# Alphariddims: A Multimodal Rhythmic Serious Game for Scaffolding Early Literacy and Socio-Emotional Development

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## Abstract

Purpose: This study examined the feasibility and preliminary outcomes of Alphariddims, a serious game that transduces hand-drummed rhythmic patterns into letters and words to stimulate early literacy in young children. Methodology: Five child–parent dyads/triad (children aged 3–6) completed a four-session Urban Griots Playground (UGP) workshop, a Music-Based Embodied Literacy Intervention (MBELI) combining face-to-face and digital drum-talk activities. Alphabetic knowledge was assessed pre- and post-intervention; analysis of the parent entry interviews and surveys, session observations, and the exit focus group was informed by Cultural-Historical Activity Theory (CHAT), providing a lens for examining focal UGP components (tools, division of labor, community). Findings: Rhythm-mediated activity produced visible gains in literacy behaviors, symbolic and emotional understanding, and social participation dispositions; effects on letter-naming were selective, suggesting further more conclusive studies. Parents' repertoires for scaffolding literacy expanded over the intervention. Originality: To our knowledge, this is the first study to integrate a drum language communication system into a rhythm-based serious game for early literacy and apply an activity system theoretical lens to investigate intervention outcomes. Impact: Findings support culturally grounded, rhythm-mediated serious games as a feasible complement to music-based interventions or print-based literacy instruction and motivate larger controlled trials.

Keywords: Early Literacy, Serious Games, Rhythm-Based Learning, Embodied Cognition, Early Childhood Education

## 1. Introduction

Early childhood education research increasingly frames ages three to six as the "golden age" of development, a period during which foundational literacy constructs are most malleable and most predictive of later outcomes (Untung, 2023). Within this window, alphabetic knowledge —

the ability to name letters, distinguish their shapes, write them, and identify their associated sounds — is considered the strongest single predictor of children's later reading and spelling ability (Hammill, 2004; Scarborough, 1998; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004). Alongside alphabetic knowledge, phonological awareness, emerging spelling and word-form recognition, and vocabulary development constitute the core constructs that preschool and kindergarten instruction is designed to cultivate. Children who enter formal schooling with weak letter-name and letter-sound knowledge are disproportionately likely to struggle with literacy instruction, fall behind their peers, and eventually be classified with reading disabilities (Gallagher, Frith, & Snowling, 2000; O'Connor & Jenkins, 1999; Torppa, Poikkeus, Laakso, Eklund, & Lyytinen, 2006). A growing evidence base further points to rhythm-linked and movement-linked activity — clapping, singing, embodied play — as a supportive, low-barrier-to-entry pathway into the phonemic awareness and aural intelligence that undergird literacy development, since rhythmic engagement (entrainment) with a beat emerges as early as infancy and requires no specialized training (Ahokas et al, 2025; Zanto et al, 2024; Ozernov-Palchik et all, 2018; Zentner & Eerola, 2010; Cole & Boykin, 2008). Consistent with this, the theoretical framework grounding the present intervention treats rhythm not as an ancillary motivator but as a legitimate semiotic domain in its own right — a set of practices that recruit multiple modalities such as sound, gesture, and symbol to make meaning (Gee, 2003) — alongside speech and print.

The predictive weight of early alphabetic and phonological skill is well established: success in reading by third grade is a consistently strong predictor of subsequent academic achievement. Despite two decades of policy attention — including the No Child Left Behind Act's requirement that prekindergarten and kindergarten standards address letter-name learning, basic sound knowledge, and letter writing — opportunity gaps in early literacy persist, with recent discourse concerning American youths' educational performance centering around an ongoing and deepening literacy crisis. In 2022, only 54% of our 4th graders in Boston, and 63% of 4th graders nationally, achieved basic reading proficiency on the National Assessment of Educational Progress (NAEP). Furthermore, most standard approaches to instruction have not incorporated the multimodal, voice-rhythm-movement learning experiences that a growing body of embodied-cognition research suggests could benefit a wider range of learners (Bentley, 2023; Williams, 2023). Much of this shortfall follows from an epistemological bias that treats the

written form of language as the principal, and often sole, object of literacy instruction; yet as literacy scholars have argued, communication “always happens as text” regardless of the mode through which it is produced (Kress, 2003), a premise that motivates broadening the instructional repertoire of early literacy beyond print alone.

The consequences of unaddressed early literacy gaps extend well beyond the classroom. Reading disability and low literacy in childhood have been linked to a range of adverse behavioral and psychosocial outcomes that persist into adolescence and adulthood, underscoring that early literacy intervention is not solely a pedagogical concern but a public-health one. Complementary evidence from the drumming and music-therapy literatures suggests that rhythm-based group activity can significantly improve a spectrum of behavioral difficulties in adolescents — including inattention, withdrawal, depression, post-traumatic stress, anxiety, attention-deficit and hyperactivity symptoms, oppositional defiance, and sluggish cognitive tempo (Ping Ho, Tsao, Bloch, & Zeltzer, 2011). African drumming in particular has been associated with encouraging social interaction, building socially transferable skills, and promoting a sense of competency (Longhofer & Floersch, 1993), with facilitating self-expression and non-verbal communication (Kalani, 2004), and with providing a constructive channel for difficult emotions such as anger and frustration (Hull, 1998), however few studies have been conducted in early childhood.

A number of prior projects have explored rhythm-, music-, and game-based approaches to early literacy and related developmental skills. Off-screen, voice-activated storytelling systems such as StoryMat and TellTale demonstrated that tangible, auditory tools could support children's sequencing and early narrative/writing behaviors without reliance on a keyboard or screen (Cassell, 2004). The Jam-O-Drum Interactive Music System, developed at Interval Research Corporation, allowed up to six simultaneous players — novice and musically trained alike — to participate in collaborative musical improvisation, embracing both types of participant “by taking advantage of their intuitive abilities and social interaction skills,” and used a call-and-response module to elicit “follow the leader” behavior while treating the community drum circle as a design metaphor for the system's form and content (Blaine & Perkis, 2000). Evidence-based studies of group drumming programs in adults and adolescents have documented biopsychosocial benefits (Bittman, Bruhn, Stevens, Westengard, & Umbach, 2003; Bittman, Dickson, & Coddington, 2009), and drumming-specific interventions have been examined for

their potential to support children's social-emotional development (Locke & Clark, 2009), literacy transformation through the rhetorical function of the drum (Gaines, 1996, 2018), and even mathematical reasoning through the semantic and syntactic structures of African drumming patterns (Sharp, 2007). Work on embodied learning and embodied design more broadly (Abrahamson & Lindgren, 2014; Horn & Wilburn, 2005) has argued that learning experiences integrating physical movement and interaction engage learners' sensory, motor, and cultural histories, and recent classroom-based studies have shown measurable effects of embodied learning on children's memory and language skills (Zanto et al, 2024; Kosmas, Ioannou, & Zaphiris, 2018). Despite this convergence of evidence, most existing drumming-in-schools programs have been founded on behavioral theories of change with comparatively little emphasis on literacy development specifically, and few, if any, serious games have combined a culturally grounded rhythmic communication system with a symbol-based literacy curriculum designed for the 3–6 age range (Burget, Tozadore & Dillenbourg, 2024). While understanding the efficacy of drumming on positive socio-emotional and behavioral change is important, what may be equally important for literacy educators and researchers is to design and examine situations to learn about the hidden power of the drum as a communication system. As drum language is very much based on verbal language, one cannot understand how it works without understanding the linguistic structures that it builds on. For digital natives, the need is to show them the application of rhythm as a modality to communicate in any language or across any domain, not just in the context of drum circles or dance classes, as beneficial as those can be.

The design motivation for Alphariddims is grounded in the specific cultural-historical status of the talking drum as a communication technology. Talking drums functioned for centuries across West and Central Africa as a genuine linguistic mode: drummers rhythmically reproduced the prosodic and syllabic features of a speaker's utterance in a form intelligible to other members of the language group, fulfilling many of the mnemonic, social, and transmissive functions of writing while operating on the aural rather than the visual plane. Analyzed through the lens of speech-act theory, such drum communications satisfy the standard linguistic model of message, addresser, addressee, shared context, contact, and common code (Jakobson, 1960), and, following Searle's (1971) account of speech acts as utterances or marks that are “characteristically said to have meaning,” qualify as legitimate discursive action rather than mere sound production. Communicating meaning via drum language therefore relates to the goals of

schooling in the same way that reading from a textbook does, in that both activities create a shared context of production and interpretation and, in Briggs and Bauman's (1992) terms, provide a means of controlling access to symbolic capital and evaluating the discursive competence of individuals. The persisting lack of awareness of the affordances of drum language as a mode for communicating and expressing meaning in the United States stands in stark contrast to its continued vitality as a pedagogical resource in some African educational contexts (Coe, 2005), and represents several lost opportunities for the international educational community to benefit from the perspective of a system of knowledge production and transmission grounded in a non-Western cultural system. Alphariddims and the broader UGP intervention operationalize this reclamation by re-encoding drum rhythms — ephemeral and invisible in their traditional aural form — into sequential, visible, multimodal objects (image, sound, text), with the explicit goal of stimulating literacy behaviors among children for whom voice-, rhythm-, and movement-linked activity is already a familiar cultural resource and tacit fund of knowledge.

The preliminary study reported here was conducted through the Urban Griots Playground (UGP), a four-session family workshop series that integrates the Drumball-Alphariddims digital orality system into a hybrid (face-to-face and digital) curriculum of voice, rhythm, and movement activities. We characterize this study as a Music-Based Embodied Literacy Intervention (MBELI), situating it within the NIH Music-Based Intervention (MBI) Toolkit's framework for rigorous intervention research (Edwards et al., 2023), extended here into early childhood literacy. The present MBELI aligns with several of the Toolkit's seven essential components of well-designed MBI research: a conceptual model grounded in embodied cognition and the cultural-historical status of drum communication as a communicative technology (Section 1.5); an explicit research question addressing children's alphabetic knowledge, multimodal literacy behaviors, and social participation; common data elements spanning literacy (letter-naming), social participation, and emotional engagement; a documented intervention description (the four-session UGP curriculum, Section 2.4.1); a detailed protocol specifying data-collection phases and instruments (Section 2.4.5); and a defined population (five focal child–parent dyads/triad, ages 2.5–6). Consistent with its status as a preliminary, design-based research pilot, the study does not yet incorporate a control or comparison group — a limitation addressed directly in Section 4.4 and a priority for future iterations of this research.

The choice of a design-based research (DBR) methodology, rather than a controlled efficacy trial, reflects the exploratory and formative stage of this line of inquiry: DBR treats educational interventions holistically, as enactments of specific theoretical claims about teaching and learning, and is oriented toward refining the relationship between theory, designed artifact, and practice rather than isolating causal effect sizes in an initial small-N study. As the Design-Based Research Collective (2003) notes, attending to context in this way is an important methodology for understanding how, when, and why educational innovations work in practice. A Cultural-Historical Activity Theory (CHAT) lens, following Engeström's (1999) model of activity systems, was adopted to analyze the critical components or "building blocks" of the UGP MBELI, namely: cultural tools (the Drumball-Alphariddims system and its rhythmic symbol code), community (the parents, children, and facilitators sharing the object of activity), division of labor (the distribution of scaffolding and performance roles between parent and child), and rules (the norms of turn-taking and call-and-response validation) — as these elements jointly shaped children's literacy and socio-emotional outcomes. This framing allows the present study to serve a dual purpose: to provide preliminary evidence on the feasibility and engagement value of the Alphariddims game as a serious game for early literacy, and to surface design principles for future iterations of the workshop, platform and curriculum.

## 2. Methods

### 2.1 Study Design

This study employed a qualitative, design-based research (DBR) approach nested within a broader iterative development process for the Drumball-Alphariddims system and the UGP curriculum. DBR was selected because the research aim was not only to test whether the intervention produced literacy gains, but to understand how the embodied, rhythm-mediated activity system functioned in situ, and to generate design principles that could inform subsequent iterations of both the hardware/software platform and the workshop curriculum (Design-Based Research Collective, 2003; Brown, 1992; Collins, 1992).

This participatory design research process focused on how to prototype a digital talking drum system inspired by trans-African cultural systems and adapted to early childhood learning conditions. Semi-structured interviews were conducted with experts in the fields of literacy, music and human-computer interaction (HCI) regarding the best practices for designing

interactive rhythm-based learning games for children. These interviews highlighted core design principles to integrate like story, mechanics, play experience/engagement (how to invite/sustain play) as well as aesthetics (physicality of the device, physics of the game, audiovisual cues). From this survey of experts, the preliminary design recommendations that emerged were:

> **Focus on the story (core narrative) anchoring the user interaction**: this presented the option between a) an incremental approach grounded in developmental theory starting with learning the basic drum sounds and symbols before introducing Alphariddims to produce letters, spell words and construct phrases and b) an immersive approach focused more on directly introducing drum vocabulary and messages as rhythms to be explored.
> **Integrate cultural framework by building on the traditional practice of drum language**: This design principle was pursued by explicitly embedding cultural referents at the level of the mechanics, dynamics and aesthetics of the main game frame.
> **Tend to both developmental and social ("fun") outcomes of the child experience**: given the hybridity of the Drumball-Alphariddims system as both a social innovation (a game grounded in the sociocultural and historical practice of drumming) and technological innovation (a learning tool informed by theories of literacy and multimodality), a fine balance had to be struck in the design process between the emotional enjoyment of users playing the game and the learning outcomes in focus by my research question on the contributions of this approach for children's aural/visual literacy skills related to letter naming and picture naming as well as how this approach offer families an alternate mode of experiencing reading and writing.

Data were interpreted through a CHAT-informed lens attentive to three interrelated planes of participation described by Rogoff (1993): apprenticeship (the communal plane), guided participation (the interpersonal plane), and participatory appropriation (the personal plane). Table 2 summarizes how the elements of Engeström's activity-system model were operationalized within the UGP context.

| Activity System Element | CHAT Construct | UGP Instantiation |
|---|---|---|
| Tools | Cultural systems and technology mediating action | Drumball hardware/app, AlphaRiddim (and related Numeriddim/Syllariddim/Georidd im) symbol codes, printed code sheets |

| | | |
|---|---|---|
| Community | The social group sharing the object of activity | Child–parent dyads/triad, facilitators, and co-present families in the circle format |
| Division of Labor | Distribution of tasks and roles among the community | Parent as scaffolder/evaluator; child as performer/explorer; facilitator as model drummer |
| Rules | Explicit/implicit norms governing activity | Circle-turn-taking conventions; call-and-response validation logic of the game |
| Object → Outcome | The goal that motivates the activity | Early literacy (alphabet knowledge, vocabulary) and socio-emotional development → school readiness |

## 2.2 Participants and Research Context

The inaugural UGP study took place over four weekly sessions at a Performing Arts Cultural Center (PACC) in Siskiyou County, Northern California, following several earlier formative trial runs conducted in Bay Area community arts centers, childcare facilities, and preschools. Five focal child–parent dyads or a triad (five children total, accompanied by their mothers, who were present for every session) completed all four workshops and all associated data-collection instruments. Children ranged from approximately two-and-a-half to six years of age. Families varied in cultural, racial, and ethnic background; all participants were English speakers or English-as-a-second-language learners.

| **Dyad/Triad** | **Child Age** | **Accompanying Parent** | **Pre–Post Letter-Naming Change** |
|---|---|---|---|
| Olem & Olivest | ~5–6 | Mother | No change (ceiling: alphabet already mastered) |
| Machi & Malabri | ~3–4 | Mother | Not separately reported |
| Arfia, Cam & Alcanat (triad) | ~2.5–5 | Mother | Arfia: +4 letters; Cam: no change (ceiling) |
| Sam & Solibren | ~4–5 | Mother | Sam: +6 letters |

## 2.3 Inclusion and Exclusion Criteria

Eligible participants were child–parent dyads (or a small parent-led group) with a child between approximately three and six years of age, able to attend all four weekly UGP sessions and complete the associated pre/post assessments, entry and exit interviews, surveys, and the culminating focus group. Families were excluded from the focal analytic sample if they did not attend all sessions or did not complete the full battery of data-collection instruments, consistent

with the study's design-based aim of tracing developmental processes across the full workshop arc rather than sampling cross-sectional snapshots.

## 2.4 Instruments and Materials

### *2.4.1 Intervention (Workshop)*

The UGP workshop series comprised four modules of approximately 90 minutes each, each structured into three recurring parts: (1) Circle – Communicate, a relationship-building segment of group activities and interpersonal communication; (2) E-Learning – Create, in which children engaged in technology-mediated tasks and multimodal production using the Alphariddims system; and (3) Practice – Celebrate, in which children engaged in drama and improvisational performance to embody and share what they had produced. Sessions were organized around a circle format that gave children and parents equal footing for participation, with the center of the circle reserved for individual or dyadic performances shared with the whole group. Each session targeted a different literacy domain (sounds, letters, words, proverbs) and was aligned to California's Visual and Performing Arts Content Standards (Artistic Perception; Creative Expression; Historical-Cultural Context; Aesthetic Valuing; Connections, Relationships and Applications) as well as to preschool early literacy and performance standards more broadly. Printed AlphaRiddim codes were distributed to families for at-home practice between sessions, with parents encouraged to practice with their child at least once between workshops.

### *2.4.2 Alphariddims (Game)*

Alphariddims is a mobile serious game extension of the Drumball platform (Tchetgen, 2017), a tangible rhythmic interface and digital-orality hypermedia system that transduces hand-drummed finger-tap and hand-stroke patterns into multimodal audiovisual output (text, image, and sound). The system is modeled on the hand-playing technique of the djembe — tone, slap, and base strikes — and encodes each alphabet letter as a unique four-beat combination of these three signs, adapting a Morse-code-like scheme (the “AlphaRiddim” code) so that letter production is simultaneously a literacy act, a numeracy act (counting beats), and a musical act. The game operates on a call-and-response interaction paradigm consistent with the communicative structure of traditional drum language: the system issues a call (a letter rendered in its rhythmic code and sounded aloud), the player listens and reproduces the pattern on the Drumball tangible interface or the app's on-screen drum pad, and the system validates the response, providing

corrective or confirmatory audiovisual feedback. In doing so, Alphariddims targets several early language and literacy constructs simultaneously — listening, speaking, early vocabulary, and symbolic communication — through embodied, multimodal, rhythmic interaction rather than through a conventional keyboard-and-screen interface.

The full Drumball-Alphariddims system combines a tangible percussive interface with a companion software application (prototyped in Processing/p5.js and in Unity/C#) that can run in a browser or as a standalone mobile/tablet app. The tangible interface uses three sensors (conductive pads or piezo microphones) mapped to the tone-slap-bass drumming principle of the djembe; hardware iterations progressed from a MakeyMakey-based prototype emulating keystrokes, to a Bela-based prototype using isochronous (audio-encoded) control signals, to a current Arduino-based prototype with a custom PCB shield designed to streamline the analog communication protocol. However, because the tangible hardware interface was not yet sufficiently robust for repeated use by children aged three to six at the time of the inaugural study, the UGP intervention reported here relied on the app-based (drum-pad-on-screen) version of Alphariddims installed on family tablets and phones, supplemented by embodied "body riddim" performance of the same codes with no device at all.

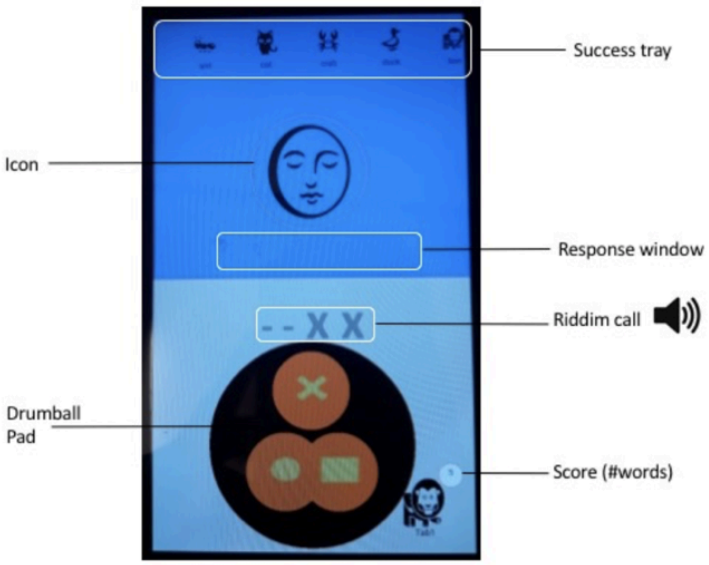


**Figure 1 – Screenshot of the user interface of the *Alphariddims* mobile game app**

The software is designed to operate in a call-and-response cycle, serving a dynamic corpus of multimodal language objects (letters, words, phrases, pictures, shapes) that children interact with

via the haptic interface. The system makes a call — a letter or word represented by its rhythmic encoding, which is also sounded aloud — the child listens and responds by playing the pattern on the Drumball pad, and an algorithm compares the input pattern to the call pattern and validates the match.

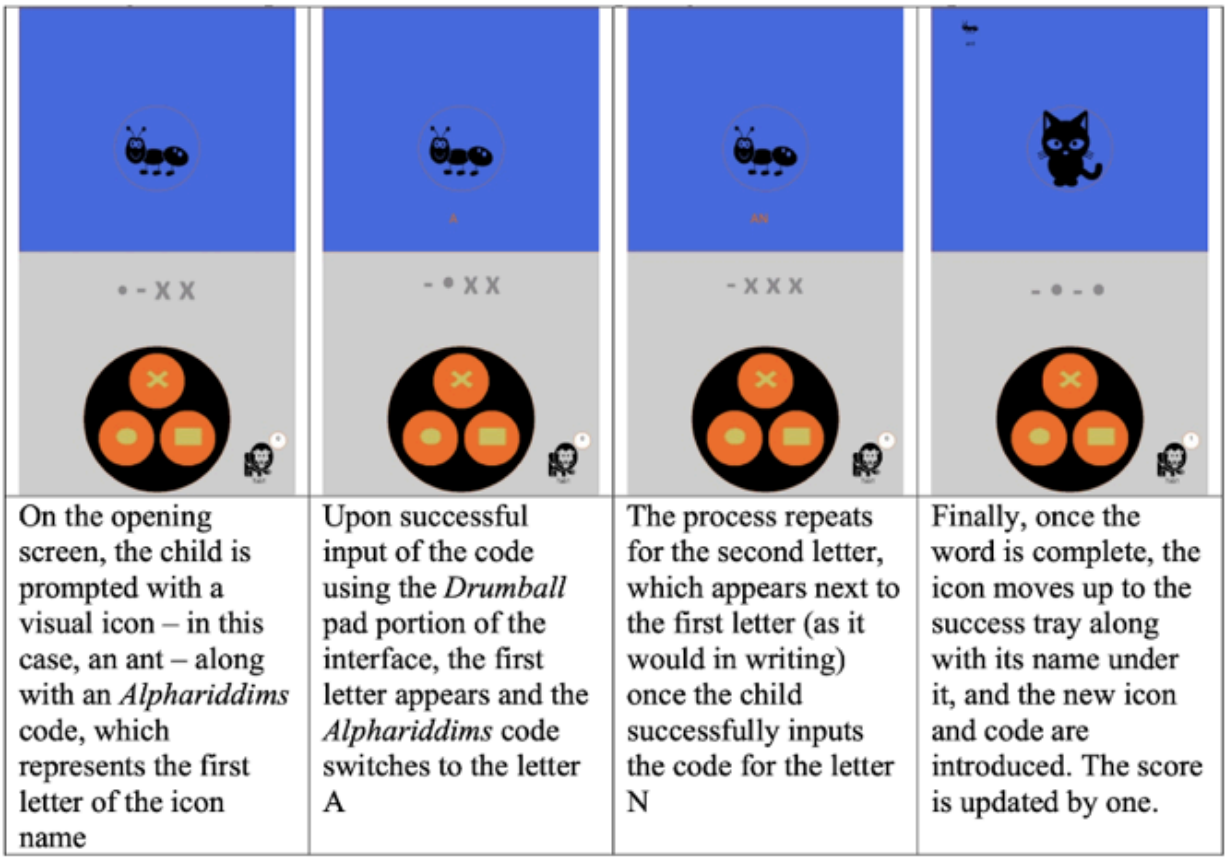


**Figure 11 – Sequence of a user spelling the word 'Ant' in the Alphariddims P5.js prototype**

If the response is correct, the corresponding letter is displayed and sounded; if incorrect, a 'Try Again' prompt is given. Each alphabet letter is represented by a unique four-beat AlphaRiddim code built from the three tone/slap/bass symbols, and once a full word is successfully spelled, it is sounded aloud in its entirety and its label and icon move to an on-screen success tray before the next item in the corpus is served. Children progress through words of increasing length (3-, 4-, and 5-plus letters), allowing the same mechanic to scale across skill levels within the 3–6 age range.

### *2.4.3 Literacy and SEL Measures (Pre/Post, and Future Game Telemetry)*

Children's alphabetic knowledge was assessed via a pre- and post-test letter-naming instrument (administered on the first and final workshop days) adapted for this age range. No standardized socio-emotional instrument was administered in this preliminary study; socio-emotional development was instead documented qualitatively through structured observation of children's engagement with visual icons representing facial emotions and with oral proverbs during the workshop sessions (see Section 2.4.4). The full Alphariddims platform additionally includes in-game micro-surveys of user satisfaction as well as an analytics dashboard intended to allow parents to monitor children's in-app learning activity over time; game telemetry of this kind was not yet systematically analyzed in the present preliminary study but is identified as a planned data source for future iterations of the research.

### *2.4.4 Family Relations and Parent-Child Interaction Measures (Survey, Focus Group, CHAT)*

Parents completed an online entry survey inventorying children's existing multimodal skills, followed by a 30-minute entry interview and, at the conclusion of the study, an exit interview, both addressing children's music and literacy habits at home. Data collection also included structured participant observation during each workshop (with attention to parent–child interaction), audio/video recordings of sessions, and a focus group conducted during the final workshop. These sources were interpreted using CHAT to characterize the UGP activity system in terms of its cultural tools, its community of practice, its division of labor, and its rules (Table 1), in order to examine parents' evolving roles as evaluators, enablers, and — in some cases — inhibitors of children's multimodal digital experiences.

### *2.4.5 Procedures and Ethical Considerations*

Data collection spanned a six-week period organized into three phases: Phase I (pre-test, pre-survey, entry interview), Phase II (the four workshops, including in-session observation, audio/video recording, and the post-test and focus group administered during the final session), and Phase III (exit interviews with focal parents). As the research involved children and their parents, the IRB study protocol required a child assent script (read aloud to all families at the first session, with time allotted for questions) and signed parent informed consent, parent permission, and media-release forms collected at arrival on the first day of the workshop.

### *2.4.6 Data Analysis*

Quantitative pre/post letter-naming scores were compared descriptively at the level of the individual child, given the small sample size; no inferential statistical testing was performed on these scores in the present preliminary study. Qualitative data (observational field notes, audio/video transcripts, interview and focus-group transcripts, and survey responses) were analyzed thematically and interpreted through the CHAT framework described above, with particular attention to the three planes of participation (communal, interpersonal, personal) through which children's and parents' engagement with the UGP activity system could be characterized.

## 3. Results

### 3.1 Participant Characteristics

The final analytic sample consisted of five focal children (two-and-a-half to six years old) across four family units — two dyads, one triad, and two additional dyads — all accompanied by their mothers throughout the four-session workshop series (see Table 1 above). Families varied in cultural and linguistic background but shared English-language proficiency sufficient to participate in all workshop activities and complete the study's interview and survey instruments.

### 3.2 Alphabetic Knowledge Outcomes

Pre- and post-test comparisons of letter-naming ability showed a mixed but instructive pattern. Two children, Sam and Arfia, improved their letter recognition by six and four letters, respectively, over the course of the four-session intervention. Two other children, Olem and Cam, showed no measurable change on the pre/post instrument, but this reflected a ceiling effect: both children had already mastered the alphabet prior to the intervention. Overall, the curriculum proved engaging and feasible to deliver, but the sample size was too small, and the observed change too modest across the full sample, to validate the efficacy of the Alphariddims symbol system for teaching letter names and word spelling; the intervention appeared most effective for the focal children whose parents were most concerned about their early literacy or socio-emotional development, while some children were too young to fully understand the intervention, given the complexity of a multimodal symbol system that requires more translation steps than standard print reading (rhythm-to-symbol, symbol-to-letter, letter-to-word).

### 3.3 Multiliteracies and Social-Emotional Engagement

Beyond the letter-naming outcomes, several qualitative findings characterized children's engagement with the UGP's multimodal literacy activities.

Finding 1 — Stimulating literacy behaviors through a multimodal symbol system. Throughout the UGP sessions, the workshop model had a motivating and stimulating impact on children's literacy behaviors and on their active social participation and understanding of language, communication, and emotional literacy in relation to visual icons and sonic objects (drum tones, rhythms). All focal children displayed visible enthusiasm and enjoyment of embodied literacy learning by representing syllables or letters as rhythms performed on their bodies. Through recognition of the Alphariddims visual symbol patterns as movement sequences representing alphabet letters, children were able to compose — with the help of their parents — body rhythms that effectively "spelled out" their first names. All focal children engaged in letter recognition and derived a sense of enjoyment and motivation from a digital spelling task involving animal and object names; for children who did not yet possess the fine-grained motor skill necessary to write with a pen, the Alphariddims app helped them develop a basic understanding of writing as the manipulation of visual symbols through sensory-motor interaction to encode meaning using a restricted set of signs.

Finding 2 — Cultivating key social participation dispositions. A key aspect of the UGP pedagogical approach was to engage children's verbal and motor skills in dyadic or circle activities centered on how rhythms and symbols can function in interpersonal and group situations, in and beyond the physical world. Conducting each session in a circle format was a deliberate organizational choice that provided everyone — children and parents alike — an equal footing for participation, using the center of the circle as a space for individual performances to be shared with the whole group, fostering listening skills, turn-taking, and expressive confidence.

Finding 3 — Scaffolding emotional understanding. In addition to cultivating literacy and social-participation behaviors, the workshop used iconic visual props representing facial emotions and the recitation and interpretation of oral proverbs to scaffold emotional literacy alongside alphabetic literacy. This positioned socio-emotional development as a parallel outcome of the same embodied, rhythm-mediated activities rather than as a separate curricular strand,

consistent with this population's documented vulnerability (see Section 1.3) to behavioral and emotional difficulties that co-occur with literacy delay.

### 3.4 Cognitive Apprenticeship Observations

Interpreting the workshop sessions through Rogoff's (1993) three planes of sociocultural participation surfaced additional developmental processes not captured by the pre/post letter-naming measure alone. On the communal plane, children's participation reflected apprenticeship into the UGP's digital drum-talk literacy practices as a community of practice, modeled by facilitators and more experienced participants. On the interpersonal plane, guided participation was evident in the dyadic activity structure, wherein parents scaffolded children's rhythmic composition and letter-naming attempts in real time, adjusting task complexity to the child's current ability — a division of labor that the entry surveys and interviews independently corroborate (see Section 4.3). On the personal plane, participatory appropriation was observed as children took up the tools and practices of the workshop for their own purposes outside the structured task: for example, spontaneously initiating Alphariddims-related play with the printed card deck before dinner, or, in one case, a child breaking into a song learned in the workshop and eventually drawing in a parent who reportedly never sings. Together, these observations suggest that the intervention's embodied, call-and-response design supported developmental processes across all three planes simultaneously, even in cases where the symbol-to-gesture mapping of the Alphariddims code proved cognitively demanding for the youngest participants.

**Case Studies:**

*Arfia (3 yrs) & Cam (6 yrs) - Though initially shy in group settings, both siblings later reengaged with the materials at home. Their mother observed spontaneous, playful use of the workshop's rhythm tools during everyday activities: "There's a little apprehension... but when they're at home... I heard them with the cards... with the*

Alcanat: And *tone slap tone base*
Cam: *Presses tone slap tone base on the Drumball pad*
System: R
*Arfia sitting on her drum playing the sounds along*

*'BOOM', 'CLAP'... just playing with it... They were singing that song about a week ago at dinner." — Alcanat, mother of Arfia & Cam*

*Olem (3 yrs) - Already literate, she benefited from the symbolic association aspect of the workshop. Her mother valued the broader literacy connections made between music, symbols, and meaning-making: "It was nice to plant a seed about symbol association… not just 'reading is just these letters' but it can incorporate other aspects… I really appreciate that." — Olivest, mother of Olem*

Olivest: So this is the next letter, so we're going to do *slap tone base base*. So which one is *slap*. Can you **find *slap***?
Olem: **This?** *(points to slap symbol on the Drumball pad then presses it)*
Olivest: Can you try a *tone?*
Olem: *presses tone*
Olivest: Ok. And *base and base*
Olem: *presses base* ***twice***
System: **N**
Olivest: Good job! Now you did N. The next letter is T. T is *slap base base base.*

## 4. Discussion

Research has found children' s learning environments to be a main contributor to successful teaching (Maltese & Tai, 2010; Hatisaru et al, 2019), and there is growing recognition of the need for educators to equip "children with opportunities to see, touch, and feel the learning in practice, within multiple embodiment ways" (Tsoukala, 2021). Recent evidence suggests that culturally grounded, rhythm-based serious games can promote engagement with, and exploration of, early literacy constructs among young children, complementing standard print-based instruction rather than replacing it (Ahokas et al, 2025; Dees & Cooper, 2025; Zanto et al, 2024, Burget, Tozadore & Dillenbourg, 2024). In line with this body of work, the present preliminary study provides evidence from a short, four-session, hybrid face-to-face/digital intervention conducted with a small family cohort, further motivating a design-based research agenda for serious rhythmic embodied learning games in early childhood.

### 4.1 Broad Effects on Literacy Exploration and Social Participation

The clearest and most consistent findings from this preliminary study concerned children's engagement with, and exploration of, the literacy content of the workshop, rather than the specific instructional target of letter naming per se. All five focal children, across an age range spanning roughly two-and-a-half to six years, displayed visible enthusiasm for embodied literacy learning and were able — with parental scaffolding — to represent letters and syllables as body rhythms and to complete digital spelling tasks involving animal and object names. These broad effects were also evident on the interpersonal and social plane: the circle-based structure of each session gave children and parents equal footing for participation and cultivated listening, turn-taking, and expressive confidence across the sample as a whole, independent of each child's baseline alphabetic knowledge. This pattern is consistent with the theoretical premise that rhythmic entrainment is a near-universal capacity present from infancy (Zentner & Eerola, 2010) and therefore offers a uniformly low barrier to entry across a heterogeneous group of young children, even when their formal literacy skills differ substantially at baseline.

### 4.2 Selective and Inconclusive Effects on Letter-Naming and Symbol-to-Gesture Mapping

Effects of the intervention on the specific instructional target of letter-naming and word-spelling were, by contrast, selective and in places inconclusive. Two children (Sam and Arfia) showed meaningful gains of six and four letters respectively, while two others (Olem and Cam) showed no change — a result attributable to a ceiling effect, as both children had already mastered the alphabet prior to the intervention rather than to a failure of the method. The intervention appeared most effective for the focal children whose parents were, by their own report, most concerned about their child's early literacy or socio-emotional development, suggesting that motivational and family-context factors moderated responsiveness to the curriculum in a manner analogous to the moderating role that baseline ability plays in other short-dose cognitive interventions. At the same time, some of the youngest children were too young to fully understand the intervention, given the complexity of a multimodal symbol system that requires translating between a rhythmic code, a visual symbol, and an alphabetic referent — more translation steps than standard reading requires. Taken together, these patterns suggest that under a brief, four-session protocol, broad exploratory and social engagement with rhythm-mediated literacy content may emerge more readily than reliable, generalizable gains on the specific symbol-decoding skill the system was designed to train, and that the symbol-to-gesture mapping

itself may need to be simplified or developmentally staged for the youngest end of the 3–6 age range. Future studies should incorporate measures specifically sensitive to age-appropriate communication targets (icons, words, letters) changes to confirm this interpretation empirically.

### 4.3 Parents as Learning Partners: Engagement, Enablement, and Tension

A further contribution of this preliminary study concerns the role of parents within the activity system's division of labor. Several parents reported that the pre-test itself was their first opportunity to present alphabet letters to their child in an order or format other than the conventional alphabet song, suggesting that the workshop's assessment and curricular materials expanded parents' own repertoires for evaluating and supporting their children's literacy development. Observationally, some parents took up the role of active participants and enablers of their children's multimodal experiences — drumming and spelling alongside their children, and extending workshop activities into spontaneous play at home, as when children initiated Alphariddims card-deck play before dinner or drew a non-singing parent into a workshop song. Other parents, by contrast, exhibited behaviors that at times inhibited children's digital experiences, a tension the workshop model had to actively reconcile through facilitation. The concluding focus group underscored parents' view that the curriculum's cultural and social framing was effective for children of this age, while also surfacing the practical concern that some of the multimodal literacy content — particularly the abstraction required to map rhythmic codes onto letters — was somewhat advanced for children at the youngest end of the target range, with consistent, repeated practice suggested as a likely precondition for fuller benefit. This feedback has since informed the development of a take-home learning kit (“GriotQuest”) intended to extend the workshop's embodied literacy and STEAM objectives into the home environment, a direction that follows directly from the parent-as-partner finding reported here but falls outside the scope of the present study.

### 4.4 Scaffolding Early Literacy Through Drum Talk Across Hybrid Contexts

The findings suggest that drum talk — reconceived here as a digitally mediated, multimodal rhythmic communication system rather than solely a musical activity — can function as a scaffold for early literacy exploration when embedded within a hybrid curriculum that moves fluidly between face-to-face embodied performance (drumming on the body, on a physical drum, or in call-and-response with peers) and digital interaction (the Alphariddims app and its tangible

interface). Because the AlphaRiddim code links each letter to a fixed four-beat rhythmic pattern, children were able to rehearse literacy content through a modality in which they already possessed intuitive competence. The hybrid structure of the workshop — moving from unmediated body rhythm, to physical drum, to digital app, and back to embodied performance in the closing "Practice – Celebrate" segment — appears to have supported this scaffolding by allowing children to approach the same symbolic content through multiple representational channels (aural, visual, kinesthetic, digital) rather than through print alone, consistent with the theoretical premise, articulated in Section 1.5, that drum communication fulfills many of the mnemonic and transmissive functions of writing while operating through a different sensory channel.

## 4.6 Limitations

This study has several limitations that should be considered when interpreting the results reported above. First, the intervention protocol consisted of four weekly workshop sessions organized around sequential tasks (drum sounds, drum letters, drum names, and digital drum talk), with use of the Alphariddims app itself limited to the culminating activity of the final workshop session, although a printed version of the rhythmic codes was available to families from week 2 onward. Accordingly, while improvements in alphabetic knowledge were partially observed following the intervention, it is not possible to attribute these gains solely to the game app as opposed to the broader embodied, rhythm-mediated curriculum in which it was embedded. Future studies should employ protocols that introduce the Alphariddims app earlier and more frequently across sessions, ideally with follow-up assessments, to determine whether app-specific effects can be isolated from the effects of the curriculum as a whole and whether either is maintained over time.

A central limitation is the very small sample (five focal children across four family units), analyzed under a single-group, pre–post design with no comparison condition. This precludes any inferential claim about the efficacy of the Alphariddims symbol system for teaching letter names or spelling; the pre/post changes reported here should be read as descriptive and hypothesis-generating rather than confirmatory. Running even a small comparison group — whether an active-control curriculum without the rhythmic symbol system, or a waitlist condition — would substantially strengthen causal inference in future iterations of this work; establishing such a group was not feasible within the constraints of the present pilot study, but this is explicitly acknowledged as a priority for subsequent research.

A related limitation concerns ceiling effects in the outcome measure itself. Two of the five focal children had already mastered the alphabet prior to the intervention, limiting the sensitivity of the pre/post letter-naming measure for the sample as a whole and constraining what could be concluded from aggregate pre–post comparisons. Future studies should recruit samples stratified by baseline alphabetic knowledge, or use EF-related measures with greater ceiling headroom, to avoid this constraint.

The complexity of the Alphariddims symbol-to-gesture mapping is a further limitation. Requiring children to translate between a rhythmic code, a visual symbol, and an alphabetic referent proved challenging for some of the youngest participants, suggesting that the encoding scheme in its current form may exceed the processing capacity of children at the younger end of the 3–6 range. Future iterations of the platform should develop and validate developmentally staged versions of the rhythmic encoding scheme, introducing the full three-symbol, four-beat mapping only once simpler precursor mappings have been mastered (e.g. three-symbol two-beat mapping for directions).

Hardware robustness represents an additional constraint. The tangible Drumball interface available at the time of this study had not yet reached a level of responsiveness, robustness, and portability sufficient for repeated, unsupervised use by children aged three to six, which necessitated reliance on the app-based interaction mode for most of the intervention. This may have understated the benefits of a fully embodied, drum-like physical interface, which a more robust prototype could offer by allowing children to draw on existing sensorimotor drumming skills without conscious cognitive translation. Future studies should field the current Arduino-based prototype with its custom PCB shield across a full multi-session intervention to test this possibility directly.

Facilitator and practice effects also cannot be ruled out as partial explanations for the observed changes. A trained facilitator was present throughout every session, and the pre- and post-tests used the same letter-naming instrument administered only four weeks apart; either factor could have contributed to the pattern of results independent of the intervention's specific content. Future studies should use alternate test forms and a longer test–retest interval to help disentangle genuine literacy gains from facilitator-driven engagement or simple task familiarity.

The absence of a standardized socio-emotional instrument is a further limitation. Socio-emotional outcomes were documented only qualitatively, through observation of children's engagement with emotion icons and oral proverbs, rather than through a standardized, validated measure, limiting comparability with other early-childhood socio-emotional intervention studies. Future work should incorporate a validated socio-emotional assessment alongside the qualitative observational record already in use.

Data were collected at a single Performing Arts Cultural Center in Northern California with a small, self-selected group of English-speaking or English-as-a-second-language families, so the generalizability of these findings to other cultural, linguistic, or geographic contexts has not yet been established. Future studies should recruit across multiple sites and language communities to test whether the reported patterns hold beyond this specific setting.

Finally, although the Alphariddims platform includes an analytics dashboard capable of logging in-app activity, this telemetric data source was not yet systematically analyzed in the present study, leaving a source of fine-grained, longitudinal behavioral data currently untapped. Future studies should incorporate this telemetry as a complement to the pre/post assessment used here.

Taken together, these limitations underscore that the present study should be interpreted strictly as a pilot feasibility investigation. The findings are preliminary and hypothesis-generating rather than confirmatory. Based on these limitations, future studies should: (1) introduce the Alphariddims app earlier and more frequently within the workshop sequence to isolate its specific contribution from the broader curriculum; (2) include an active-comparison or waitlist condition to rule out practice and non-specific engagement effects; (3) recruit larger, baseline-stratified samples to avoid ceiling effects and enable inferential analysis; (4) develop and validate developmentally staged versions of the Alphariddims symbol code; (5) field a more robust, portable tangible interface to test whether embodied drumming yields stronger effects than the app-based mode used here; (6) incorporate a standardized socio-emotional measure and multi-site recruitment; and (7) systematically analyze in-game telemetry as a longitudinal complement to the pre/post assessment.

## 5. Conclusion

This paper introduced Alphariddims, a serious game that reimagines African talking-drum communication as a multimodal, rhythm-based system for early literacy instruction, and reported preliminary findings from an Music-Based Embodied Literacy Intervention (MBELI) conducted through the Urban Griots Playground. The pattern of results was consistent with a broad-versus-selective distinction: engagement, exploration of literacy content, social participation, and emotional engagement improved consistently across the small sample, whereas gains on the specific instructional target of letter-naming and word-spelling were selective, present for some children and inconclusive for others, in part reflecting ceiling effects and the cognitive demands of the multimodal symbol system itself. Notably, the intervention also

expanded parents' own repertoires for evaluating and supporting their children's early literacy development, positioning them as learning partners within the activity system rather than passive bystanders to a child-only intervention. These findings position culturally grounded, rhythm-mediated serious games as a promising, underexplored complement to conventional print-based early literacy instruction, particularly for families and communities for whom voice-, rhythm-, and movement-linked activity is an already-familiar cultural resource, while underscoring that the present study should be interpreted strictly as a pilot feasibility investigation rather than a confirmatory efficacy trial.

Based on the limitations enumerated above, future research on Alphariddims and the broader UGP model should: (1) recruit larger and more diverse samples sufficient to support inferential (rather than purely descriptive) analysis of pre–post literacy outcomes; (2) incorporate a waitlist or active-comparison condition to rule out practice and non-specific engagement effects; (3) field a more robust, portable tangible Drumball interface to test whether a fully embodied physical drum — rather than the app-based interaction mode used here — yields stronger or more consistent literacy gains; (4) develop and validate developmentally staged versions of the Alphariddims symbol code for the youngest children in the 3–6 range; (5) incorporate a standardized socio-emotional measure alongside the current qualitative observation of emotional engagement; (6) systematically analyze in-game telemetry from the Alphariddims analytics dashboard as a longitudinal, fine-grained complement to the pre/post assessment; and (7) evaluate the GriotQuest take-home kit as a mechanism for extending workshop gains through the sustained, repeated practice that focus-group parents identified as a likely precondition for fuller benefit.

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