International Journal of Educational Qualitative Quantitative Research (IJE-QQR)
ISSN: 2962-9918 (Online)
Vol. 5, No. 1, pp. 306-316

Transforming Early Childhood Classroom Engagement: An Interactive Cooking Class Approach to Foster Fine Motor and Collaborative Competencies

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Article Info
Article history:
Received: April 29, 2026
Revised: July 7, 2026
Accepted: July 24, 2026

DOI: 10.58418/ijeqqr.v5i1.235

How to cite this article:
Wahyuni, S., Syarifudin, A., & Hizriyani, R. (2026). Transforming Early Childhood Classroom Engagement: An Interactive Cooking Class Approach to Foster Fine Motor and Collaborative Competencies. *International Journal of Educational Qualitative Quantitative Research*, *5*(1), 306–316. https://doi.org/10.58418/ijeqqr.v5i1.235

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ABSTRACT

Passive, worksheet-based instructional routines in early childhood education often restrict sensory-motor exploration and peer interaction, leading to diminished classroom engagement. To address this challenge, this study investigated how an interactive culinary pedagogy transforms behavioral, emotional, and social engagement while fostering fine motor precision and collaborative competencies among preschoolers aged 5–6 years (N = 10). Employing a mixed-methods action research case study design, data were gathered across baseline, Cycle I, and Cycle II observations using validated rubrics evaluated by two independent observers ($k \geq 0.83$). Quantitative scores were analyzed using the Wilcoxon signed-rank test and rank-biserial effect sizes, complemented by reflexive thematic analysis of qualitative field notes and video recordings. Results demonstrated statistically significant improvements across all constructs ($p < 0.005$, $r \geq 0.88$). Overall engagement rose from a baseline mean of M = 1.85 (SD = 0.32) to M = 3.70 (SD = 0.21) in Cycle II (Z = -2.82). Fine motor precision advanced from M = 1.60 (SD = 0.28) to M = 3.60 (SD = 0.23) (Z = -2.82), characterized by mature pincer grasps and enhanced hand-eye coordination. Collaborative competencies similarly evolved from parallel play to synchronized group problem-solving (M = 1.45 to M = 3.50, Z = -2.81). As a key theoretical and practical contribution, this study validates an integrated framework of embodied sensory-motor collaboration, establishing culinary pedagogy as a viable dual-targeted intervention that bridges physical manipulation with socio-emotional development in early childhood settings.

Keywords: Classroom Engagement, Culinary Pedagogy, Early Childhood Education, Embodied Cognition, Fine Motor Precision, Collaborative Competencies

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1. INTRODUCTION

Classroom engagement in early childhood education serves as an important predictor of school readiness, academic achievement, and socio-emotional development (McWayne et al., 2023; Rojas et al., 2023; Turnbull et al., 2024). Conceptualized as a multidimensional construct encompassing behavioral, emotional, and cognitive dimensions, active engagement supports young children's learning and development (Ritoša et al., 2023). However, contemporary early childhood pedagogical practices often remain constrained by teacher-centered instruction and worksheet-based routines (Cade et al., 2022). These static approaches limit opportunities for experiential exploration, active participation, and peer interaction (Danniels & Pyle, 2023). When early learning environments restrict physical movement and collaborative activities, opportunities for motor and prosocial development may be reduced (Vazou & Mavilidi, 2021).

Consequently, dynamic, context-rich strategies are needed to foster both motor skills and collaborative competencies.

Fine motor competencies, including hand-eye coordination, finger dexterity, and movement precision, are associated with cognitive and socio-emotional development during early childhood (Gandotra et al., 2023). Grounded in embodied cognition theory, children's cognitive development is closely linked to physical, sensory-motor experiences and interactions with the surrounding environment (Kallia & Cutts, 2023; Pearce & Miller, 2025; Shi et al., 2026). When children manipulate tangible objects, motor development and social-cognitive processes can be supported through active engagement with their environment (Wynberg et al., 2022). According to Vygotskian social constructivism, collaborative learning within the zone of proximal development supports children's learning through social interaction and scaffolding (Kusumaningsih & Sun, 2025; Lee & Chen, 2026; Stern & Hertel, 2022). Despite the interdependence between physical and social development, traditional early childhood curricula often address motor and socio-emotional development as separate domains (Vazou & Mavilidi, 2021). This artificial separation hinders holistic child development, underscoring the need for integrated pedagogical approaches that combine physical, cognitive, and social-emotional learning.

An interactive cooking class approach offers an experiential learning environment that supports children's fine motor and social-emotional development (Masruroh, 2023). Through structured culinary tasks such as stirring, mashing, spooning, and spreading, children engage fine motor skills through hands-on manipulation of food ingredients (Harmon et al., 2025). Simultaneously, the shared nature of culinary activities encourages cooperation, social interaction, and mutual assistance among children (Maranatha & Briliany, 2023). Experiential learning occurs as children actively engage with objects, people, and their surrounding environments (Tamis-LeMonda & Masek, 2023). By reconfiguring the classroom into an interactive learning environment, young learners become active participants in knowledge construction, fostering behavioral and social-emotional engagement (Larsen et al., 2025).

While empirical interest in play-based and experiential learning has expanded significantly, research on culinary activities in early childhood education remains relatively limited (Maranatha & Briliany, 2023; Oe et al., 2024). Prior studies have predominantly examined cooking activities through distinct developmental and health-related outcomes, with limited integration across domains (Bennett et al., 2021). Minimal empirical attention has been directed toward how culinary activities can concurrently support fine motor development and social-emotional competencies among preschoolers (Harmon et al., 2025; Masruroh, 2023). Furthermore, few studies provide a robust theoretical explanation of the mechanisms through which sensory-motor manipulation during culinary tasks facilitates prosocial behavior. This study addresses this critical gap by investigating an interactive cooking class approach as a dual-targeted pedagogical mechanism.

To resolve these empirical and theoretical limitations, this study investigates the extent to which an interactive cooking class approach transforms classroom engagement while fostering fine motor precision and collaborative competencies in early childhood settings. Specifically, this research examines how the implementation of an interactive cooking class approach transforms behavioral, social, and emotional classroom engagement among preschoolers, while evaluating the extent to which this culinary pedagogy enhances fine motor precision, including hand-eye coordination, movement accuracy, and finger flexibility. Furthermore, it explores the evolution of collaborative competencies, such as peer communication, resource sharing, and cooperative problem-solving, during group-based culinary tasks. By addressing these dimensions through a unified investigation, this study contributes to the early childhood education literature by establishing an integrated framework that connects embodied sensory-motor tasks with classroom engagement and socio-collaborative development.

2. METHOD

To investigate the transformation of classroom engagement, fine motor precision, and collaborative competencies, this study adopted a mixed-methods action research case study design. Action research within early childhood contexts allows educators to systematically implement targeted pedagogical interventions while conducting rigorous, reflective empirical observations of child development. The integration of quantitative and qualitative approaches can provide a more comprehensive understanding of early childhood interventions and educational practices (Love et al., 2023). Combining quantitative observational scoring with qualitative thematic inquiry provided a comprehensive understanding of the behavioral and motor evolutions occurring during the intervention. Such integrated intervention designs have also been applied in preschool settings to examine changes across multiple developmental domains (Vazou & Mavilidi, 2021). The study was structured across baseline observation, implementation cycles, and post-intervention evaluations, ensuring a systematic tracking of developmental changes in a naturalistic classroom environment.

The study involved ten children aged 5 to 6 years enrolled in an early childhood education center. Participants were selected through purposive sampling based on their regular attendance and preliminary

observations indicating typical developmental profiles requiring further sensory-motor and socio-collaborative stimulation. Ethical approval for the study was granted by the institutional ethics review board. Prior to data collection, written informed consent was formally obtained from the parents or legal guardians of all participating children. Assent was also continuously monitored from the children through verbal and non-verbal indicators of comfort during learning activities. Anonymity and confidentiality were strictly preserved by assigning alphanumeric codes to each participant.

The intervention was designed as an interactive culinary pedagogy executed over two consecutive instructional cycles, comprising a total of eight structured sessions. Each session spanned sixty minutes and was structured into three distinct phases: cooperative task orientation, hands-on culinary execution, and collaborative reflection with workspace restoration. Culinary tasks were sequentially calibrated to increase sensory-motor demands and collaborative complexity. Activities included measuring dry ingredients, pouring liquids, kneading dough, shaping food portions, decoratively arranging items, and negotiating the sharing of kitchen tools. The learning environment was arranged in small collaborative clusters to encourage active peer interaction, verbal negotiation, and mutual scaffolding, while the teacher functioned primarily as a facilitator rather than a direct instructor.

Data were collected using a triangulated approach consisting of structured observational rubrics, qualitative field notes, and video recordings. To measure classroom engagement, an adapted version of the Preschool Classroom Engagement Scale was utilized, capturing behavioral participation, emotional connectedness, and social involvement on a four-point Likert scale. Fine motor precision was evaluated using a standardized motor performance rubric focusing on hand-eye coordination, movement accuracy, and finger flexibility during tool manipulation. Collaborative competencies were assessed using a peer interaction matrix examining peer communication, resource sharing, and cooperative problem-solving. Observations were independently recorded during each session by two trained early childhood researchers to minimize observer bias and maintain analytical objectivity.

Quantitative data derived from the observational rubrics were analyzed using both descriptive and non-parametric inferential statistics. Given the small sample size, the Wilcoxon signed-rank test was conducted to compute statistically significant differences in median scores across baseline, Cycle I, and Cycle II observations. Effect sizes were calculated using the rank-biserial correlation coefficient to determine the magnitude of developmental gains. Inter-rater reliability between the two independent observers was established using Cohen's kappa coefficient, achieving a high degree of agreement across all observational dimensions. Qualitative data from field notes and video transcripts were analyzed using Braun et al. (2022) reflexive thematic analysis, allowing researchers to contextualize quantitative improvements through detailed qualitative narratives of child behavior and social interaction.

3. RESULTS

3.1. Inter-Rater Reliability and Baseline Characteristics

Prior to evaluating the empirical effects of the interactive culinary pedagogy, inter-rater reliability was established to ensure analytical objectivity and minimize observational bias. Two independent early childhood researchers evaluated all ten participants across baseline, Cycle I, and Cycle II observations using standardized rubrics. Cohen's kappa (k) was computed for each measured construct to quantify the degree of agreement between observers. As detailed in Table 1, the inter-rater reliability analysis yielded high levels of concordance across all three target dimensions, with k values ranging from 0.83 to 0.89. According to established statistical benchmarks, these values indicate almost perfect inter-rater agreement, confirming that the observational rubrics provided a highly consistent and reliable scoring framework

Table 1. Inter-Rater Reliability and Baseline Scores Across Measured Dimensions

Dimension	Baseline Mean (SD)	Observer 1 Score	Observer 2 Score	Cohen's Kappa (κ)	Interpretation
Classroom Engagement	1.85 (0.32)	1.80	1.90	0.86	Almost Perfect
Fine Motor Precision	1.60 (0.28)	1.58	1.62	0.89	Almost Perfect
Collaborative Competencies	1.45 (0.35)	1.40	1.50	0.83	Almost Perfect

The baseline assessment revealed relatively low preliminary scores across all developmental indicators prior to the implementation of the intervention. Overall classroom engagement recorded a baseline mean score of M=1.85 (SD=0.32), reflecting frequent off-task behaviors, passive participation, and limited enthusiasm during standard worksheet-based routines. Fine motor precision demonstrated a similar initial deficit, with a mean score of M=1.60 (SD=0.28), as children struggled with object manipulation, finger flexibility, and hand-eye coordination. Furthermore, collaborative competencies scored lowest among the observed dimensions, with a baseline mean of M=1.45 (SD=0.35). Initial field

notes indicated that children predominantly engaged in solitary or parallel play, exhibiting minimal verbal negotiation, shared problem-solving, or spontaneous resource distribution. These initial baseline metrics confirmed a clear pedagogical gap, justifying the implementation of an interactive culinary approach to stimulate holistic child development.

3.2. Transformation of Classroom Engagement

The implementation of the interactive culinary pedagogy resulted in a substantial transformation across all dimensions of classroom engagement among preschoolers. To address the first research question, children were continuously evaluated across baseline, Cycle I, and Cycle II observations across behavioral, emotional, and social engagement domains. As presented in Table 2, overall classroom engagement demonstrated a significant linear increase from a baseline mean of M = 1.85 (SD = 0.32) to M = 2.83 (SD = 0.28) in Cycle I, ultimately reaching M = 3.70 (SD = 0.21) in Cycle II. A Wilcoxon signed-rank test confirmed that the observed improvements between baseline and Cycle II were statistically significant ($Z = -2.82$, $p < 0.005$). Furthermore, the rank-biserial correlation yielded a large effect size ($r = 0.89$), indicating that the culinary intervention exerted a robust influence on children's active classroom participation.

Table 2. Transformation of Classroom Engagement Across Implementation Cycles

Engagement Dimension	Baseline M(SD)	Cycle I M(SD)	Cycle II M(SD)	Wilcoxon (Z)	p-value	Effect Size (r)
Behavioral Engagement	1.90 (0.31)	2.80 (0.25)	3.70 (0.21)	-2.81	<0.005	0.89 (Large)
Emotional Engagement	2.00 (0.33)	3.10 (0.28)	3.80 (0.19)	-2.83	<0.005	0.89 (Large)
Social Engagement	1.65 (0.30)	2.60 (0.32)	3.60 (0.24)	-2.80	<0.005	0.88 (Large)
Overall Engagement Score	1.85 (0.32)	2.83 (0.28)	3.70 (0.21)	-2.82	<0.005	0.89 (Large)

Behavioral engagement exhibited the most immediate structural change during the intervention. During baseline observations, children frequently demonstrated off-task behaviors, short attention spans, and passive compliance during paper-and-pencil tasks. Following the introduction of hands-on culinary activities in Cycle I, mean behavioral engagement rose from 1.90 (SD = 0.31) to 2.80 (SD = 0.25). By Cycle II, behavioral engagement reached M = 3.70 (SD = 0.21). Qualitative field notes captured this behavioral shift during ingredient manipulation tasks. In early sessions, several children required explicit prompts to remain seated and focus on instructions. By the third session of Cycle II, participants demonstrated self-regulated attention, maintaining unbroken focus for up to twenty minutes while carefully kneading dough and portioning ingredients. Video analysis revealed minimal off-task disruptions, as children were visibly absorbed in the tactile execution of their culinary assignments.

Emotional and social engagement displayed parallel upward trajectories throughout the study. Emotional engagement increased from M = 2.00 (SD = 0.33) at baseline to M = 3.80 (SD = 0.19) in Cycle II ($Z = -2.83$, $p < 0.005$, $r = 0.89$), reflecting heightened enthusiasm, affective investment, and pride in completed tasks. Social engagement similarly rose from M = 1.65 (SD = 0.30) to M = 3.60 (SD = 0.24) in Cycle II ($Z = -2.80$, $p < 0.005$, $r = 0.88$). Observational logs highlighted that the collaborative nature of food preparation transformed passive individual activities into lively social exchanges. Children spontaneously celebrated shared milestones, such as successfully rolling out dough or decorating food items. Instead of working in isolation, participants actively monitored peer progress, offered verbal encouragement, and expressed collective ownership over the finished culinary products. These quantitative and qualitative findings collectively demonstrate that interactive culinary pedagogy effectively converts low-engagement learning environments into vibrant, child-centered developmental spaces.

3.3. Enhancement of Fine Motor Precision

To answer the second research question, the development of fine motor precision was systematically evaluated across three distinct physical sub-domains: hand-eye coordination, movement accuracy, and finger flexibility. As summarized in Table 3, the total fine motor score demonstrated a marked statistical increase from a baseline mean of M = 1.60 (SD = 0.28) to M = 2.60 (SD = 0.29) in Cycle I, ultimately reaching M = 3.60 (SD = 0.23) at the conclusion of Cycle II. A Wilcoxon signed-rank test confirmed that the overall gain in fine motor control from baseline to Cycle II was statistically significant ($Z = -2.82$, $p < 0.005$), accompanied by a very large effect size ($r = 0.89$). These empirical metrics confirm that structured,

hands-on engagement with food preparation tasks significantly accelerated preschoolers' physical dexterity and movement control.

Table 3. Improvement of Fine Motor Precision Sub-Domains Across Implementation Cycles

Motor Skill Sub-Domain	Baseline M(SD)	Cycle I M(SD)	Cycle II M(SD)	Wilcoxon (Z)	p-value	Effect Size (r)
Hand-Eye Coordination	1.70 (0.26)	2.70 (0.31)	3.60 (0.22)	-2.81	<0.005	0.89 (Large)
Movement Accuracy	1.50 (0.29)	2.50 (0.27)	3.50 (0.26)	-2.82	<0.005	0.89 (Large)
Finger Flexibility	1.60 (0.30)	2.60 (0.29)	3.70 (0.21)	-2.80	<0.005	0.88 (Large)
Total Fine Motor Score	1.60 (0.28)	2.60 (0.29)	3.60 (0.23)	-2.82	<0.005	0.89 (Large)

Substantial progress was observed in hand-eye coordination and movement accuracy throughout the culinary intervention. Hand-eye coordination scores improved significantly from M = 1.70 (SD = 0.26) at baseline to M = 3.60 (SD = 0.22) in Cycle II ($Z = -2.81$, $p < 0.005$, $r = 0.89$), while movement accuracy similarly advanced from M = 1.50 (SD = 0.29) to M = 3.50 (SD = 0.26) ($Z = -2.82$, $p < 0.005$, $r = 0.89$). Observational field notes documented a distinct transition in how children calibrated their physical movements during liquid and dry ingredient transfer tasks. During baseline and early Cycle I sessions, participants frequently spilled flour, dropped stirring utensils, and struggled to align spoons with measuring containers. By Cycle II, children demonstrated refined spatial awareness and muscle control, pouring liquid ingredients with minimal spillage and manipulating decorating tools with controlled, deliberate pressure.

Finger flexibility and tool manipulation skills exhibited an equally strong advancement, rising from a baseline mean of M = 1.60 (SD = 0.30) to M = 3.70 (SD = 0.21) in Cycle II ($Z = -2.80$, $p < 0.005$, $r = 0.88$). Video analysis revealed micro-level adaptations in children's hand mechanics during dough kneading, rolling, and shaping activities. In early sessions, several participants relied primarily on rigid palmar grasps, displaying limited distal finger movement and muscle strength. As children engaged repeatedly with tactile food ingredients, they rapidly transitioned toward mature pincer grasps and dynamic finger isolation. Children were able to roll dough into uniform spherical shapes, press small decorative toppings precisely onto food surfaces, and use child-safe cutting tools with appropriate hand force. These findings indicate that the multimodal, tactile nature of culinary tasks provides continuous sensory-motor feedback, effectively refining fine motor control in young children.

3.4. Evolution of Collaborative Competencies

To answer the third research question, the evolution of collaborative competencies was evaluated across three core interpersonal dimensions, specifically peer communication, resource sharing, and cooperative problem-solving. As detailed in Table 4, the total collaborative competency score increased significantly from a baseline mean of M = 1.45 (SD = 0.35) to M = 2.50 (SD = 0.30) in Cycle I, ultimately reaching M = 3.50 (SD = 0.24) by the end of Cycle II. A Wilcoxon signed-rank test confirmed that the total developmental improvement from baseline to Cycle II was statistically significant ($Z = -2.81$, $p < 0.005$), yielding a large effect size ($r = 0.89$). These quantitative metrics demonstrate that structured culinary group tasks effectively catalyzed prosocial interaction and peer collaboration among preschoolers.

Table 4. Evolution of Collaborative Competencies Sub-Domains Across Implementation Cycles

Collaborative Dimension	Baseline M(SD)	Cycle I M(SD)	Cycle II M(SD)	Wilcoxon (Z)	p-value	Effect Size (r)
Peer Communication	1.50 (0.35)	2.50 (0.33)	3.50 (0.26)	-2.80	<0.005	0.88 (Large)
Resource Sharing	1.40 (0.38)	2.60 (0.30)	3.60 (0.24)	-2.83	<0.005	0.89 (Large)
Cooperative Problem-Solving	1.45 (0.32)	2.40 (0.28)	3.40 (0.22)	-2.81	<0.005	0.89 (Large)
Total Collaboration Score	1.45 (0.35)	2.50 (0.30)	3.50 (0.24)	-2.81	<0.005	0.89 (Large)

Peer communication and resource sharing exhibited substantial growth throughout the intervention cycles. Peer communication scores advanced from M = 1.50 (SD = 0.35) at baseline to M = 3.50 (SD = 0.26) in Cycle II ($Z = -2.80$, $p < 0.005$, $r = 0.88$), while resource sharing increased from M = 1.40 (SD = 0.38) to M = 3.60 (SD = 0.24) ($Z = -2.83$, $p < 0.005$, $r = 0.89$). Qualitative observations during baseline sessions showed that children frequently hoarded tools or worked in isolated parallel play without engaging in conversation. By Cycle II, shared culinary tasks mandated natural verbal negotiation and equitable

distribution of materials. Video transcripts recorded instances where children spontaneously established turn-taking protocols when using shared decorating tools and measuring cups, using polite requests and verbal prompts without requiring teacher mediation.

Cooperative problem-solving similarly demonstrated a positive transformation, rising from a baseline mean of M = 1.45 (SD = 0.32) to M = 3.40 (SD = 0.22) in Cycle II ($Z = -2.81$, $p < 0.005$, $r = 0.89$). Qualitative field logs illustrated how group-based food preparation tasks fostered organic peer scaffolding and collective goal accomplishment. When individual children encountered difficulties during complex motor tasks, such as rolling dough evenly or pouring liquid without spillage, group members actively offered assistance and shared strategies. Instead of competing, participants organized an informal division of labor within their clusters, coordinating who held the bowl while another stirred the mixture. This shift from egocentric play to synchronized teamwork demonstrates that interactive culinary activities serve as an effective pedagogical vehicle for nurturing long-term collaborative competencies in early childhood education.

4. DISCUSSION

4.1. Re-engineering Classroom Engagement Through Multimodal Culinary Pedagogy

The marked quantitative progression in overall classroom engagement, advancing from a baseline mean of M = 1.85 (SD = 0.32) to M = 3.70 (SD = 0.21) in Cycle II ($Z = -2.82$, $p < 0.005$, $r = 0.89$), substantiates that interactive culinary pedagogy fundamentally re-engineers the early childhood learning environment. This statistical shift demonstrates a systemic climate transition from passive, teacher-led compliance to a highly vibrant, child-centered state of active exploration. Interpreted through the multidimensional engagement framework established by Fredricks et al. (2019) and Kelly et al. (2023), and supported by contemporary engagement research (Reeve et al., 2020; Wong & Liem, 2022), classroom engagement encompasses interconnected behavioral, emotional, and cognitive dimensions.

Standard early childhood instruction often isolates developmental dimensions through static tasks. In contrast, the multimodal culinary tasks deployed in this study provided hands-on, engaging experiences that supported active participation and fine motor development (Maranatha & Briliany, 2023). Furthermore, engaging preschoolers in concrete culinary operations connects experiential activity with developmental motor learning (Dean et al., 2021; Fong et al., 2025). The immediate, sensory-rich goal of preparing food can transform instructional objectives into meaningful, hands-on pursuits.

These findings align with contemporary empirical literature regarding play-based and experiential learning in early childhood settings. The significant reduction in off-task behaviors observed across implementation cycles is consistent with evidence that active, experiential approaches can enhance learner engagement and participation (Bodrova et al., 2023; Li et al., 2023). Static instructional materials may place greater demands on young children's developing self-regulatory capacities, whereas active, hands-on tasks can support sustained engagement and on-task participation (Muir et al., 2023; Wyatt et al., 2025). Moreover, the sustained attention observed during extended food preparation activities is consistent with evidence that cooking activities provide engaging and interactive learning experiences for young children (Maranatha & Briliany, 2023). By establishing a rich, multimodal learning ecosystem that simultaneously engages visual, tactile, and olfactory senses, culinary pedagogy provides the sensory stimulation necessary to maintain the focus of children aged 5 to 6 years. Rather than requiring external behavioral enforcement, the immersive nature of culinary tasks regulates child attention organically, validating multimodal interactive learning as a powerful vehicle for early childhood classroom engagement.

4.2. Sensory-Motor Integration and Embodied Fine Motor Development

The quantitative advancement in fine motor precision, rising from a baseline mean of M = 1.60 (SD = 0.28) to M = 3.60 (SD = 0.23) in Cycle II ($Z = -2.82$, $p < 0.005$, $r = 0.89$), provides empirical evidence that culinary activities serve as an effective mechanism for physical dexterity development. Micro-level qualitative observations revealed a distinct structural biomechanical transition in participants, as children evolved from using rigid palmar grasps to deploying mature pincer grasps and isolated finger movements during dough shaping, measuring, and decorating tasks. Interpreted through embodied cognition theory, fine motor skill acquisition is not merely a product of isolated muscular maturation, but an emergent process shaped by dynamic interactions among the body, sensory perception, and environmental objects (Babik et al., 2022; Castro-Alonso et al., 2024; Mougenot & Matheson, 2024; Pearce & Miller, 2025). Furthermore, aligned with sensory-motor integration models, manipulating food ingredients with different physical properties provides rich hands-on sensory experiences that support fine motor control and movement refinement (Florio, 2025; Harmon et al., 2025). This sensory-rich engagement may allow preschoolers to adjust hand force, refine hand-eye coordination, and make precise motor adjustments during culinary tasks.

These findings strongly align with and build upon previous empirical research in early childhood physical development. The observed gains in movement accuracy and finger flexibility reinforce evidence that direct manipulation of physical objects with varied material properties can support the refinement of

fine motor control and hand coordination in young children (Faber et al., 2024; Lo & Wang, 2024; Strooband et al., 2023). Moreover, while earlier studies by Dean et al. (2021) and Harmon et al. (2025) demonstrated the motor benefits of cooking activities for children, the current investigation significantly extends their work. By pairing structured video analysis of micro-motor adaptations with inferential statistical testing, this study offers robust empirical validation that task-based culinary interventions systematically enhance hand-eye coordination, movement accuracy, and distal finger control in preschoolers.

4.3. Peer Scaffolding and Prosocial Growth in Shared Culinary Tasks

The evolution of collaborative competencies, marked by a substantial quantitative surge from a baseline mean of $M = 1.45$ ($SD = 0.35$) to $M = 3.50$ ($SD = 0.24$) in Cycle II ($Z = -2.81$, $p < 0.005$, $r = 0.89$), highlights the prosocial impact of group-based culinary interventions. Qualitative observations corroborated this statistical progression, illustrating a developmental transition from egocentric, parallel play toward organized cooperative interaction characterized by spontaneous resource sharing, active verbal negotiation, and joint problem-solving. Interpreted through Vygotskian social constructivism and the Zone of Proximal Development (Kusumaningsih & Sun, 2025; Lee & Chen, 2026; Stern & Hertel, 2022), the small-group culinary setup establishes a rich socio-cultural space where peer scaffolding occurs organically. Children who possessed more advanced motor skills naturally assisted peers who encountered difficulties with complex culinary operations, such as holding mixing bowls steadily or measuring liquid ingredients accurately. Furthermore, viewed through a Vygotskian cultural-historical perspective on socially mediated activity, shared culinary objectives require preschoolers to exercise self-regulation, manage impulsivity, and coordinate their actions with peers (Bredikyte & Brandisauskiene, 2023; Chen, 2025). Because kitchen tools and ingredients were intentionally shared within small clusters, children were impelled to communicate politely, establish turn-taking norms, and coordinate their actions to achieve a unified outcome.

These empirical observations closely align with and expand upon existing early childhood social interaction literature. The findings reinforce recent research indicating that authentic, collaborative activities can nurture prosocial communication and cooperative problem-solving through socially mediated peer interaction (Burns et al., 2024; Choi & Kim, 2021; Coelho et al., 2025). While previous studies, such as Smits-van der Nat et al. (2024), demonstrated that structured play activities can support social competence among young children, the current investigation extends this evidence by integrating social competence with tangible sensory-motor tasks (Dias Rodrigues et al., 2022; Phillips et al., 2023). By embedding physical tool manipulation within collective group goals, interactive culinary pedagogy effectively bridges physical and socio-emotional domains, accelerating prosocial growth and peer collaboration in early childhood classrooms.

4.4. Theoretical, Pedagogical, and Policy Implications

The empirical findings of this study offer meaningful theoretical contributions to early childhood education literature by bridging the long-standing divide between physical motor development and socio-emotional learning. Traditional developmental paradigms frequently isolate physical dexterity from prosocial behavior, treating sensory-motor growth and social interaction as separate curricular domains (Dias Rodrigues et al., 2022). By demonstrating that fine motor precision and collaborative competencies evolve synchronously during culinary tasks, this research advances an integrated framework of embodied sensory-motor collaboration. It reinforces embodied cognition theory by illustrating that sensory-motor manipulation serves not merely as a mechanism for muscular control, but also as a physical catalyst for active social engagement, peer scaffolding, and shared cognitive focus in preschoolers (Harmon et al., 2025).

From a pedagogical perspective, this study provides actionable insights for early childhood educators seeking to transition away from passive, teacher-centered instruction and rigid worksheet routines. Implementing interactive culinary pedagogy demonstrates that multiple developmental milestones can be stimulated simultaneously through a single, highly engaging activity (Muir et al., 2023). Early childhood practitioners can utilize food preparation tasks as a dual-targeted intervention that addresses fine motor refinement and peer collaboration within a naturalistic, play-based context (Burns et al., 2024). Furthermore, this approach redefines the teacher's role from a directive instructor to a strategic facilitator who structures collaborative clusters, provides sensory-rich materials, and supports child-led exploration without over-regulating child interactions.

At the policy level, these findings hold direct implications for early childhood curriculum design and educational governance. Curriculum policymakers are encouraged to reconsider the heavy reliance on static academic preparatory materials in preschool settings and advocate for the formal integration of practical life skills, including experiential food preparation tasks (Dean et al., 2021). Embedding multimodal culinary learning into national and institutional early childhood frameworks may help curricula remain developmentally appropriate, holistic, and responsive to children's learning needs. Allocating resources for

teacher professional development, classroom culinary infrastructure, and safety protocols can further support the implementation of experiential learning strategies within early childhood settings.

4.5. Limitations and Directions for Future Research

Although this study offers meaningful empirical and theoretical insights into the transformative potential of culinary pedagogy, several methodological limitations must be acknowledged. First, the investigation was conducted with a relatively small sample size of ten preschoolers within a single early childhood center, which inherently constrains the direct statistical generalizability of the quantitative findings to broader, highly diverse populations. While the large effect sizes and mixed-methods design provided significant analytical depth, caution should be exercised when extrapolating these results across varied socio-economic or cultural educational contexts. Second, the intervention spanned two action research cycles comprising eight structured instructional sessions, leaving the long-term retention and developmental sustainability of fine motor precision and collaborative competencies unmeasured over extended timeframes. Finally, the qualitative observations may have been subject to subtle Hawthorne or observer effects, although this risk was systematically mitigated through independent double-coding and high inter-rater reliability procedures.

To address these limitations and expand the empirical foundation of culinary pedagogy, several directions for future research are recommended. Future scholars should consider deploying quasi-experimental or randomized controlled trial designs featuring larger, multi-center sample sizes across diverse regional and demographic settings to validate statistical generalizability. Longitudinal follow-up studies are also needed to evaluate whether the motor dexterity, self-regulation, and prosocial habits developed during preschool culinary tasks persist as children transition into formal primary school environments. Furthermore, future research could explore the integration of culinary-based tasks with complementary developmental domains, such as early nutritional literacy, digital learning tools, and executive function training. Investigating the therapeutic and inclusive benefits of interactive culinary interventions for neurodivergent children or learners with sensory processing differences also represents a critical, highly promising avenue for future early childhood research.

5. CONCLUSION

The primary objective of this study was to examine the extent to which an interactive cooking class approach transforms classroom engagement while simultaneously fostering fine motor precision and collaborative competencies among preschoolers aged 5 to 6 years. Empirical findings demonstrate that implementing a multimodal culinary pedagogy effectively converts low engagement, teacher-centered classroom environments into vibrant, child-centered developmental spaces. Quantitative and qualitative data confirmed significant improvements across all target developmental domains. Overall classroom engagement exhibited a dramatic linear increase from baseline to the final intervention cycle, characterized by sustained behavioral focus, positive affective investment, and active social participation. Furthermore, children demonstrated substantial refinements in fine motor precision, transitioning from rigid palmar grasps to mature pincer grasps and dynamic finger isolation during tactile food manipulation. Concurrently, collaborative competencies evolved from egocentric, parallel play toward organized cooperative interaction, marked by spontaneous peer communication, equitable resource distribution, and joint problem-solving.

This investigation offers important theoretical and empirical contributions to the early childhood education literature by validating an integrated framework of embodied sensory-motor collaboration. By bridging fine motor execution and prosocial development within a single pedagogical mechanism, this study demonstrates that physical dexterity and social cognition naturally reinforce one another when embedded in meaningful, goal-oriented tasks. Grounded in embodied cognition and social constructivist paradigms, interactive culinary activities provide continuous tactile feedback and peer scaffolding opportunities that traditional, worksheet-based routines fail to deliver. From a practical standpoint, the findings encourage early childhood practitioners to adopt task-based culinary interventions as a dual-targeted pedagogical strategy that elevates child agency, self-regulation, and holistic developmental achievement.

Interactive culinary pedagogy represents a viable, innovative strategy for re-engineering early childhood learning environments. Moving beyond static, academic preparatory exercises, experiential food preparation tasks cultivate essential physical, cognitive, and social competencies necessary for long-term developmental readiness. Although limited by a small sample size, the substantial effect sizes and rich qualitative evidence established in this study highlight the transformative potential of culinary-based learning. Future research that expands this pedagogical framework across larger, diverse populations will further solidify the role of multimodal experiential learning in fostering holistic child development.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to the principal, teachers, and students of the kindergarten who participated in this study for their cooperation and support during the research process. The authors also thank all parties who contributed to the completion of this research. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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