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Exploring the Role of Maze Media in Supporting Arithmetic Learning among Children with Cognitive Stunting

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ABSTRACT

Basic arithmetic skills, especially addition and subtraction, are an important foundation for students' success in learning more complex mathematical concepts. However, children with cognitive stunting often experience difficulties in understanding numbers, recognizing mathematical symbols, maintaining attention, and completing arithmetic operations independently. This study aims to explore the role of the Labyrinth learning media in supporting arithmetic learning of addition and subtraction in children with cognitive stunting. This study uses a descriptive qualitative approach with a constructivist paradigm. The subjects were 20 grade IV.C students of SDN 072 Palembang who were identified as having learning difficulties related to cognitive stunting characteristics based on school health records, teacher reports, and classroom observations. Data were collected through observation, semi-structured interviews, documentation, and descriptive pre-post indicators as supporting data. Qualitative data were analyzed using reflective thematic analysis, while descriptive indicators were used to strengthen interpretations without inferential statistical testing. The results showed that the Labyrinth media acts as a concrete, visual, kinesthetic, and collaborative media that helps students understand addition through forward movements and subtraction through backward movements on the game track. This media also encourages learning engagement, prolongs attention span, increases students' willingness to try, and shifts students' behavior from passive to more active in solving simple arithmetic problems. These findings suggest that the Labyrinth media can be an alternative arithmetic learning strategy that is inclusive, enjoyable, and tailored to the learning needs of children with cognitive disabilities in elementary school.

ABSTRAK

Kemampuan aritmetika dasar, khususnya penjumlahan dan pengurangan, merupakan fondasi penting bagi keberhasilan siswa dalam mempelajari konsep matematika yang lebih kompleks. Namun, anak dengan karakteristik stunting kognitif sering mengalami hambatan dalam memahami bilangan, mengenali simbol matematika, mempertahankan perhatian, dan menyelesaikan operasi hitung secara mandiri. Penelitian ini bertujuan untuk mengeksplorasi peran media pembelajaran Labirin dalam mendukung pembelajaran aritmetika penjumlahan dan pengurangan pada anak dengan karakteristik stunting kognitif. Penelitian ini menggunakan pendekatan kualitatif deskriptif dengan paradigma konstruktivistik. Subjek penelitian adalah 20 siswa kelas IV.C SDN 072 Palembang yang diidentifikasi memiliki kesulitan belajar terkait karakteristik stunting kognitif berdasarkan catatan kesehatan sekolah, laporan guru, dan observasi kelas. Data dikumpulkan melalui observasi, wawancara semi-terstruktur, dokumentasi, serta indikator deskriptif pra-pasca sebagai data pendukung. Data kualitatif dianalisis menggunakan analisis tematik reflektif, sedangkan indikator deskriptif digunakan untuk memperkuat interpretasi tanpa pengujian statistik inferensial. Hasil penelitian menunjukkan bahwa media Labirin berperan sebagai media konkret, visual, kinestetik, dan kolaboratif yang membantu siswa memahami penjumlahan melalui gerakan maju dan pengurangan melalui gerakan mundur pada lintasan permainan. Media ini juga mendorong keterlibatan belajar, memperpanjang durasi perhatian, meningkatkan keberanian mencoba, serta mengubah perilaku siswa dari pasif menjadi lebih aktif dalam menyelesaikan masalah aritmetika sederhana. Temuan ini menunjukkan bahwa media Labirin dapat menjadi alternatif strategi pembelajaran aritmetika yang inklusif, menyenangkan, dan sesuai dengan kebutuhan belajar anak dengan hambatan kognitif di sekolah dasar.

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INTRODUCTION

Children with cognitive stunting face significant barriers in learning basic arithmetic, particularly addition and subtraction operations. This condition, resulting from chronic nutritional deficiencies during the first 1,000 days of life, affects not only physical growth but also brain development and cognitive functioning (Black et al., 2013; Sari, 2024). In the context of elementary education, these developmental barriers may appear in the form of limited attention span, slow information processing, difficulty recognizing numerical symbols, and weak retention of basic mathematical concepts. In this study, the term children with cognitive stunting is used operationally to refer to students who have school health records or teacher-identified learning characteristics associated with stunting-related cognitive delay. At SDN 072 Palembang, Grade IV.C includes approximately 20 students who show persistent difficulties in number recognition, symbol interpretation, and simple arithmetic tasks. These conditions indicate the need for learning approaches that are more concrete, visual, repetitive, and emotionally supportive.

The mastery of addition and subtraction represents a critical foundation for subsequent mathematical learning (Wiworo, 2021). These operations constitute essential competencies within the Indonesian Kurikulum Merdeka framework, which emphasizes numeracy literacy as a core skill for all students (Hanifah et al., 2024; Nuraini et al., 2023). However, conventional mathematics instruction that relies heavily on abstract symbols, teacher explanation, and worksheet-based exercises is often insufficient for students with cognitive delays. These students may become passive, easily distracted, and reluctant to participate because arithmetic is perceived as difficult, confusing, and unrelated to concrete experience.

From the perspective of Piaget's theory of cognitive development, elementary school students generally operate within the concrete operational stage, where they think logically about tangible objects and benefit from hands-on experiences (Agustyaningrum et al., 2022). For children with cognitive stunting, the need for concrete and multisensory learning experiences becomes more crucial because stunting has been associated with cognitive developmental barriers, lower numerical scores, and difficulties in learning achievement (Lestari et al., 2024; Maulina et al., 2023).

Therefore, arithmetic learning for these students should not rely solely on symbolic manipulation, but should involve concrete media that allow students to see, touch, move, and physically experience mathematical operations.

Previous research has established that physical manipulatives and visual tools can bridge abstract concepts with real world experiences for typical learners (Cahyani et al., 2024; Husnaeni et al., 2024). Other studies in mathematics education indicate that manipulative based instruction can support mathematical outcomes for students at risk or identified with disabilities, particularly when it is organized through a concrete, representational, anda abstract learning sequence (Ebner et al., 2025; Peltier et al., 2020). In addition, recent empirical studies have shown that concrete, representational, and abstract instruction can support students with special learning needs in understanding number concepts, place value, addition, and subtraction (Flores et al., 2024; Kaya & Yildiz, 2024). Thus, concrete media such as Maze Media are pedagogically relevant because they bridge physical action, visual representation, and abstract arithmetic symbols, enabling children with cognitive stunting to construct arithmetic understanding through structured, meaningful, and engaging learning activities.

Educational games, particularly board games incorporating maze or labyrinth structures, offer promising potential for supporting arithmetic learning among children with special cognitive needs. The labyrinth board game (Labirin) integrates visual spatial elements, kinesthetic manipulation, and social interaction features that align with the multimodal learning requirements of children with cognitive delays (Lesmana et al., 2024; Putra et al., 2024). In this regard, maze based media has strong potential to support arithmetic learning for children with cognitive stunting. Maze Media, locally referred to as Labirin, is a board game based learning medium that integrates visual-spatial pathways, physical movement, turn-taking, and problem-solving activities. In the context of addition and subtraction, movement through the maze can represent arithmetic operations in a concrete way: addition is represented through forward movement, while subtraction is represented through backward movement. This embodied representation helps students experience arithmetic as an action rather than merely as a written symbol.

In addition and subtraction, movement through the maze can represent arithmetic operations in a concrete way Prihandoko and Yunianta (2021) developed the

board game Labyrinth in the Forest for number material and showed that the media was valid, practical, and potentially effective for mathematics learning. Fathurrohman et al. (2023) also explained that Labirin; The Board Game has potential as an educational board game that supports mathematical skills, problem solving, strategic thinking, and social interaction. Furthermore, Putra et al. (2024) found that Labirin: The Board Game improved students' numeracy ability and helped students learn mathematics more easily, especially in whole number and fraction materials. These findings indicate that maze-based board games can function as meaningful learning media in mathematics classrooms. However, existing studies have mostly focused on general students and quantitative learning outcomes, while limited attention has been given to how maze media supports children with cognitive stunting in learning basic arithmetic.

This gap is important because children with cognitive stunting represent a vulnerable group whose learninpppepresentation, emotional safety, and opportunities for active participation. More specifically, there is still limited research exploring how maze media helps these students engage with addition and subtraction, how their learning behaviors change during game-based activities, and how the media shapes their perceptions of mathematics. Thus, the novelty of this study lies in its focus on children with cognitive stunting and its qualitative exploration of Maze Media as a concrete, visual, kinesthetic, and socially interactive support for arithmetic learning.

This study aims to explore the role of Maze Media in supporting addition and subtraction learning among children with cognitive stunting at SDN 072 Palembang. Using a descriptive qualitative approach, this research investigates how the media supports students' engagement, conceptual understanding, learning behavior, and perceptions during arithmetic activities. This study is expected to contribute to constructivist learning theory by showing how concrete and game based media can facilitate mathematical understanding among students with compromised cognitive development. Practically, the findings may provide insights for elementary school teachers in designing inclusive, enjoyable, and developmentally appropriate arithmetic instruction for diverse learners.

METHOD

This study employed a qualitative descriptive design situated within a constructivist paradigm. This design was selected because the study aimed to describe and interpret students' learning experiences, behavioral responses, and meaning-making processes during arithmetic learning with Maze Media in a natural classroom setting. A constructivist perspective assumes that mathematical understanding is constructed through interaction with concrete objects, social participation, and contextual learning experiences (Creswell & Poth, 2018). Although this study incorporated pre–post descriptive indicators to contextualize students' arithmetic performance and engagement, the numerical data were not used for inferential statistical testing. Instead, they served as supplementary descriptive evidence to triangulate classroom observations, interview data, and documentation, consistent with qualitative dominant research in which numerical indicators are used to support, rather than determine, the interpretation of qualitative findings (Maxwell, 2013).

The participants were 20 Grade IV.C students at SD Negeri 072 Palembang who were identified as having learning difficulties associated with cognitive stunting characteristics. The participants were selected purposively based on several criteria: (1) review of school health records documenting chronic nutritional deficits or low birth weight during the first 1,000 days of life; (2) administration of a teacher-completed developmental screening checklist aligned with Indonesian Ministry of Education guidelines for learning difficulties; (3) systematic classroom observations confirming persistent challenges in number recognition, working memory, attention regulation, and response to conventional instruction; and (4) consultation with the school health coordinator to rule out diagnosed neurological or sensory impairments. Written parental consent and student assent were obtained before the study was conducted. The term children with cognitive stunting in this study was used as an operational educational category, referring to students who demonstrated learning characteristics associated with stunting-related cognitive delay, not as a new clinical diagnosis.

Maze Media, locally referred to as Labirin, was implemented in two 60-minute classroom sessions as an exploratory learning activity for addition and subtraction. Each session consisted of four pedagogical phases. First, in the introduction phase the teacher explained game mechanics and explicitly mapped forward movement to

addition and backward movement to subtraction. Second, in the g*uided practice* phase, students navigated maze pathways in small groups using tactile tokens, with teacher scaffolding focused on prompting rather than correcting. hird, in the collaborative play phase, students worked in mixed-ability pairs, solving arithmetic checkpoints while peer tutoring and strategy-sharing emerged organically. Fourth, in the reflection and documentation phase, students verbalized problem-solving steps while teachers recorded field notes. The media featured high-contrast color coding, graduated difficulty levels, and tactile game pieces designed to accommodate fine motor variability and sustain visual-kinesthetic engagement. Teachers adopted a facilitative role, minimizing direct instruction to encourage trial-and-error exploration and self-regulated problem-solving.

Data were gathered through methodological triangulation: (1) structured classroom observations using a validated rubric tracking attention span, participation frequency, error-correction patterns, and non-verbal engagement cues; (2) semi-structured interviews with the classroom teacher, shadow teacher, and six parents to capture pedagogical feasibility and home-context transfer; (3) multimedia documentation (photographs, video recordings, and reflexive field notes); and (4) descriptive pre–post learning indicators measuring number recognition accuracy, addition/subtraction success rates, and sustained focus duration. Pre–post measures were administered as low-stakes classroom tasks embedded within natural lesson flow, avoiding formal testing conditions that could induce anxiety or alter naturalistic behavior.

The qualitative data were analyzed using reflexive thematic analysis. The analysis followed several stages: familiarization with observation notes, interview transcripts, and documentation; generation of initial codes; clustering of codes into preliminary themes; reviewing and refining themes; naming the final themes; and writing interpretive descriptions supported by data excerpts and classroom evidence (Braun & Clarke, 2006). The coding process was conducted inductively, allowing themes to emerge from students' learning behaviors and classroom interactions. Preliminary themes included embodied arithmetic, affective engagement, peer scaffolding, attention regulation, and reduced mathematics anxiety. Descriptive pre–

post indicators were summarized using percentages and time averages to provide contextual support for qualitative findings. These descriptive data were not used to test hypotheses or determine statistical effectiveness.

Credibility was ensured through data triangulation, member checking (sharing preliminary interpretations with the classroom teacher for validation), and prolonged engagement across multiple sessions. Transferability was supported by thick description of contextual, procedural, and participant characteristics. Dependability was maintained via a transparent audit trail documenting analytical decisions, codebook revisions, and reflexivity notes, while confirmability was addressed through researcher bracketing and positionality statements acknowledging prior assumptions about game-based learning. Observation rubrics and interview protocols underwent expert validation by three specialists in mathematics education and special needs pedagogy (Content Validity Index = 0.89), followed by a pilot trial with five non participant students to refine clarity, timing, and ecological feasibility.

RESULTS AND DISCUSSION

Results

The findings are synthesized into three analytical themes derived from the triangulation of observational field notes, interview transcripts, and documentation. To contextualize the qualitative observations, descriptive frequencies were calculated based on a structured observational rubric and task-completion checklists administered during the sessions. The percentages presented represent the proportion of the 20 students who successfully demonstrated the targeted behavioral or arithmetic skill during the post-intervention observations, serving as supplementary descriptive indicators rather than inferential statistical outcomes.

Behavioral Transformation in Arithmetic Engagement

Prior to the intervention, baseline observations revealed that students with cognitive stunting exhibited pronounced avoidance behaviors toward arithmetic tasks. They frequently displayed short attention spans (averaging 5–10 minutes), passive postures, and visible frustration when confronted with abstract numerical symbols on worksheets. The transition to the *Labirin* media catalyzed a notable behavioral shift. During the intervention, students demonstrated increased voluntary engagement and

sustained attention, extending their focus duration to 15–20 minutes. This transformation was particularly evident in their approach to addition and subtraction. Instead of waiting for teacher directives, students began initiating problem-solving attempts. A classroom teacher articulated this shift during an interview: *"Before using the maze, they would just stare at the board or ask to go to the toilet to avoid math. Now, they arrive early specifically to play the math game. They no longer see it as a 'lesson', but as a challenge they want to solve."* (Teacher Interview, Session 2).

Descriptive Shifts in Addition and Subtraction Performance The implementation of the *Labirin* media was associated with observable enhancements in arithmetic task completion. To provide descriptive context to the qualitative findings, task-completion rates were recorded using an observational checklist. The results indicated positive shifts across targeted indicators: number recognition accuracy rose from a baseline of 45% to 85% of students achieving mastery; independent addition task completion increased from 30% to 78%; and subtraction accuracy improved from 25% to 72%. Furthermore, active participation, measured by the frequency of voluntary problem-solving attempts, increased from 20% to 88% of the observed student population.

Table 1. Pre-post comparison of student arithmetic skills and engagement

No	Indicator	Before Intervention	After Intervention	Change Category
1	Number Recognition (1–500)	Frequently confused symbols; mixed up digits	Accurately identified numbers; matched symbols to quantities	Improved
2	Simple Addition (1–500)	Required constant teacher assistance; rarely completed independently	Solved problems autonomously; showed work processes	Significantly Improved
3	Simple Subtraction (1–500)	Numerous calculation errors; reversed operations	More accurate and faster responses; correct procedures	Improved
4	Focus Duration	5–10 minutes before disengagement	15–20 minutes of sustained attention	Improved
5	Active Participation	Passive; waited for teacher direction	Actively solved labyrinth routes; initiated problem-solving	Greatly Improved

As detailed in Table 1, the most prominent qualitative shift was the transition from passive reliance on teacher scaffolding to autonomous rule-governed problem-

solving. The physical mechanics of the *Labirin*—where moving a token forward represented addition and moving backward represented subtraction—provided an embodied representation of abstract operations. This concrete mapping allowed students to visualize the concept of "taking away" (subtraction) as a physical retreat, reducing the calculation errors and operational reversals that characterized their baseline performance.

Triangulated Stakeholder Perspectives and Meaning-Making

Data integration was achieved through convergent triangulation, where observational field notes were cross-referenced with interview transcripts and video documentation to identify recurring analytical themes. This process ensured that findings were not reliant on single-source artifacts but were validated across multiple perspectives.

Table 2. Aggregated qualitative findings from stakeholder interviews

Data Source	Key Statement	Interpreted Outcome
Classroom Teacher	"Students arrive early specifically to play the math game"	Intrinsic motivation activated
Shadow Teacher	"Forward movement = addition; backward = subtraction makes sense to them"	Concrete operational alignment
Parents	"My child teaches his younger sister counting using bottle caps as game pieces"	Learning transfer to home context
Parents	"First time she asks to practice math instead of avoiding homework"	Affective transformation
Students	"Math is fun now, like playing a game with friends"	Perceptual reframing of mathematics

The triangulated data reveal that the *Labirin* media facilitates mathematical meaning-making by aligning with the students' cognitive developmental needs. The shadow teacher's observation that *"forward movement = addition; backward = subtraction makes sense to them"* indicates that the media successfully operationalizes Piaget's concrete operational stage. For children with cognitive stunting, whose abstract reasoning is compromised, this kinesthetic mapping bridges the gap between physical action and mathematical logic.

Furthermore, parent interviews highlighted the transfer of learning beyond the classroom. One parent noted: *"My child teaches his younger sister counting using bottle caps as game pieces, making a maze on the floor. It is the first time she asks to practice*

math instead of avoiding homework." (Parent Interview, Follow-up). This quote is analytically significant as it demonstrates conceptual internalization. The student is not merely memorizing procedures but is actively reconstructing the spatial-arithmetic rules of the *Labirin* in a novel home context, indicating a profound affective and cognitive reframing of mathematics from a source of anxiety to an engaging, meaningful activity.

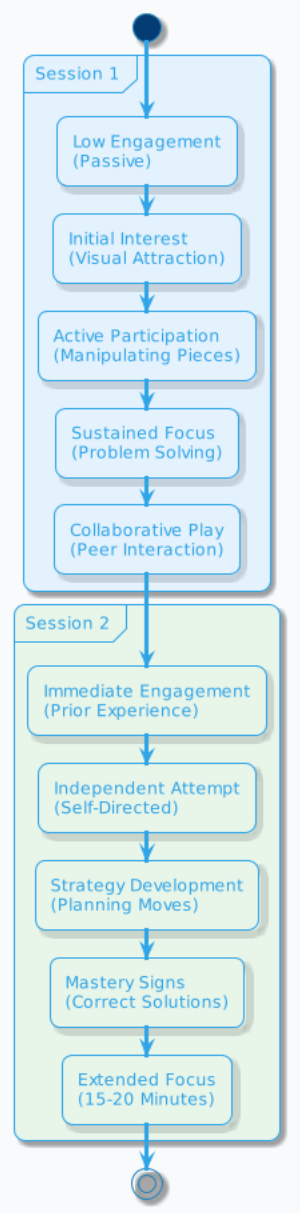

Figure 1. Student Engagement Timeline During Labyrinth Sessions

The timeline diagram in Figure 3 captures the progressive nature of student engagement across the two intervention sessions. Session 1 demonstrates a gradual escalation from passive observation to active collaborative play, mediated by teacher guidance and hands-on exploration. Session 2 shows accelerated engagement patterns

reflecting prior experience, with students entering at higher baseline readiness and progressing more rapidly toward independent mastery. The comparison reveals that the Labirin medium not only produced immediate engagement but also built cumulative learning capacity that enhanced subsequent instructional efficiency.

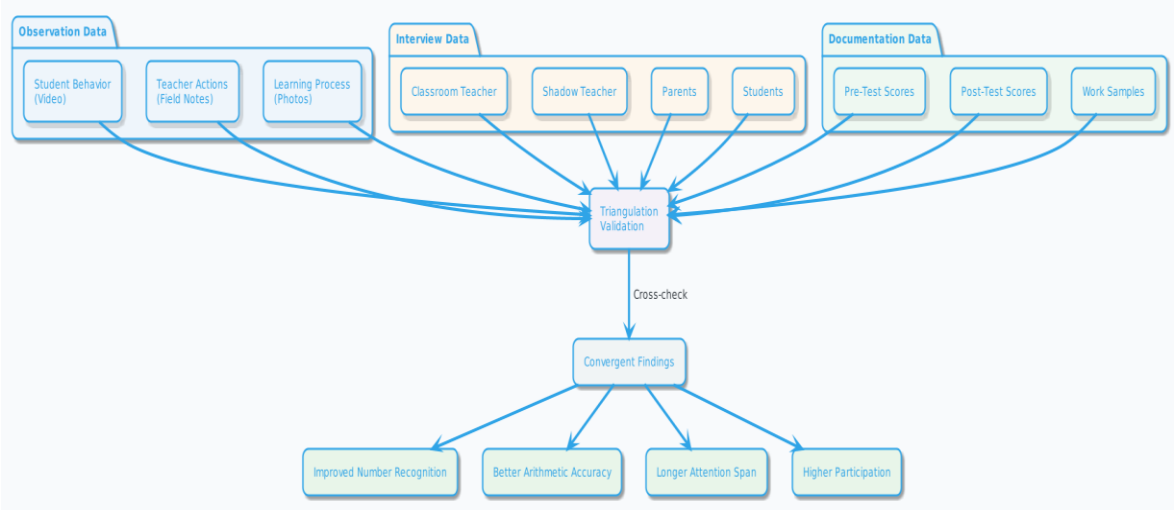

Figure 2. Data Triangulation Framework

The triangulation diagram in Figure 4 illustrates how three independent data sources converged to produce robust findings. Observation data captured real-time behavioral changes, interview data provided interpretive context from multiple perspectives, and documentation supplied objective performance metrics. The central validation process ensured that conclusions were supported by multiple evidence streams rather than single-source artifacts. The four convergent findings emerging from this triangulated analysis address the core research question regarding Labirin effectiveness with exceptional reliability.

Learning Outcome Assessments

The learning assessment results confirmed the findings from the behavioral and perceptual data, where pre-test scores on addition and subtraction problems averaged only 32% correct answers with no students achieving mastery, while after two intervention sessions, post-test scores increased to an average of 76%, with 14 of the 20 students achieving the independence criterion. This improvement exceeds the learning outcomes typically achieved through conventional methods in the same timeframe. In terms of attention, student engagement duration also increased significantly, from only 23% of learning time spent focused before the intervention to

78% during the Maze-based sessions, with a decrease in unfocused behaviors such as averting gaze or interacting out of context. Furthermore, participation patterns shifted from passive to active, as evidenced by an increase in student initiative in asking or commenting from 0.3 to 2.1 times per minute, which was no longer dominated by requests for help but also included sharing strategies and expressions of success. Non-verbal indicators such as forward-leaning postures and more lively facial expressions also increased, indicating deeper engagement in the learning process.

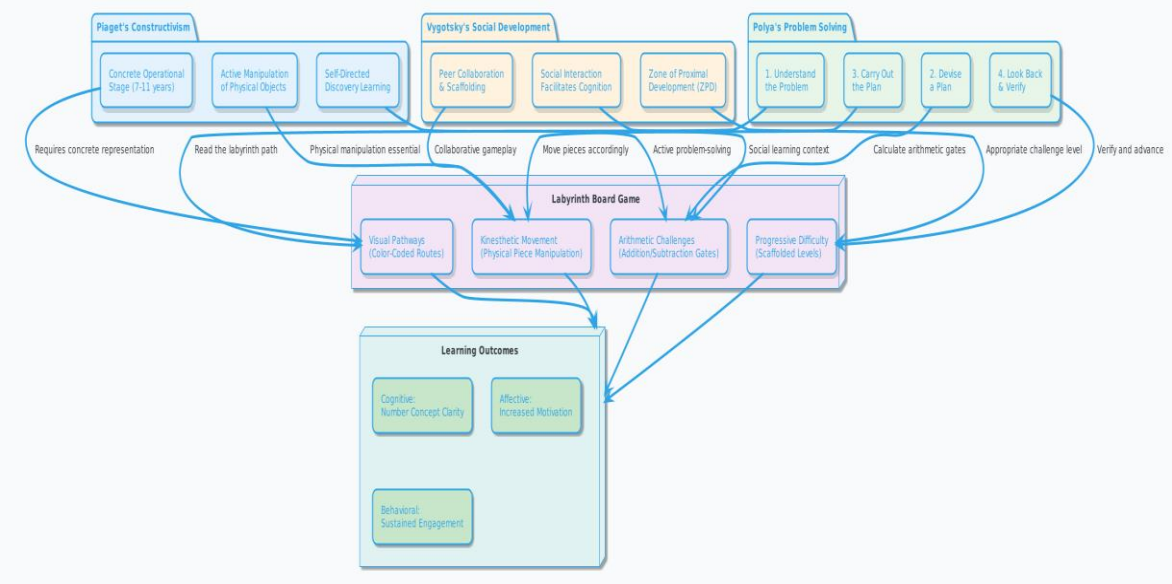

Figure 3. Theoretical Mechanism Framework

Figure 3 presents a streamlined theoretical framework illustrating how the *Labirin* intervention translates core educational theories into specific learning outcomes. To clarify the relationships and reduce visual complexity, the diagram maps three distinct theoretical pathways: (1) Piaget's constructivism, operationalized through visual-kinesthetic manipulation to build concrete arithmetic understanding; (2) Vygotsky's sociocultural theory, activated via peer collaboration to enhance social and affective engagement; and (3) Polya's problem-solving framework, embedded in the game's sequential steps to foster independent execution. These parallel pathways converge to produce the integrated cognitive, affective, and behavioral improvements observed in the students.

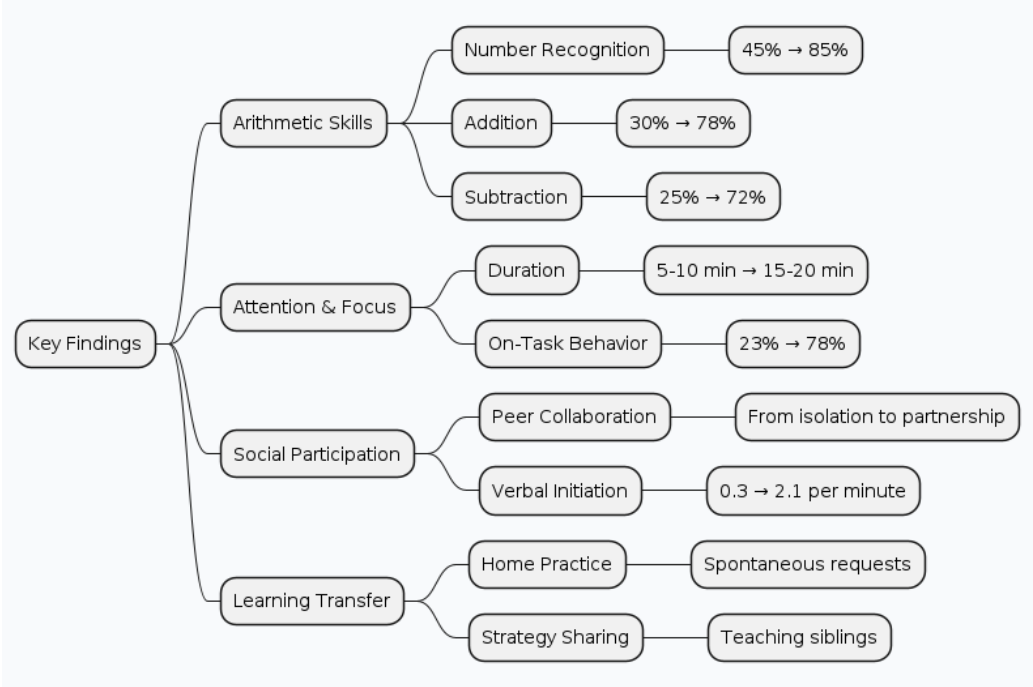

Figure 4. Key Findings Mind Map

The mind map in Figure 6 organizes the principal findings into four interconnected domains. Arithmetic skills demonstrate quantitative improvements in accuracy and speed. Attention and focus document regulatory enhancements essential for academic functioning. Social participation reveals transformative changes in peer interaction patterns. Learning transfer indicates that benefits extended beyond the classroom into home environments. Together, these domains illustrate the comprehensive impact of the Labirin intervention on children with cognitive stunting.

Social Dynamics and Peer Scaffolding

Observational data and video documentation revealed a shift in social dynamics. Students who previously worked in isolation began forming spontaneous collaborative groups. Advanced students naturally assumed mentoring roles, explaining arithmetic routes to peers. This aligns with Vygotsky's zone of proximal development, where peer collaboration scaffolds learning. The game structure naturalized assistance; peer support was framed as collaborative strategy-sharing rather than remedial help, effectively mitigating the social stigma often associated with cognitive delays.

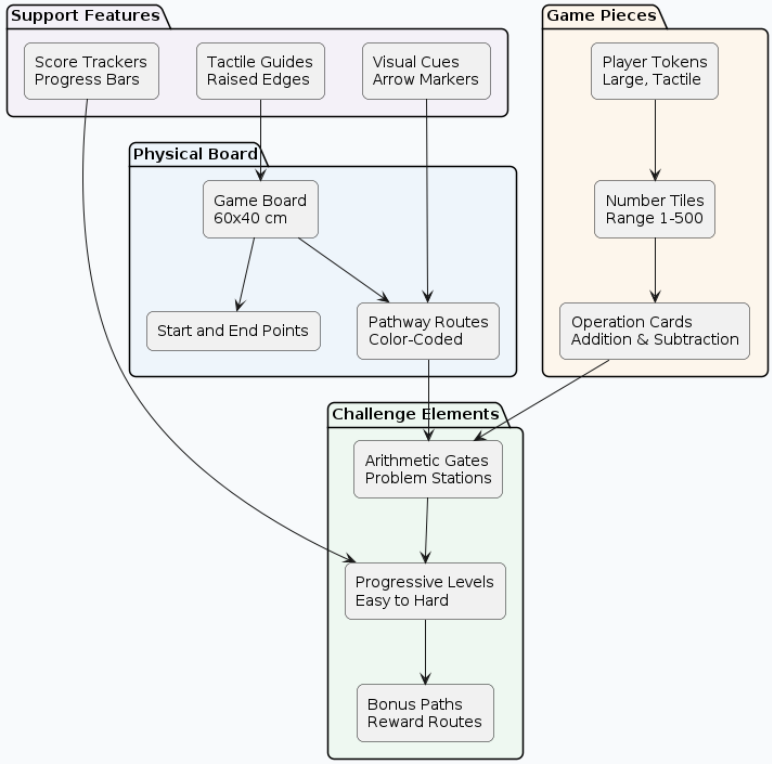

Figure 5. Labirin Media Component Structure

The component diagram in Figure 7 details the structural elements of the Labirin medium that contributed to its effectiveness. The physical board provides spatial organization for learning activities. Game pieces offer tactile engagement appropriate for fine motor limitations. Challenge elements create scaffolded progression from simple to complex tasks. Support features ensure accessibility without compromising challenge. This integrated design addresses multiple barriers simultaneously, explaining the comprehensive nature of observed improvements.

Individual Progression and Sustainability

Comparisons of individual student progress indicated that the intervention's benefits were felt across all baseline levels. Students with moderate cognitive delays experienced the greatest absolute gains, moving from non-participation to independent learning, while students with more severe delays showed smaller gains, but still proportional to their baseline. Even students with the most severe challenges progressed from being unable to recognize numbers to consistently recognizing single-digit numbers, a crucial foundation for later arithmetic learning. In terms of time efficiency, the intervention proved effective, as improvements across multiple areas could be achieved in just two sixty-minute sessions, making it easy to integrate into the

learning schedule without major curriculum changes. Furthermore, the minimal teacher training requirements and the use of reusable media suggest potential for broad and cost-effective implementation. Sustainability of impact was also evident in follow-up interviews, where students continued to show interest in the Maze activity and parents reported continued numerical games at home, indicating that the intervention fostered a lasting interest in mathematics.

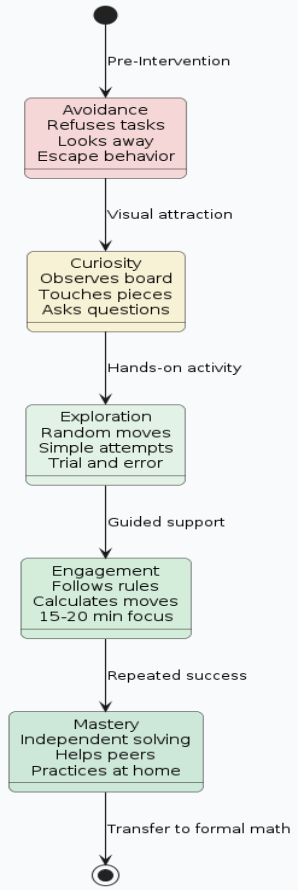

Figure 6. Student Learning Progression State Machine

The state machine diagram in Figure 8 models the sequential transformation of student learning behaviors during the intervention. Students entered from a state of mathematics avoidance characterized by refusal and escape behaviors. Visual attraction to the Labirin board triggered curiosity, which hands-on exploration converted into active engagement. Scaffolding support facilitated progression from random exploration to rule-governed problem-solving. Repeated success experiences culminated in mastery, where students demonstrated independence, peer assistance, and home practice. This progression illustrates how the Labirin medium systematically addresses both emotional and cognitive barriers to mathematics learning.

Integrated Mechanism of Effectiveness

The state machine diagram in Figure 8 illustrates the gradual change in students' learning behavior during the intervention, starting from a state of math avoidance characterized by rejection, then changing to curiosity through the visual appeal of the Maze media, and then active engagement through direct exploration. With scaffolding support, students move from random exploration to rule-based problem-solving, and finally reach the mastery stage characterized by independence, the ability to help friends, and practice at home. This pattern indicates that the Maze media is effective in simultaneously addressing emotional and cognitive barriers. More broadly, the effectiveness of the Maze is supported by various complementary mechanisms: the visual aspect that helps focus attention, the kinesthetic aspect that supports cognitive processing through direct experience, the game structure that increases motivation, and social interactions that expand the learning process. Furthermore, the concrete design that is appropriate to the child's developmental stage allows for appropriate stimulation without burdening their abilities. The combination of quantitative improvements in learning outcomes, qualitative changes in behavior, and validation from teachers and parents provides strong evidence that the Maze media is effective in improving arithmetic learning in children with cognitive stunting, while simultaneously changing the perception of mathematics from a stressful activity to a fun and meaningful one.

Discussion

The findings of this study demonstrate that the Labirin board game functions as an effective visual-kinesthetic learning medium for improving addition and subtraction skills among children with cognitive stunting. The observable improvements in these specific operational tasks align with contemporary research on game-based learning in early numeracy instruction. A systematic review by Vankúš (2021) analyzing 57 journals found that 54% of articles reported positive influences on student motivation and engagement, with 84% documenting beneficial outcomes. Similarly, Manzano-León et al (2021) concluded that educational games possess significant potential for enhancing academic performance and commitment. These convergent findings substantiate the observed effectiveness of the Labirin intervention.

However, the magnitude of improvement in the current study exceeds effect sizes typically reported with typically developing populations. The increase in active participation from 20% to 88% suggests that children with cognitive stunting may derive disproportionately greater benefits from well-designed game media. Coelho et al (2025) demonstrated that integrating multiple game elements produces superior outcomes compared to isolated elements. The Labirin medium simultaneously provides visual stimulation, kinesthetic engagement, social interaction, and cognitive challenge, explaining its notable positive influence on students' operational engagement.

The theoretical foundation rests upon Piaget's constructivist theory, which posits that children in the concrete operational stage require physical manipulation to construct mathematical understanding. Siller & Ahmad (2024) confirmed that blended concrete-virtual manipulatives significantly improve mathematical achievement. Chen et al (2023) established that concrete manipulatives confer advantages over abstract symbol-only approaches. The current study extends these findings by demonstrating that board game manipulatives produce meaningful improvements in basic calculation accuracy for children with compromised cognitive development.

Chen et al (2023) revealed significant associations between concrete manipulative use and spatial reasoning development. The physical act of moving game tokens engages multiple sensory modalities, creating neural connections that symbolic instruction cannot achieve. This multimodal engagement is critical for children with cognitive stunting, whose neurological development benefits from enriched sensory input. The current findings suggest that embodied experiences can provide effective pedagogical accommodations that mitigate learning barriers associated with cognitive delays resulting from early malnutrition.

The social learning dynamics align with Vygotsky's sociocultural theory emphasizing the zone of proximal development. A meta-analysis reported moderate effect sizes for social development ($g = 0.38$) and cognitive development ($g = 0.46$). The observation that students with severe delays participated as valued team members suggests successful inclusive learning environments. This finding implies that well-designed game media can circumvent social stigma associated with cognitive disabilities.

Peer tutoring dynamics differ qualitatively from traditional ability grouping, which reinforces stigma and isolation. The game format naturalizes assistance by framing peer support as collaborative strategy-sharing. Research on game-based interventions for reading difficulties shows socially embedded gameplay produces superior outcomes. The Labirin's capacity to transform ability differences into complementary roles represents a significant contribution to inclusive education.

Comparison with prior labyrinth research reveals both consistencies and unique contributions. Prihandoko & Yunianta (2021) reported improved learning outcomes with "Labyrinth in the Forest." Tsani et al (2021) documented positive effects on creative reasoning with Go-Metra. Putra et al (2024) and Lesmana et al. (2024) validated Labirin's effectiveness for numeracy. The current study advances this literature by targeting children with cognitive stunting.

The doubling of sustained attention from 5-10 to 15-20 minutes is particularly significant, as attention deficits characterize cognitive stunting. This unique contribution suggests labyrinth media have specific affordances for supporting attentional regulation during structured learning tasks. The mechanism involves multiple complementary pathways rather than single-factor effects. The visual component provides salient perceptual input that captures and maintains focus.

The kinesthetic component engages motor systems supporting cognitive processing through embodied cognition. The game structure introduces contingency and reward that motivate sustained effort. The social component leverages peer dynamics extending learning beyond teacher-student interactions. This integrated design aligns with NCTM/CEC recommendations for multiple representations and the CSA approach.

The practical implications extend beyond the specific medium to inform broader intervention principles. First, minimal training requirements suggest scalability in resource-constrained contexts. Second, reusable materials offer cost-effectiveness advantages in low-resource settings. Third, home learning transfer indicates family-level support activation without extensive parent training. These characteristics address implementation barriers limiting real-world impact.

Several limitations warrant acknowledgment. The two-session duration precludes conclusions about long-term maintenance. The small sample limits generalizability to broader populations. The absence of a control group prevents definitive attribution to the Labirin medium specifically. Future research should employ randomized designs with larger samples and extended follow-up periods.

Additionally, neuroimaging could illuminate whether Labirin learning produces measurable brain activation changes. Such research would strengthen theoretical bases and guide media refinement. In conclusion, this study provides preliminary evidence that the Labirin board game represents a promising pedagogical approach for supporting addition and subtraction learning among children with cognitive stunting. The integration of constructivist principles, embodied cognition, social dynamics, and motivational structures produces observable benefits in task engagement and operational accuracy, offering a practical accommodation for diverse learners.

CONCLUSION

This study provides compelling evidence that the Labirin board game serves as an effective visual-kinesthetic learning medium for enhancing arithmetic competencies among children with cognitive stunting, demonstrating substantial improvements in number recognition, addition accuracy, subtraction precision, sustained attention, and active participation. The findings align with and extend prior research on game-based learning, constructivist theory, and embodied cognition, while offering a unique contribution by targeting a previously understudied population with notable improvements in attention regulation. By combining forward-backward movement mechanics with peer collaboration, the Labirin media provides concrete scaffolding that supports arithmetic learning for students experiencing cognitive delays from early malnutrition. Practical implications include scalability in resource-constrained contexts, cost-effectiveness through reusable materials, and spontaneous learning transfer to home environments. Despite limitations regarding sample size, intervention duration, and absence of a control group, this research establishes a promising foundation for inclusive mathematics education, suggesting that thoughtfully designed game media can transform developmental barriers into pathways for learning and offering a model for educational policy and practice in high-stunting prevalence settings.

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