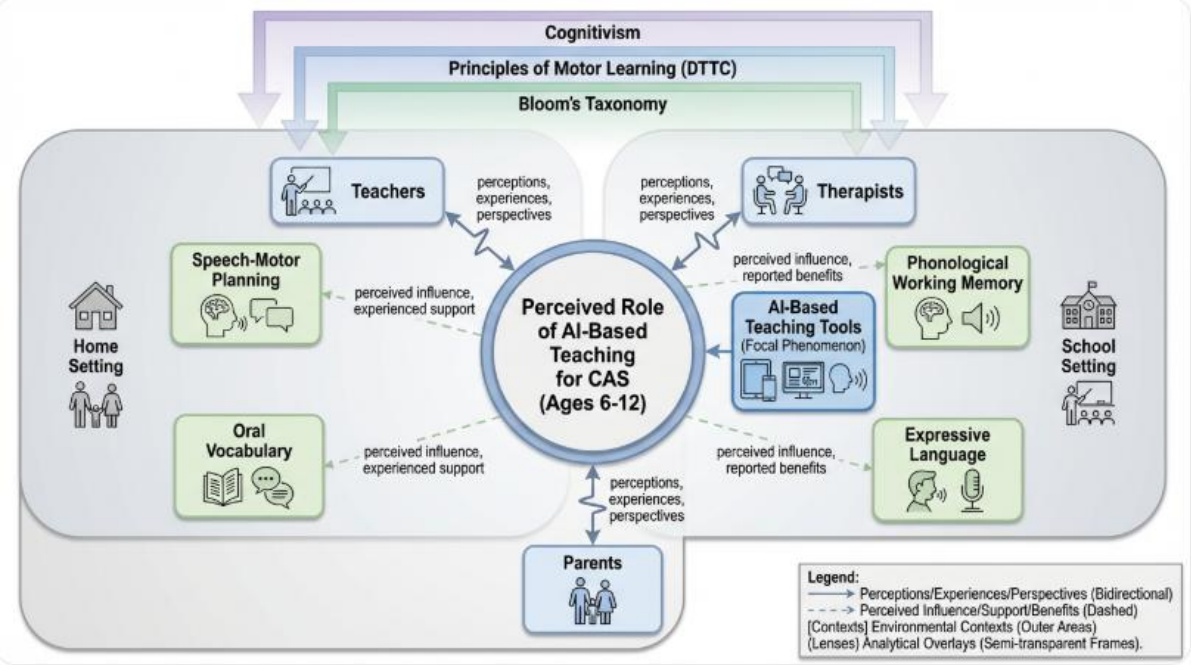

Figure 2. *Conceptual framework*

3. Methods

3.1. Design and Setting

A descriptive exploratory qualitative design was used to investigate stakeholder experiences and perceptions in an under-researched area. The study involved participants in Saudi Arabia, the United Arab Emirates, and Pakistan. Interviews were conducted in person where feasible and online for geographically dispersed participants. The qualitative design was selected to capture contextualized accounts of how AI-assisted tools were used or observed in home, educational, and therapeutic settings rather than to test clinical efficacy.

3.2. Participants and Sampling

Purposive sampling was used to recruit 12 participants with direct experience of children with CAS aged 6–12: three special educators, two occupational therapists, three speech-language pathologists, one cognitive-behavior therapist, and three parents. Professional participants had relevant experience working with children with CAS or speech/language needs, while parent participants had children diagnosed with CAS. The range of stakeholder roles was intended to provide contrasting perspectives across education, therapy, and home practice.

3.3. Data Collection

Data were collected through semi-structured, open-ended interviews lasting approximately 40–50 minutes using Zoom, Google Meet, or in-person sessions. A pilot process was used to review

the interview questions. The interview schedule explored participants' overall views of AI applications, observations of engagement and motivation, perceived academic changes, perceived speech-motor changes, and desired future features. Audio responses were transcribed and prepared for thematic coding. Direct observation of therapy or classroom sessions was restricted by access limitations; consequently, the primary evidence base was participant report.

3.4. Reflexivity and Ethics

The researcher is both a parent of a child with CAS and an experienced special educational needs educator. This positionality provided contextual knowledge but also created the possibility of interpretive bias. Reflexive consideration was therefore used to distinguish personal experience from participant accounts. Written and verbal consent were obtained, participants were informed of the study purpose and procedures, and confidentiality and anonymity were maintained through protected data storage and de-identification.

3.5. Trustworthiness and Analysis

Trustworthiness was considered through credibility, transferability, dependability, and confirmability, drawing on qualitative research principles associated with Lincoln and Guba and later methodological discussion (Stahl & King, 2020). Data were analyzed using Braun and Clarke's thematic approach: familiarization with transcripts, generation of initial codes, grouping codes into candidate themes, reviewing themes against the data set, defining and naming themes, and producing an interpretive account. Codes included academic improvement, articulation and phoneme practice, engagement, independence, supervision, personalization, and accessibility. Themes were compared across parent and professional perspectives.

4. Results

4.1. Theme 1: Gradual but Meaningful Academic and Phonological Growth

Participants commonly described improvements in foundational literacy and language-related learning, including word recognition, reading fluency, spelling, sentence construction, vocabulary recall, and sound–letter correspondence. Some also reported improvements in numeracy, attention, executive functioning, and classroom participation. These gains were generally attributed to repeated exposure, auditory–visual pairing, immediate feedback, and the willingness of children to repeat activities. Importantly, not every participant observed academic improvement, indicating variability across children and applications. One special educator summarized the classroom effect by noting that a student had "more confidence

reading aloud" and improved vocabulary recall. The pattern across accounts therefore suggested gradual support for learning rather than uniform or immediate academic change.

4.2. Theme 2: AI Supports Speech Practice but Does not Replace Therapy

Parents and professionals described AI-assisted tools as useful for additional practice in articulation, phoneme accuracy, sound sequencing, and production of multisyllabic words. Some participants perceived smoother or more consistent speech, while others reported only slight changes or considered physical and clinician-led methods more effective for speech-motor planning. A parent emphasized the boundary clearly: "nothing can replace conversations and speaking to humans." Speech-language pathologists similarly framed AI as supplemental support that can increase practice and provide immediate feedback, while clinical decision-making remains with trained professionals. This theme was one of the strongest areas of agreement between stakeholder groups.

4.3. Theme 3: Engagement, Motivation, and Independence are Major Perceived Benefits

Engagement emerged consistently across the interviews. Participants reported that children often preferred AI-based tasks because of visual rewards, game-like progression, immediate responses, and interactive presentation. They associated these features with longer attention, more speech attempts, greater curiosity, and increased independence. For tasks requiring many repetitions, motivation was viewed as particularly important because children may resist conventional drill-based practice. Participants therefore perceived gamification not as an outcome in itself but as a mechanism that can make purposeful repetition more acceptable and sustainable.

4.4. Theme 4: Positive Attitudes are Accompanied by Caution and Supervision

Participants generally viewed AI favorably but did not support unrestricted use. They emphasized adult supervision, time-limited sessions, clear therapeutic or educational purpose, and integration with established clinical approaches. Concerns included excessive screen exposure, inaccurate feedback, technical glitches, overreliance on applications, and the possibility that generic programs may not match an individual child's motor-speech profile. Professional participants were particularly cautious about interpreting automated feedback as equivalent to clinical assessment.

4.5. Theme 5: Personalization, Clinical Alignment, Multilingual Support, and Affordability are Priorities

Participants wanted future tools to provide personalized and adaptive speech exercises, motor-planning-related analytics, therapist or educator dashboards, progress tracking, school-specific

vocabulary, multisensory feedback, sentence-level support, and culturally appropriate multilingual content. Cost and technical stability were also recurring concerns. One special educator called for "customized less cost applications" with fewer glitches and greater language availability. These responses indicate that stakeholders are not simply requesting more technology; they are asking for tools that better reflect individualized educational and clinical goals.

Across the five themes, parent and professional perspectives converged on four points: AI can increase engagement and opportunities for repeated practice; literacy and phonological skills may benefit from structured use; AI should remain supplemental to professional intervention; and future tools require greater personalization and clinical relevance. Professionals were more conservative than parents in attributing changes in speech-motor planning directly to AI, a distinction that is important when interpreting the findings.

5. Discussion

The findings suggest that the perceived value of AI-assisted teaching for school-age children with CAS lies primarily in extending structured practice rather than replacing therapy. Participants repeatedly linked digital tools with repetition, immediate feedback, visual and auditory support, and increased willingness to engage. This is consistent with the study's theoretical framing: Cognitivism emphasizes active processing and the connection of new learning to existing knowledge, while Bloom's Taxonomy encourages purposeful progression from recognition and understanding toward application and more independent use. In practical terms, an application is educationally useful only when its activities are connected to a defined learning or communication goal.

The first theme, concerning academic and phonological growth, should be interpreted as perceived change rather than measured treatment effect. Participants described word recognition, vocabulary recall, reading fluency, sound–letter correspondence, and classroom confidence. These observations are plausible in light of literature on computer-assisted speech and language practice, where repeated and consistent stimulus presentation can support learning opportunities (Furlong et al., 2017; McCormack et al., 2017). However, the present study did not administer standardized pre/post assessments. It therefore cannot establish that AI caused the reported academic changes.

The distinction between speech practice and speech-motor treatment is equally important. CAS involves planning and programming speech movements, and motor-based interventions require individualized cueing and clinical judgment. DTTC is dynamic precisely because cueing

changes in response to the child's performance. Recent DTTC research supports intensive, individualized motor practice (Grigos et al., 2024), but a generic application cannot be assumed to reproduce tactile cueing, perceptual judgment, or moment-to-moment clinical adjustment. The participants' preference for AI as a supplement is therefore consistent with the theoretical and clinical framework of the study.

At the same time, digital tools may contribute to practice intensity. Participants valued the ability to repeat targets frequently at home and to receive immediate responses. This reflects principles of motor learning concerning practice amount, feedback, and progression, although the optimal schedule and type of feedback for an individual child remain clinical questions. AI-assisted practice may be most useful after a clinician or educator has selected appropriate targets and established how the child should practice them.

Engagement was one of the most consistent findings. Participants described game elements, visual rewards, levels, and interactive tasks as increasing attention and willingness to practice. For children who find repetitive speech work demanding, this motivational function may have practical significance. From a cognitive perspective, attention and active participation affect the opportunity to encode and retrieve information. From an educational perspective, gamification can help sustain practice, but only if the activity remains linked to the intended skill. High engagement with an application should therefore not be treated as evidence of clinical effectiveness by itself.

The findings also highlight the importance of family–professional collaboration. Parents valued accessible home practice, while professionals emphasized supervision and goal alignment. A hybrid model can reconcile these positions: therapists establish clinically appropriate speech targets and monitor progress; educators connect communication goals with curriculum and classroom participation; parents support short, consistent practice at home; and AI tools provide structured repetition, modeling, feedback, or communication access within those boundaries. Such a model preserves human expertise while using technology to increase continuity across settings.

Multilingual and cultural accessibility is particularly relevant to the regional context of this study. Saudi Arabia and the UAE include highly multilingual populations, while participants also represented Pakistan. Tools trained primarily on a narrow range of English accents may misinterpret speech differences, especially when the child already has a speech sound disorder. Participants' requests for Arabic, Urdu, and culturally appropriate content therefore concern both inclusion and accuracy. Developers should validate speech-recognition systems across languages, dialects, ages, and speech profiles before such systems are relied upon for feedback.

Cost, technical reliability, and training further shape implementation. A theoretically strong tool may have little practical value if families cannot afford subscriptions, schools lack compatible devices, or practitioners do not understand how to interpret automated outputs. Professional development should therefore focus not only on operating applications but also on selecting appropriate tools, protecting privacy, recognizing inaccurate feedback, setting measurable goals, and deciding when technology should not be used.

Overall, the study contributes a stakeholder-centered perspective to an emerging field. Its strongest implication is not that AI independently improves CAS, but that parents and professionals see value in carefully supervised AI-assisted practice. The convergence of stakeholder views around repetition, engagement, personalization, and human oversight provides a practical foundation for future intervention studies that can test these perceptions using standardized clinical and educational outcomes.

6. Conclusion, Implications, and Future Research

This exploratory qualitative study examined how parents, special educators, speech-language pathologists, occupational therapists, and a cognitive-behavior therapist perceive AI-assisted teaching for children with CAS aged 6–12. Participants associated structured AI use with increased engagement, repeated practice, phonological and vocabulary support, and greater independence. They also reported perceived improvements in aspects of articulation and speech sequencing, although professionals emphasized that speech-motor intervention requires individualized clinical expertise. The findings therefore support AI as a supplemental educational and practice resource rather than a substitute for speech-language therapy.

For practice, the findings favor a hybrid approach. Clinicians should define and monitor speech targets; educators should connect activities to classroom learning; parents should support short, consistent home practice; and AI tools should be selected for a clear purpose. Developers should prioritize personalization, transparent progress data, multilingual and culturally appropriate content, affordability, and validation for children with speech sound disorders. Training for educators and caregivers is also necessary so that automated feedback is interpreted cautiously and technology use remains purposeful.

6.1. Limitations

The study is limited by its small purposive sample, reliance on stakeholder perceptions, geographic and professional heterogeneity, and lack of direct classroom or therapy observation. No standardized pre/post clinical measures were used, so reported improvements cannot be

interpreted as evidence of treatment efficacy or causation. The researcher's dual position as a SEN educator and parent of a child with CAS may also have influenced interpretation despite reflexive procedures. These limitations restrict generalizability but are consistent with the exploratory purpose of the study.

6.2. Future Research

Future studies should use larger and more diverse samples, longitudinal designs, objective speech and language measures, and comparisons between clinician-led therapy alone and carefully specified AI-supported practice. Research should also examine accent and dialect recognition, Arabic- and Urdu-language tools, privacy and data governance, accessibility and cost, and the extent to which AI-supported practice generalizes to spontaneous communication and classroom participation.

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Disclosure Statement

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Notes on Contributors

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