

Implementing Adaptive Applied Behavior Analysis to Improve Functional Communication in Inclusive Early Childhood Education

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Abstract

This study aimed to examine the implementation of adaptive Applied Behavior Analysis (ABA) and its association with functional communication improvement in an inclusive early childhood education classroom. Although ABA is well established in structured clinical settings, evidence on its adaptation to naturalistic classroom routines remains limited. A Single Subject Research A-B design was implemented with one 5-year-old child with functional communication difficulties at an inclusive early childhood education centre in West Java, Indonesia. Five baseline and five intervention sessions were conducted. The intervention incorporated positive reinforcement, prompting, modelling, shaping, fading, and Functional Communication Training during routines, play, transitions, and daily activities. Structured observations recorded the frequency of functional communication, supported by field notes and classroom documentation. Data were analysed through visual inspection of level, trend, and stability, supplemented by Percentage of Non-overlapping Data (PND) and Tau-U. Functional communication ranged from 1–3 responses per session during baseline ($M = 1.8$) and from 4–8 during intervention ($M = 6.0$). The intervention phase showed an immediate level increase, an upward trend, and greater stability; PND was 100% and Tau-U was .95. The findings indicate that adaptive ABA may be feasibly embedded in inclusive classroom activities to support functional communication, consistent with naturalistic behavioural-intervention principles. However, the A-B design, one-participant sample, and short observation period limit causal inference. Future studies should use multiple-baseline or reversal designs with larger samples and longer follow-up.

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Introduction

In the context of inclusive Early Childhood Education (PAUD), the functional communication skills of children with special needs are a crucial factor in determining the success of social interactions and the learning process (Gastador et al., 2025-Aziz et al., 2021). Based on initial observations conducted during several learning sessions in inclusive PAUD classes, a problem was identified in the low functional communication skills of children (Kim & Noh, 2025-Costa & de Matos, 2025-Lamônica et al., 2021). The results showed that, from a total of five initial meetings (baseline phase), the frequency of children's functional communication was still relatively low. On average, children only engaged in functional communication 1–3 times per session, dominated by simple responses such as nodding or pointing, while meaningful verbal communication was still very rare (Washington et al., 2023 - Wang & Black Delfin, 2024).

Therefore, a more precise measurement approach is needed in the form of a percentage of communication success, namely the ratio between the number of functional communication responses and the total number of communication opportunities available (responses per opportunity). For example, if a child responds 1–3 times out of 10–15 communication opportunities per session, then the communication success rate is in the range of 6–30%. Using this percentage-based measure makes the analysis more proportional and can reduce bias caused by differences in classroom activity structure or variations in interaction demands between sessions.

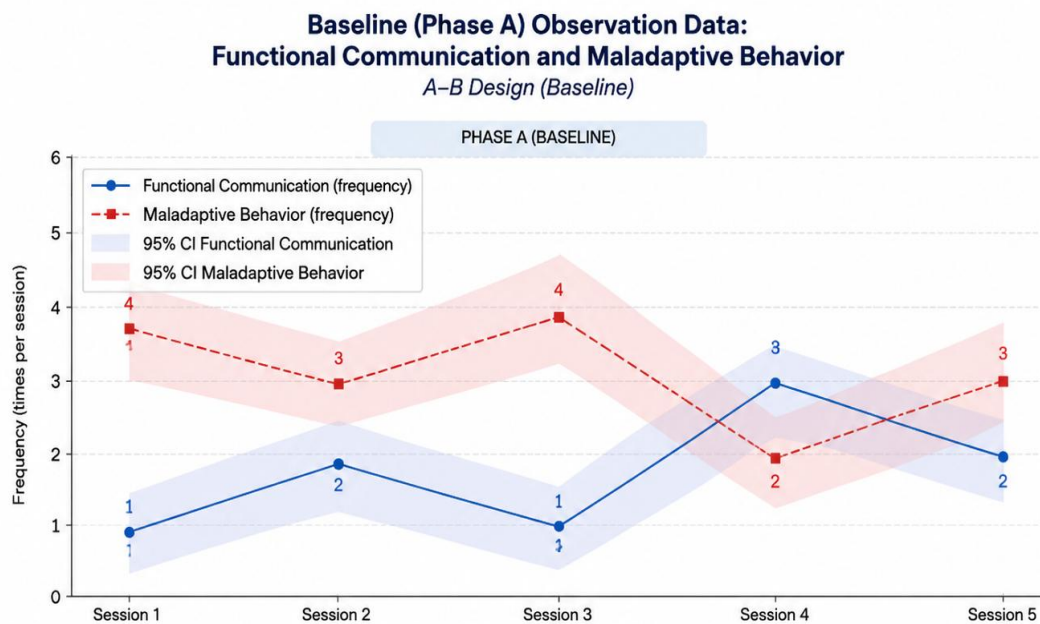


Figure 1. initial baseline observation data

The gap between expected functional communication skills and actual conditions in the field indicates the need for more structured and data-based interventions (Mulderry et al., 2024- Namasivayam et al., 2024) . The learning efforts that have been carried out by teachers have not specifically used a systematic behavior analysis approach, so that the changes in behavior that occur are still limited and inconsistent. This shows that the learning approach currently used is not fully able to answer the individual needs of children with special needs (Gallud et al., 2023 - Trillo-Espinoza et al., 2023 - Du et al., 2024).

Based on these conditions, an intervention approach is needed that not only focuses on general learning but also improves communication behavior in a measurable and gradual manner. Applied Behavior Analysis (ABA) is considered a relevant approach because it focuses on strengthening positive behaviors and reducing maladaptive behaviors through systematic strategies (L. K. Anderson, 2023 - A. Anderson & Hudson, 2022 - Gitimoghaddam et al., 2022). However, the implementation of ABA in inclusive early childhood education settings remains limited, particularly in adaptive forms integrated with natural classroom routines. Therefore, research is needed that not only examines the effectiveness of ABA but also how its application can be adapted to the dynamic, activity-based context of early childhood learning (Polat et al., 2023 - Puig & Evenson, 2023 - Diken et al., 2025).

Inclusive education at the Early Childhood Education (ECE) level reflects a global commitment to ensuring equal access to education for all children, including children with special needs (CSN)

(Nelis et al., 2023 - Sari et al., 2025 - Jusni et al., 2023). Despite this commitment, the implementation of inclusion in early childhood settings continues to face significant challenges, particularly in supporting the development of functional communication skills (Vivanti et al., 2022 - Xovoxon, 2024).

Functional communication refers to a child's ability to express needs, initiate interactions, and respond appropriately to environmental demands. For children with autism, ADHD, and other developmental disorders, communication difficulties are frequently associated with maladaptive behaviors that function as alternative but ineffective forms of communication (Schuck et al., 2022 - Simcoe et al., 2025 - Swain et al., 2025). These communication barriers significantly limit children's social participation and access to meaningful learning experiences in inclusive classrooms (Cəfərova, 2025) (Rasmitadila et al., 2021) (Bhuttah et al., 2024).

Applied Behavior Analysis (ABA) has been widely recognized as an evidence-based approach for improving communication skills and reducing problem behaviors among children with special needs. Core principles such as reinforcement, prompting, shaping, and Functional Communication Training (FCT) have consistently demonstrated effectiveness in developing adaptive communication behaviors (Bruder et al., 2020 - Macy et al., 2024 - Ravanis, 2022). Empirical syntheses further indicate that ABA-based interventions significantly enhance expressive and receptive language skills in children with autism (Giambona et al., 2023 - Mounzer et al., 2023). In particular, FCT has been shown to effectively replace maladaptive behaviors with socially appropriate communication responses (Courtenay & Perera, 2022 - Methlagl et al., 2024 - Jahreie, 2023).

However, most empirical studies on ABA have been conducted in structured clinical environments characterized by one-to-one intervention models and high levels of environmental control (Chandrawijaya, 2021 - Eckes et al., 2023). These controlled conditions differ substantially from inclusive early childhood classrooms, which are heterogeneous, socially dynamic, and grounded in natural interaction. Previous research highlights a gap between the demonstrated effectiveness of ABA in experimental contexts and its practical implementation in school-based inclusive settings (Baştuğ & Bakkaloğlu, 2025 - Butterworth et al., 2024 - Forsythe & Larson, 2023). Early childhood teachers often encounter difficulties when translating structured ABA procedures into play-based learning environments that align with young children's developmental characteristics (Ueda et al., 2021 - Agbenyega & Klibthong, 2025 - Yadav & Huddar, 2025).

Recent developments such as Naturalistic Developmental Behavioral Interventions (NDBI) represent efforts to integrate ABA principles into natural social interactions and developmentally appropriate classroom practices (Dechsling et al., 2021 - D'Agostino et al., 2023 Tiede & Walton, 2019). Although these approaches show promising results, systematic adaptation and empirical examination of such models within inclusive early childhood classrooms particularly in the Indonesian context remain limited. This situation indicates both a conceptual and practical gap in understanding how ABA principles can be flexibly recontextualized within inclusive ECE environments (Bartolo et al., 2021) (Lynch & Soni, 2025) (Störbeck, 2024).

Given these conditions, there is a clear need for an adaptive ABA model that remains grounded in evidence-based principles while being meaningfully integrated into classroom routines, play activities, and daily social interactions (Reichow et al., 2025 - Silva, 2025 - S. Kim et al., 2025). Functional communication is a fundamental prerequisite for social participation and academic engagement among children with special needs. Without contextual and systematic intervention,

children may develop increased dependence on adult assistance and exhibit higher frequencies of maladaptive behaviors (Kibaara, 2024) (Movahedazarhouligh & Warr, 2025).

Therefore, this study aims to develop and examine the implementation of adaptive ABA in inclusive early childhood settings and to analyze its contribution to improving functional communication skills among children with special needs. Specifically, this study addresses two research questions: (1) How is adaptive ABA implemented in inclusive early childhood classrooms? and (2) How does adaptive ABA improve functional communication skills of children with special needs? By addressing these questions, the study seeks to contribute conceptually by recontextualizing ABA principles within inclusive early childhood practice and practically by offering a flexible, evidence-based intervention model.

Method

This study employed a Single Subject Research (SSR) approach using an A–B design. SSR is an experimental methodology specifically developed to evaluate individual behavioral change through repeated and systematic measurement (Irfan et al., 2023 - Smith et al., 2023). The A–B design consisted of two phases: baseline (A) and intervention (B). This design was selected because the study aimed to examine the functional relationship between the implementation of adaptive Applied Behavior Analysis (ABA) and the improvement of functional communication skills in a child with special needs. SSR is particularly appropriate for behavioral intervention research, as ABA is conceptually grounded in experimental behavior analysis, emphasizing observable and measurable behavior change (Ward et al., 2023).

Time and Research Setting

The study was conducted in an inclusive Early Childhood Education (ECE) center located in West Java, Indonesia. The institution provides educational services for children with diverse developmental backgrounds, including children with special needs, within a regular classroom setting. The intervention was integrated into daily classroom routines and play-based learning activities to ensure ecological validity and natural interaction within the inclusive environment.

Research Subject

This study involved one 5-year-old child with special needs as a research participant. In Single Subject Research (SSR), the individual serves as the primary unit of analysis, and behavioral changes are examined through repeated measurements across multiple phases. Participants were selected using purposeful sampling based on the following criteria: (1) the child exhibited functional communication difficulties, such as limited ability to express needs, initiate interactions, or respond appropriately to instructions; (2) the child was actively enrolled in an inclusive class; and (3) written consent from the parent was obtained through a Consent Form prior to participation, as well as expert recommendation. The identity of the participants was withheld to protect confidentiality and privacy.

Procedure

The research procedure consisted of two main phases. During the baseline phase (A), systematic observations were conducted to obtain stable data regarding the child's functional communication performance before intervention. Multiple observation sessions were conducted to ensure data stability and consistency.

During the intervention phase (B), adaptive ABA strategies were implemented within classroom activities. The intervention integrated key ABA principles, including positive reinforcement, prompting, modeling, shaping, fading, and Functional Communication Training (FCT). Reinforcement was used to strengthen appropriate communication responses, while prompting and fading were applied gradually to promote independence. The adaptive aspect refers to the contextual adjustment of ABA strategies to align with early childhood developmental characteristics and natural classroom interactions (Knuutinen et al., 2021).

During the intervention phase (B), adaptive ABA strategies were implemented within natural, contextual PAUD classroom activities. This intervention integrated positive reinforcement, prompting, modeling, shaping, fading, and Functional Communication Training (FCT) to improve children's functional communication skills. Intervention activities were conducted within classroom routines such as transitions, structured play, simple instructional activities, and daily activities like eating and washing hands. Each session lasted 30–45 minutes, 3–5 times per week, with 10–15 response opportunities per session. The teacher served as the primary implementer, assisted by the researcher, after receiving brief training.

Instruments

The primary instrument was a structured observation sheet designed to record the frequency of functional communication behaviors during each learning session. The operational definition of functional communication included the child's ability to: (1) express needs or requests, (2) respond to teacher instructions, (3) express acceptance or refusal, and (4) initiate simple interaction with teachers or peers. Supporting instruments included field notes written by the classroom teacher and documentation of learning activities to provide contextual evidence of the intervention process.

The primary instrument of this study was a structured observation sheet used to record the frequency of children's functional communication behaviors during each learning session. Functional communication is operationally defined as meaningful verbal and nonverbal responses, including the child's ability to express needs or requests, respond to teacher instructions, express acceptance or rejection, and initiate simple interactions with the teacher or peers. A behavioral episode begins when a communication opportunity arises, such as an instruction, need, or social interaction situation, and ends when the child provides a clear response and no further response occurs within a specified time. Data coding was conducted by the primary researcher through direct observation during learning, supported by classroom teacher field notes and activity documentation to reinforce contextual data.

Data Collection Techniques

Data were collected through systematic observation conducted during both baseline and intervention phases. Frequency recording was used to quantify each occurrence of target communication behaviors during classroom sessions. In addition, qualitative data were gathered through field notes documenting classroom dynamics, child responses, and contextual factors influencing communication behavior. Documentation, such as photos and activity records (where permitted), served as supporting data to ensure the fidelity of intervention implementation.

Data Analysis Techniques

Data analysis was conducted using visual analysis, which is the primary analytic procedure in SSR (Kenyon et al., 2020) (Widodo et al., 2020). The analysis focused on examining changes in behavioral

level, trend direction, and data stability between phases. Improvement in functional communication skills was determined by increased frequency and consistency of communication behaviors during the intervention phase compared to baseline. Descriptive analysis was also employed to explain behavioral changes contextually, including reductions in maladaptive responses and increased independence in communication.

Data stability is determined based on the stability envelope criterion, namely if at least 80% of the data in a phase is within $\pm 25\%$ of the median of that phase; data is considered stable if it consistently meets this threshold. Behavioral trends are estimated visually using a trend line that depicts the direction of increase or decrease in the frequency of functional communication behavior from session to session. Changes in levels are calculated by comparing the median or average values between phases (baseline and intervention) to see the extent of behavioral improvement after treatment is given.

Ethical Considerations

This study involved human participants; therefore, ethical standards were strictly observed. Written parental consent was obtained prior to data collection. The participant's identity was anonymized in all documentation and publications. All collected data were used exclusively for research purposes to protect the participant's rights and future well-being.

Result and Discussion

Changes in Functional Communication Across Phases

The results of this study showed a very significant increase in the frequency of children's functional communication after the implementation of adaptive Applied Behavior Analysis (ABA) intervention in an inclusive early childhood education setting. In the baseline phase (A), children's functional communication skills were still relatively low and unstable, characterized by limited frequency of communication behavior and fluctuations between observation sessions.

After the adaptive ABA intervention was implemented in phase B, there was a clear change in the child's communication patterns. The frequency of functional communication consistently increased from session to session, indicating a stable positive trend. The child began to express needs more frequently, respond to teacher instructions, and demonstrate initiative in interacting with the classroom environment.

Effect size analysis reinforced these findings. A Percentage of Non-Overlapping Data (PND) value of 100% indicated that all data in the intervention phase exceeded the highest data in the baseline phase. This indicates that the intervention had a very strong and consistent impact on improving target behaviors. The Tau-U analysis result of 0.95 also indicates a very strong intervention effect and statistically indicates a significant increase in behavior after the intervention. This value reflects behavioral changes that are not only increasing but also stable and not influenced by random variation.

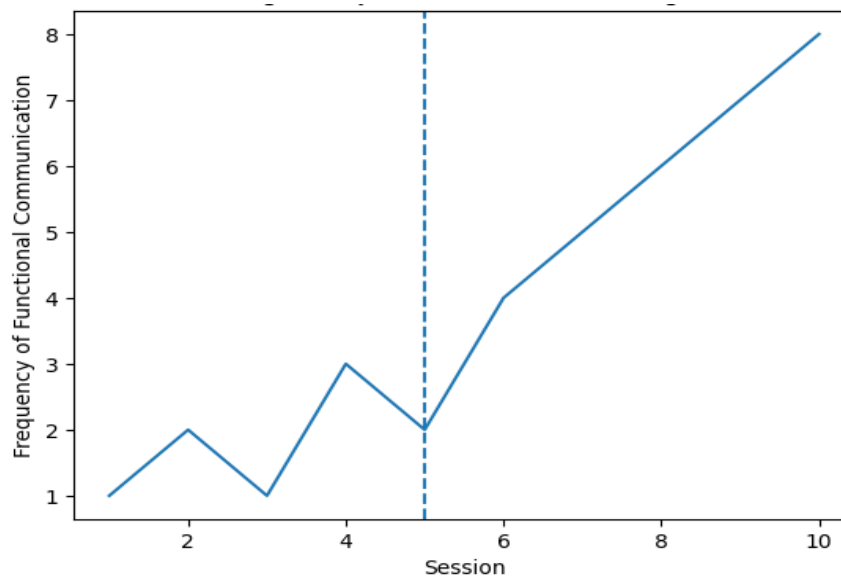


Figure 1. Single Subject Research (A–B Design)

The results of the Single Subject Research (A–B design) are presented in Figure 1. The baseline phase consisted of five observation sessions conducted prior to the implementation of adaptive ABA. During this phase, the frequency of functional communication behaviours ranged from 1 to 3 occurrences per session, with an average of 1.8 responses. The data demonstrated low performance with moderate variability and a relatively flat trend, indicating that the child’s communication skills did not show meaningful spontaneous improvement before intervention.

Following the implementation of adaptive ABA strategies in Session 6, a clear behavioural change was observed. The intervention phase also consisted of five sessions. The frequency of functional communication increased progressively from 4 responses in the first intervention session to 8 responses in the final session, with an average of 6 responses per session. This indicates a substantial increase compared to the baseline condition.

In accordance with established procedures in Single Subject Research (SSR), the data were analyzed through visual inspection focusing on changes in level, trend direction, and stability across phases. The transition from the baseline phase to the intervention phase demonstrated a clear and immediate level change, as reflected by the increase from 2 responses in the final baseline session to 4 responses in the first intervention session. This shift indicates an early intervention effect following the implementation of adaptive ABA strategies. Beyond this immediate change, the overall trend pattern also transformed substantially. While the baseline data displayed a relatively flat trajectory with limited fluctuation, the intervention phase showed a consistent upward trend across sessions, suggesting progressive and sustained improvement in functional communication performance. Furthermore, variability decreased during the intervention phase, and the communication behaviors became more stable and predictable. This increased stability strengthens the interpretation that the observed improvement was systematically associated with the intervention rather than occurring by chance.

To further substantiate the magnitude of the intervention effect, non-overlap analysis was conducted using the Percentage of Non-Overlapping Data (PND) method (Scruggs & Mastropieri, 1998). The highest baseline data point was 3, and all intervention data points ranged between 4 and 8, resulting in a PND score of 100%. According to conventional benchmarks, a PND exceeding 90%

reflects a highly effective intervention. Complementing this analysis, Tau-U was calculated to estimate effect size in single-case research designs. The obtained Tau-U value of .95 indicates a strong intervention effect, confirming that the magnitude of behavioral change was substantial and statistically meaningful within the context of SSR.

Discussion

The findings of this study indicate a substantial improvement in functional communication skills following the implementation of adaptive Applied Behavior Analysis (ABA). The immediate level change, consistent upward trend, increased behavioral stability, and strong effect size (PND = 100%; Tau-U = .95) suggest that the intervention produced a meaningful and systematic behavioral transformation. From a theoretical standpoint, these results can be explained through the fundamental principles of operant conditioning underlying ABA. According to (Shaffer et al., 2023), behavior is shaped and maintained by environmental contingencies, particularly reinforcement. The consistent increase in communication frequency observed during the intervention phase suggests that positive reinforcement successfully strengthened desired communication behaviors, thereby increasing their probability of occurrence. These findings are consistent with (Hidayati et al., 2024), which showed that communication skills improve when instruction is systematically structured and contextually embedded.

The improvement in communication performance also aligns with the theoretical framework of Functional Communication Training (FCT), which posits that maladaptive behaviors often serve communicative functions and can be replaced with socially appropriate alternatives when systematically reinforced. In this study, the reduction of frustration behaviors and the increased use of verbal or functional requests indicate that communication responses were effectively reshaped to serve the same function as previous maladaptive behaviors. This supports the functional perspective of behavior, which emphasizes that behavior change occurs when replacement responses fulfill the same environmental function more efficiently.

Moreover, the gradual reduction of prompts and increased independence observed during the intervention phase reflect the theoretical principles of shaping and fading within behavior analysis. Shaping allows complex behaviors to be developed through successive approximations, while fading ensures that prompts do not become permanent supports. The increasing stability of communication behaviors across sessions suggests that the responses were internalized and maintained by naturally occurring reinforcement within the classroom environment, rather than remaining dependent on artificial prompts.

Importantly, the present findings extend ABA theory into the context of inclusive early childhood education. Traditional ABA research has often emphasized structured, clinic-based interventions with high levels of environmental control (Jansen et al., 2024) (Weisberg & Jones, 2019). However, the successful implementation of adaptive ABA within daily classroom routines in this study supports the theoretical integration proposed in Naturalistic Developmental Behavioral Interventions (NDBI), which combine behavior analytic principles with developmentally appropriate and socially embedded practices. The findings therefore provide empirical support for the argument that ABA principles are not inherently rigid but can be flexibly recontextualized within naturalistic and inclusive educational settings (Crank et al., 2021) (Wainer et al., 2025).

From a broader theoretical perspective, the results reinforce the assumption that functional communication is a prerequisite for social participation and learning engagement in inclusive

environments. When children are provided with systematic and contextually embedded behavioral support, they are more likely to replace maladaptive behaviors with adaptive communication, thereby improving both social interaction and classroom participation. Thus, this study contributes to bridging the theoretical gap between behavior analytic intervention models and inclusive early childhood pedagogy.

The novelty of this study lies in its contextual adaptation of Applied Behavior Analysis (ABA) within an inclusive early childhood education classroom rather than a highly structured clinical or one-to-one intervention setting. While previous ABA research has predominantly focused on controlled therapeutic environments, this study demonstrates how core behavioral strategies, including positive reinforcement, prompting, shaping, fading, and Functional Communication Training, can be integrated into natural classroom routines, play activities, transitions, and daily self-care practices. The study contributes theoretically by linking behavior analytic principles with inclusive early childhood pedagogy and Naturalistic Developmental Behavioral Intervention perspectives. Practically, it offers an initial classroom-based model for teachers to support functional communication through structured but developmentally appropriate strategies embedded in everyday learning interactions. Although the findings are limited to one participant and should not be generalized broadly, they provide preliminary evidence that adaptive ABA may serve as a feasible approach for strengthening communication participation among children with special needs in inclusive early childhood settings.

This study should be interpreted in light of several limitations. First, the A-B Single Subject Research design involving one 5-year-old child limits the strength of causal inference because changes in functional communication may have been influenced by maturation, classroom familiarity, reactivity to observation, or other time-related factors. Second, the study was conducted in one inclusive early childhood education setting in West Java and included only five baseline and five intervention sessions; therefore, the findings may not be generalisable to children with different developmental profiles, classroom conditions, or sociocultural contexts. Third, functional communication was primarily assessed through direct observation, which may be vulnerable to observer expectancy and variation in the number of communication opportunities across sessions. Future studies should employ multiple-baseline, A-B-A-B, or randomised single-case designs involving more participants and schools. Subsequent research should also include interobserver agreement, treatment-fidelity measures, standardised communication assessments, follow-up observations, and generalisation probes across teachers, peers, and home settings to examine whether the effects of adaptive ABA are sustained beyond the intervention period.

Conclusion

This study concludes that adaptive Applied Behavior Analysis (ABA) can be effectively implemented within inclusive early childhood classrooms by integrating reinforcement, prompting, shaping, fading, and Functional Communication Training into daily learning activities. The findings demonstrate a clear improvement in functional communication skills, reflected in increased frequency, consistency, and behavioral stability. The strong effect size indicates that adaptive ABA successfully strengthened communication behaviors while reducing maladaptive responses.

Theoretically, this study confirms the relevance of behavior analytic principles in promoting functional communication and shows that these principles can be flexibly adapted to natural classroom settings. Practically, the results provide guidance for teachers in applying structured yet

developmentally appropriate behavioral strategies in inclusive education. Overall, adaptive ABA offers a feasible and evidence-based model for enhancing functional communication in inclusive early childhood education..

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