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Development of 'NumBiz Kidz' Mobile Game Based on MSME Context of Tembokrejo Broiler Chicken to Enhance Early Childhood Numeracy Literacy

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ABSTRACT

Numeracy literacy is a fundamental skill for early childhood to understand basic quantitative concepts relevant to daily life, including simple entrepreneurial contexts that foster an entrepreneurial mindset from an early age. However, conventional learning methods often fail to connect abstract mathematical concepts with practical, engaging applications, necessitating the development of innovative learning media. This study aims to conduct the initial development stage of an educational mobile game called "NumBiz Kidz" based on simple entrepreneurship contexts to enhance early childhood numeracy literacy, with a primary focus on the Define stage (Needs Analysis) of the 4D development model (Define, Design, Develop, Disseminate). The research employed a Research and Development (R&D) design using the 4D model, limited to the Define stage. Data collection techniques included observation, in-depth interviews with early childhood teachers and education experts, and document review of curricula, social arithmetic materials, and entrepreneurship case studies from broiler chicken MSMEs in Tembokrejo, Pasuruan. Instruments included observation sheets, semi-structured interview guidelines, and a document review matrix. Data were analyzed using descriptive qualitative methods following Miles and Huberman's interactive model. The findings from the Define stage revealed high urgency for technology-based learning media (mobile games) that explicitly integrate basic numeracy literacy with simple entrepreneurship concepts (e.g., buying and selling, profit, loss) that are contextual and appropriate for early childhood characteristics. Learner analysis indicated that children preferred bright colors (40%), cute characters (35%), and instant rewards (25%). Task analysis produced a simplification matrix that transformed real business concepts (e.g., strategic profit optimization, cost of goods sold calculation, change calculation) into game missions that teach addition, subtraction, quantity comparison, and duration concepts. The final output is a Product Specification Blueprint including functional requirements (simple store, inventory, change calculator, coin leaderboard) and non-functional requirements (Android/iOS platform, 2D animation, inclusive characters).

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1. Introduction

The rapid development of the 21st century demands a transformation in the quality of human resources who are not only cognitively superior but also possess adaptive fundamental skills, one of which is numeracy literacy (Daminik et al., 2024; Wakhidah et al., 2024). Numeracy literacy is defined as an individual's ability to reason, analyze, and solve quantitative problems in various real-life contexts, an absolute prerequisite for effective participation in increasingly complex, data-driven societies (Dila & Zanthy, 2020; Purba et al., 2024). This ability is a crucial foundation that must be built from early childhood, considering that the current era of digital disruption and economic uncertainty places basic calculations, mathematical logic, and simple financial concepts as essential survival skills (Achmad et al., 2024; Anwar & Mashudi, 2024; Nisfa et al., 2024). Failure to instill this foundation in early childhood will have a chain reaction, leading to difficulties in learning mathematics at higher levels and an inability to reason quantitatively in daily life.

Despite numeracy literacy being recognized as a basic competency, the reality of education in Indonesia still faces major challenges in its achievement. International studies, such as the Program for International Student Assessment (PISA), consistently show that Indonesian students' mathematical literacy skills remain at concerning levels, reflecting a gap between the formal curriculum and its practical application in everyday life (Hilyani et al., 2020). This gap is increasingly felt at the early childhood education (ECE) level, where teaching materials are often delivered conventionally, abstractly, and disconnected from contexts relevant to children's world. Learning methods that rely on worksheets, rote memorization, and chalkboard instruction create a perception that mathematics, including numeracy, is difficult and boring, extinguishing children's interest and motivation from the start (Rahmata & Ekawati, 2021). Observational field data from a kindergarten in Pasuruan Regency, East Java, collected by the research team in February 2025, revealed that of the four numeracy sessions observed, three used only printed number cards and counting exercises, without any contextual story or game elements. Teachers admitted that students became distracted after 5–7 minutes, and only 30% of children could correctly answer simple questions like "If you have 5 marbles and give away 2, how many are left?" when presented verbally without visual aids.

The early childhood period (ages 4–6 years) is a golden age for cognitive development, including the formation of quantitative thinking schemes and logical reasoning. Numeracy at the ECE level is not merely about counting but about introducing basic concepts such as comparison, sequence, quantity, and value relevant to the surrounding environment (Reza Lestari et al., 2024). However, curricula and teaching practices often prioritize memorizing numbers or simple arithmetic operations without providing deep contextual understanding of why these concepts matter or how to use them. The fundamental problem identified in this study is the failure of conventional methods to make quantitative concepts tangible and engaging. Children need direct, enjoyable experiences to internalize concepts, and this is precisely what static classroom learning lacks. Previous research has highlighted that media incorporating play and interaction elements, such as digital comics or educational games, are more effective in increasing student engagement and bridging abstract material, including social arithmetic (Rahmata & Ekawati, 2021; Darmayanti, 2022a). Therefore, learning media development must be explicitly designed for ECE characteristics: game-based, visual, interactive, and most importantly, contextualized within children's daily lives or play experiences.

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To overcome the abstraction of numeracy concepts in early childhood, this study proposes using a simple entrepreneurship context, mathematically known as social arithmetic (Annisa et al., 2023; Pakpahan et al., 2023). Concepts such as buying and selling, profit, loss, and price are quantitative ideas very close to children's daily experiences, even in their play. Introducing entrepreneurship from an early age is not intended to make children traders but to cultivate an entrepreneurial mindset—the ability to recognize opportunities, take calculated risks, and make simple financial plans—all of which require numeracy reasoning (Alif & Suwarno, 2022). Integrated entrepreneurship education with basic learning has been shown to positively influence entrepreneurial attitudes and future entrepreneurial intentions, highlighting the importance of cultivating these skills from preschool age (Sengaji & Wailmi, 2022). The focus on social arithmetic (e.g., discount calculations, capital, and profit) provides a solid framework for teaching mathematical functions contextually. By packaging these in simple simulations relevant to ECE, abstract numeracy concepts like addition and subtraction can be interpreted as "calculating remaining money" or "determining selling price," thereby integrating key variables in mathematics and entrepreneurship education.

The simple entrepreneurship context chosen for this study refers to real-world situations in the field, specifically microenterprises that require the practical application of social arithmetic to survive and optimize profits. Based on empirical data from document reviews and observations, it was revealed that even at the micro-enterprise level, lack of practical social arithmetic mastery can cause undetected losses, such as product weight shrinkage, inaccurate determination of Cost of Goods Sold (COGS), and failure to determine optimal profit strategies (Julianto, 2021). Business risk management issues, such as accounts receivable risk, storage risk, and price fluctuations, are also real challenges that require periodic evaluation and strategy adjustments, as reflected in broiler chicken company case studies. These real-world cases, although complex, provide rich contextual material that can be simplified (e.g., calculating remaining stock or determining change amount) for simulation in ECE educational games. Thus, the development of "NumBiz Kidz" is based on the empirical need to integrate numeracy problem-solving rooted in real economic contexts—simple buying and selling—which directly supports efforts to optimize profits and manage basic transactions (Palahudin et al., 2025; Widarman et al., 2022).

Although the urgency of numeracy literacy and the importance of the entrepreneurship context have been identified, the most obvious gap lies in the available learning media for ECE. Conventional media, such as workbooks or chalkboards, are inadequate to achieve the level of engagement, interaction, and motivation required of digital-generation children (Rahmata & Ekawati, 2021). There is a lack of media that explicitly and integratively combine basic numeracy with a simple, contextual entrepreneurship simulation (Dila & Zanthy, 2020). The majority of existing educational apps or games tend to focus on only one aspect: either just practicing counting without context or providing play simulations without a strong numeracy framework. This study sees that the solution must be media that leverages technology close to ECE children, namely mobile games, which offer a safe, fun, and repeatable learning environment (Darmayanti, 2022b). The use of mobile games allows concepts such as profit, loss, and transactions to be simulated visually and interactively, enabling children to learn through experiential learning, the most effective method in ECE (Sulyati & Rahman, 2025; Wardah Ningsih et al., 2024). The presence of technology-based media is an important step to bridge the gap between abstract mathematical concepts and their practical application in real life (Gusteti et al., 2024; Hasanah et al., 2022).

The novelty of this research lies in three key areas. First, it explicitly integrates two main variables—basic numeracy literacy and simple entrepreneurship education—into a single mobile game product designed specifically for early childhood, whereas previous studies typically addressed these separately. Second, the game's context is derived from empirical observation of real micro-enterprises (broiler chicken MSMEs in Tembokrejo, Pasuruan), ensuring authenticity and relevance, rather than using generic or imaginary business scenarios. Third, this study focuses on the rigorous Define stage of the 4D model, producing a validated Product Specification Blueprint that will guide subsequent Design, Development, and Dissemination phases and minimize prototyping failure risk. This approach contrasts with many R&D studies that rush into prototyping without adequate needs analysis. Therefore, this research aims to conduct the initial development stage of the "NumBiz Kidz" educational mobile game to enhance early childhood numeracy literacy, with a primary focus on the Define stage (Needs Analysis) of the 4D model, to comprehensively formulate product specifications based on empirical data from teachers, experts, and document analysis.

2. Method

2.1 Research Design and Development Model

This study adopts a Research and Development (R&D) design, chosen because its systematic, cyclical characteristics are ideal for developing innovative products (educational mobile game media) as a measurable solution to educational challenges (Creswell & Creswell, 2023). The development model used is the 4D model (Define, Design, Develop, Disseminate) pioneered by Thiagarajan, Semmel, and Semmel, known for providing a comprehensive framework for designing, testing, and disseminating educational products. However, it is critical to emphasize that this research is strictly limited to the first stage: Define (Needs Analysis). This limitation aims to ensure that the product's conceptual foundation is truly solid and relevant to practical challenges faced by ECE teachers (conventional abstract methods) and aligned with the simple entrepreneurship context (social arithmetic) to be integrated. The Define stage in this R&D framework serves as an intensive pre-development phase, during which descriptive qualitative data are collected and analyzed to produce a validated Product Specification Blueprint that will serve as the definitive guide for the subsequent Design stage, thereby minimizing prototype failure risk (Sari et al., 2022).

2.2 Location and Subjects

The research location was a formal kindergarten institution, TK Dharma Wanita Persatuan X, in Pasuruan Regency, East Java, selected through purposive sampling because the location represents a school environment still relying on conventional numeracy learning methods. The selection of East Java also has contextual relevance to document study results on local entrepreneurial practices, such as broiler chicken traders in Pasuruan and surrounding areas, underscoring the urgency of practical social arithmetic mastery. The main subjects of the research, who were key informants in the Define stage, consisted of three categories: (1) Two ECE classroom teachers directly responsible for numeracy learning, (2) One Early Childhood Education expert from a university for pedagogical validation and ECE characteristics, and (3) One Content/Entrepreneurship expert to ensure the suitability of simple social arithmetic concepts relevant to ECE and the business world (Alif & Suwarno, 2022). These subjects were selected to provide

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triangulation perspectives (field practitioners, pedagogy experts, and content experts) on the need for media development.

2.3 Data Collection Techniques and Instruments

Data collection in this Define stage was conducted through three main techniques: Observation, In-depth Interview, and Document Study. An observation was conducted to map the ongoing numeracy teaching methods and the level of basic numeracy literacy of ECE students in the classroom, while also identifying visual and interactive constraints of existing media. In-depth interviews with teachers and experts aimed to explore specific product needs, including features, appropriate difficulty levels, and feasibility of integrating simple buying-and-selling contexts. Document study was used to analyze the curriculum (e.g., ECE learning outcomes), social arithmetic materials, and empirical data on micro-enterprise cases (e.g., COGS calculation and optimal profit in broiler chicken businesses) (Palahudin et al., 2025). Instruments included: Observation Sheet (recording actual conditions of numeracy learning, media used, and non-verbal responses), Semi-Structured Interview Guideline (open-ended questions about urgency of media digitalization, teacher understanding, and integration of simplified micro-economic concepts), and Document Review Matrix (organizing information from curriculum, journals, and entrepreneurship case data). Table 1 presents the matrix of data collection techniques.

Table 1. Matrix of Data Collection Techniques in the Define Stage

No.	Data Collection	Data Source	Focus of Information Collected
1	Observation	Teachers and ECE Students	Conventional numeracy learning methods, student engagement levels, barriers to concept visualization (e.g., difficulty calculating remaining stock)
2	In-depth Interview	ECE Teachers, Education Expert, Entrepreneurship Expert	Urgent need for digital media, desired gameplay features, pedagogical feasibility of simple entrepreneurship concepts (e.g., profit/loss), ideal numeracy literacy levels for ECE
3	Document Study	ECE Curriculum, Social Arithmetic Modules, Entrepreneurship Journals (Chicken Business Case)	Analysis of material suitability, boundaries of numeracy concepts taught, simplification of real business models (e.g., loss risk due to weight shrinkage, accounts receivable management) for game context

2.4 Data Analysis Technique

Data analysis applied descriptive qualitative analysis presented in narrative form to formulate the Product Needs Matrix. The analysis process followed the interactive model introduced by Miles and Huberman, covering three simultaneous activity streams: Data Reduction, Data Display, and Conclusion Drawing/Verification. In the Data Reduction stage, the researcher selected, focused on, and abstracted raw data from observations, interviews, and document results (e.g., specifically recording teacher complaints about the lack of interactive media or real-world case data on the importance of accurate COGS calculation). Then, the reduced data were displayed in narrative and matrix form, facilitating understanding of the relationship between the problem (numeracy abstraction) and the proposed solution (mobile game). The final stage was Conclusion Drawing, during

which the researcher formulated the final specifications for the NumBiz Kidz product (e.g., required features, simplified entrepreneurship concepts) to address the identified urgency, thereby providing a logical framework for the Design stage (Sari et al., 2022).

2.5 Data Validity and Limitations

To ensure the validity of qualitative data obtained in the Define stage, the researcher used Triangulation techniques, specifically Source Triangulation and Method Triangulation. Source Triangulation was conducted by comparing findings (e.g., the need for interactive media) across three subject groups: ECE Teachers (practitioners), Education Expert (pedagogical perspective), and Entrepreneurship Expert/Documents (content and real-world perspective). Method Triangulation was performed by matching direct classroom observation results (e.g., students' difficulty calculating change) with narrative data from teacher interviews. This validity is absolutely critical when formulating product specifications that will serve as the development blueprint, ensuring that the need for NumBiz Kidz as a media combining numeracy literacy and entrepreneurship is not merely a researcher's assumption but a need cross-validated by practitioners and experts (Hilyani et al., 2020). The main limitation of this study lies in the scope of the R&D model, which stops at the Define phase, meaning the research produces only a conceptual framework and functional specifications for the "NumBiz Kidz" educational mobile game, and does not yet reach prototype design, validity testing, practicality, or product effectiveness. Consequently, the findings cannot empirically demonstrate that the proposed mobile game truly improves ECE numeracy literacy; they only show the urgency and conceptual feasibility.

3. Result

3.1 Front-End Analysis: Urgency of Digital Media for Numeracy Literacy

The results from the Front-End Analysis (Needs Gap Analysis) revealed significant urgency to integrate numeracy literacy with entrepreneurship values through interactive digital media. Field findings from observations and teacher interviews revealed that basic numeracy learning (such as arithmetic operations with numbers 1–20 and comparison) in ECE is still dominated by conventional paper-based methods or limited physical teaching aids, leaving Generation Z students, who are technology-savvy, less motivated. Teachers acknowledged that although they try to instill entrepreneurial values (buying and selling), such simulations are often disconnected from the mathematical concepts that should underpin them. One teacher stated, "I tell them about selling and buying, but they don't connect it to counting money. When I ask how much change to give for Rp5,000 if something costs Rp3,000, only three children could answer" (Interview, February 12, 2025). This gap is reinforced by literature highlighting the importance of digital media and integration of 21st-century skills (such as critical thinking) into mathematics (Inganah et al., 2023). The analysis concluded that media explicitly contextualizing social arithmetic concepts from an early age is urgently needed.

3.2 Learner Analysis: Characteristics and Preferences of ECE Children

Learner Analysis was conducted to understand the cognitive, affective, and social characteristics of children aged 4–6 years. Observation results showed that children's attention span for numeracy activities averaged only 5–8 minutes when using conventional media, but when shown animated videos or interactive games on teacher tablets, attention extended to 15–20 minutes. Through structured interviews with teachers about their

students' preferences, data were collected on the game design elements most appealing to ECE children. Figure 1 presents the percentage distribution of preferences.

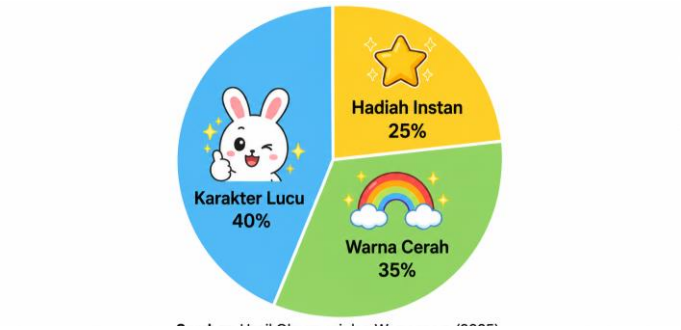

Figure 1. Preferences of ECE Children for Mobile Game Design Elements

Figure 1 illustrates the percentage of mobile game design elements preferred by ECE children, showing that Bright Colors (40%) and Cute Characters (35%) are the main attraction factors, while Instant Rewards (25%) serve as a motivation for learning. These results served as the primary basis for designing the NumBiz Kidz game's UI/UX. Additionally, the analysis revealed that children responded positively to narratives (storylines) where they acted as "shopkeepers" or "cashiers," suggesting that role-play elements are highly compatible with entrepreneurship themes. Teachers also noted that competitive elements (e.g., earning coins, leaderboards) must be presented carefully to avoid frustration; therefore, NumBiz Kidz will use positive reinforcement (earning coins) without negative penalties.

3.3 Content Analysis: Numeracy and Entrepreneurship Material Mapping

Content analysis was conducted to identify numeracy concepts appropriate for ECE (ages 4–6) that could be integrated with simple entrepreneurship contexts. Based on the ECE curriculum document review and expert input, the numeracy scope included: (1) Recognizing numbers 1–20, (2) Addition and subtraction within 1–20, (3) Comparing quantities (more/less/same), (4) Recognizing coin values (Rp500, Rp1,000), and (5) Simple time concepts (duration). From the entrepreneurship side, the analysis simplified real business concepts into four main themes: (a) Buying and selling transactions (customers buy products, sellers calculate total price), (b) Calculating change (paying with larger denomination coins), (c) Managing stock (counting remaining goods, comparing incoming and outgoing stock), and (d) Time-limited service (encouraging quick calculation). The Entrepreneurship Expert confirmed that these simplifications maintain the essence of social arithmetic (profit/loss, transactions) without introducing inappropriate complexity. The material mapping yielded a matrix linking numeracy concepts to entrepreneurship tasks, which served as the basis for game mission design.

3.4 Task Analysis: Simplifying Real Business Concepts into Game Missions

Task Analysis played a crucial role in bridging real-world entrepreneurship scenarios with simple gameplay mechanisms for ECE. This activity involved simplifying the workflow of micro-enterprise traders (broiler chicken sellers in Tembokrejo, Pasuruan) into numeracy tasks manageable for children. For example, complex concepts like strategic profit optimization or operational risk management were simplified into missions such as calculating remaining stock or changes to maximize coin profits. Table 2 presents concrete examples of this simplification.

Table 2. Matrix of Entrepreneurship Concept Simplification into NumBiz Kidz Game Tasks

Real Business Social Arithmetic Concept (Broiler Chicken Example)	NumBiz Kidz Game Task Simplification (For ECE)	Core Numeracy Trained
Strategic Profit Optimization (setting selling price, managing costs)	Mission: Complete transaction + Bonus = Maximum total coins	Addition (1-20)
COGS & Variable Cost Calculation (feed, medicine, chick costs vs revenue)	Mission: Match incoming stock (input) with customer demand (output)	Quantity Comparison, Calculating Difference
Accounts Receivable Risk Management (late payments, bad debts)	Mission: Calculate change correctly (if wrong, profit coins decrease)	Subtraction (1-20)
Sales Time Segmentation (peak hours vs slow hours)	Mission: Serve customers within time limit to get extra reward	Introduction to Duration/Time Concept (secondary numeracy)

Source: Task Analysis and Literature Review (2025)

Table 2 details how social arithmetic and profit management concepts from real business case studies are simplified into tasks manageable for ECE children in the "NumBiz Kidz" game, focusing on practicing basic arithmetic operations and comparisons. The Task Analysis also involved discussion with teachers regarding specific student difficulties in social arithmetic, such as difficulty interpreting word problems (Hilyani et al., 2020; Dila & Zanthy, 2020). Therefore, NumBiz Kidz must emphasize visual representation of problem narratives so children can more easily identify the problem, aligning with mathematical literacy indicators.

3.5 Field Condition Realities and Implementation Challenges

The implementation of the exploratory stage in the field faced a series of logistical and non-logistical challenges, reflecting the reality of R&D research. Logistically, the research team overcame unpredictable weather conditions during school observations. This environmental condition forced the team to adjust schedules, especially for in-depth interviews with teacher subjects. Additionally, non-logistical challenges emerged from human resource aspects, namely the mood or availability of free time of education expert informants. This challenge required the research team to have high time management skills to ensure data from experts could still be obtained optimally. Despite various obstacles, the research team implemented rigorous logistical procedures to ensure data authenticity and representativeness. This strategy focused on efficient allocation of research budget expenditures, particularly for accommodation and transportation. This measured allocation ensured the research team could gain direct access to research subjects (ECE children, teachers, schools) and relevant research locations, ensuring the collected data were truly authentic and representative of the numeracy-literacy problem in ECE that has not been integrated with an entrepreneurship context.

3.6 Product Output Specifications: Blueprint from Define Stage

The main output of the entire Define stage is the Product Needs Specification document (Blueprint), which serves as a detailed guide for the Design stage. This document summarizes all qualitative findings regarding user needs and content. Functionally, NumBiz Kidz must have four main features: (1) Simple Store (for buying-and-selling simulation, children act as cashiers), (2) Inventory (to practice stock counting and

comparison, e.g., "Do we have enough chicken for 5 customers?"), (3) Change Calculator (to practice subtraction and currency value recognition), and (4) Coin Leaderboard (as reward and motivation, showing accumulated profit). The document also includes non-functional specifications: platform (Android minimum version 8.0, also responsive web for iOS via browser), use of bright colors (primary palette: yellow, orange, green), 2D animation with smooth transitions, and inclusive characters (various skin tones, traditional Indonesian clothing options). The Blueprint also specifies difficulty progression: Level 1 (numbers 1–10, no time limit); Level 2 (numbers 1–20, with a time limit); and Level 3 (introduction to coin denominations and change calculation). Documentation ensures that the product to be designed in the next stage is not only conceptually valid in education (numeracy and entrepreneurship) but also practical and engaging for ECE, as shown in Learner Analysis results.

3.7 Validation of Integration Between Numeracy and Entrepreneurship

The Define stage validated that explicit integration of two main variables—Basic Numeracy Literacy and Simple Entrepreneurship Education—is not only feasible but also urgently needed based on triangulated data. The Education Expert confirmed that social arithmetic concepts (profit, loss, selling price) are developmentally appropriate for ages 5–6, as children at the preoperational stage can understand them through concrete props and role-play (Vygotsky, 1978). The Entrepreneurship Expert added that introducing the concept of "profit" as "extra coins after serving customers" builds a foundational understanding of value creation, which is the essence of entrepreneurship without requiring complex calculations. Teachers also reported that during observation, children spontaneously engaged in "pretend selling" during free play, indicating that the context is intrinsically motivating. Thus, the integration in NumBiz Kidz is not forced but leverages children's existing play schemas.

3.8 Visual Design Preferences and UI/UX Recommendations

Based on Learner Analysis (Figure 1), detailed UI/UX recommendations were formulated. Bright colors (40% preference) dictate a warm, saturated palette: a background in light yellow or soft orange to reduce eye strain, and interactive buttons in bright green or blue for contrast. Cute characters (35% preference) will be realized as animal helpers (a friendly chicken named "Kiki" as the shop assistant, a smart rabbit named "Bunny" as the customer). Characters will have large eyes, rounded shapes, and gentle animations (such as bobbing and blinking). Instant rewards (25% preference) will be implemented as coin collection with sound effects (a "cha-ching" ping) and visual celebration (stars bursting) after each correct answer, without negative sounds for wrong answers (instead, a gentle "try again" prompt). The UI must be intuitive: minimal text instructions (since many ECE children are pre-readers), icons instead of words (a coin icon for reward, a shopping cart for store), and large touch targets (minimum 80x80 dp) to accommodate fine motor development.

3.9 Content Difficulty Progression Framework

The Content Analysis and Task Analysis produced a difficulty progression framework to ensure the game remains challenging yet achievable (flow state). Level 1 (Beginner, ages 4–5): Numbers 1–10, addition only (e.g., "Customer buys 3 chicken pieces and 2 pieces. How many total?"), no time limit, reward for any correct answer. Level 2 (Intermediate, ages 5–6): Numbers 1–20, addition and subtraction (e.g., "You have 15 pieces. Customer buys 8. How many are left?"), simple time limit (30 seconds per question). Level 3 (Advanced, age 6): Introduction to coin denominations (Rp500,

Rp1,000), making change (e.g., "Customer pays Rp5,000 for Rp3,500 chicken. How much change?"), Time limit: 20 seconds, bonus coins for speed. This progression aligns with the ECE curriculum's learning outcomes and was validated by the Education Expert as developmentally appropriate.

4. Discussion

The findings of this study confirm that conventional numeracy learning methods in Early Childhood Education (ECE) are no longer sufficient to meet the characteristics of digital-native children from Generation Alpha and Z. Children showed significantly higher engagement when learning through digital media, with attention spans increasing from only 5–8 minutes in traditional instruction to 15–20 minutes when using interactive digital platforms. This finding supports the work of Rahmata & Ekawati (2021), who argued that paper-based mathematics instruction often fails to attract young learners because it lacks interactive and visual stimulation. Similarly, Darmayanti (2022a) found that digital narrative-based media improved student engagement and comprehension. Extending these studies, the present research introduces entrepreneurship simulation as the narrative foundation for numeracy learning, indicating that digital games should become an integral pedagogical tool in ECE classrooms rather than merely supplementary media.

Another important finding is the successful integration of social arithmetic concepts—such as buying, selling, profit, and loss—into early childhood numeracy learning through simplification strategies. Previous studies by Dila & Zanthy (2020) and Hilyani et al. (2020) showed that many elementary and junior high school students struggle with contextual social arithmetic because they were never introduced to such concepts during early childhood. Through NumBiz Kidz, these concepts are transformed into simple numeracy operations such as addition, subtraction, and comparison, making them developmentally appropriate for young learners. This contextualization aligns with Annisa et al. (2023) and Pakpahan et al. (2023), who emphasized the importance of contextual digital learning media for arithmetic instruction, although their work focused primarily on older students. Therefore, this study contributes a novel approach by applying entrepreneurship-based numeracy learning at the ECE level.

The study also demonstrates that mobile games can function as experiential learning laboratories where children safely experiment with mathematical transactions without fear of social embarrassment or real financial loss. Supported by gamification theories from Ananda et al. (2024) and Uran et al. (2025), the reward systems, progression levels, and narrative interactions in NumBiz Kidz provide immediate feedback and intrinsic motivation. The finding that 25% of children strongly preferred instant rewards validates the inclusion of coin-based reinforcement systems and sound effects. Moreover, the game activates multiple intelligences simultaneously, including logical-mathematical, linguistic, and interpersonal intelligence, as proposed by Wardah Ningsih et al. (2024). Consequently, gamification elements in the game are not merely decorative but pedagogically meaningful tools that transform numeracy learning into an engaging and self-directed activity.

A distinctive contribution of this study lies in its contextual grounding in real MSME (Micro, Small, and Medium Enterprise) activities, specifically broiler chicken businesses in Tembokrejo, Pasuruan. Julianto (2021) and Sari et al. (2022) previously documented how local chicken traders frequently experience losses due to inaccurate cost calculations and inventory management. NumBiz Kidz simplifies these real-world economic challenges into child-friendly tasks such as matching stock with customer demand and calculating change correctly. This authentic localization strengthens meaningful learning because

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children are already familiar with traditional market environments and chicken-selling activities in their communities. Hasanah et al. (2022) emphasized that culturally relevant contexts improve retention and learning meaning, while Gusteti et al. (2024) argued that familiar cultural situations enhance mathematical self-efficacy. The inclusion of Indonesian cultural elements, such as batik-themed characters, further increases children's identification with the game environment.

The integration of numeracy and entrepreneurship in NumBiz Kidz also aligns closely with 21st-century learning frameworks, particularly the 6C competencies proposed by Inganah et al. (2023): Critical Thinking, Creativity, Communication, Collaboration, Character, and Citizenship. The game develops critical thinking through transaction-based problem solving, creativity through role-playing activities, and character education through honesty and responsibility in simulated buying-and-selling interactions. Unlike traditional worksheets that isolate mathematical computation, NumBiz Kidz embeds numeracy tasks within meaningful narratives that require interpretation and decision-making. Melliani & Triadi (2024) similarly argued that entrepreneurship education should be experiential rather than purely theoretical. Therefore, the game represents a practical realization of project-based and contextual learning encouraged within Indonesia's Kurikulum Merdeka policy framework (Kemdikbud, 2021).

This study further addresses several barriers identified by teachers during the Define stage, including limited creativity in designing simulations, inconsistency between school and home reinforcement, and the absence of objective assessment tools. NumBiz Kidz responds to these concerns by offering ready-to-use interactive content that reduces teacher preparation time. Additionally, the Blueprint incorporates parent guidance activities, such as "playing store at home," to strengthen consistency between school learning and family practices, supporting the recommendations of Anwar & Mashudi (2024). The built-in analytics system—including records of correct answers, completion time, and coins earned—also provides continuous formative assessment data that teachers can use to monitor individual student progress more objectively, overcoming the limitations of traditional observational methods noted by Hilyani et al. (2020).

Despite its contributions, the study remains limited to the Define stage of the 4D development model, meaning that several aspects require further investigation. The actual effectiveness of the developed game in improving numeracy literacy compared to conventional instruction still needs empirical testing through experimental or randomized controlled studies. Furthermore, usability testing is necessary to determine whether young children can easily navigate the interface and understand the visual icons. The level progression system may also require refinement after pilot implementation, especially for children with diverse learning needs such as dyscalculia or attention deficits. Nevertheless, these limitations do not weaken the study's contribution; rather, they establish a clear roadmap for future research and development, consistent with the recommendations of Gusteti et al. (2024) and Hasanah et al. (2022).

Overall, this study contributes both theoretically and practically to the fields of early childhood education, numeracy literacy, and educational technology. Theoretically, it extends the application of the 4D development model into entrepreneurship-based numeracy learning through mobile game media. Practically, it provides a validated Product Blueprint that can guide educators, developers, and policymakers in designing culturally relevant digital learning tools for ECE. By transforming abstract arithmetic concepts into meaningful entrepreneurial activities, NumBiz Kidz has the potential to reshape children's perceptions of mathematics from a difficult subject into a useful and enjoyable life skill.

As emphasized by Reza Lestari et al. (2024), negative attitudes toward mathematics often emerge from abstract and decontextualized instruction; therefore, contextualized game-based learning may become an effective strategy for fostering positive mathematical identities from early childhood onward.

5. Conclusion

sBased on the research findings and needs analysis (Define stage of the 4D model) for the development of the "NumBiz Kidz" educational mobile game, several main conclusions can be drawn. First, the Front-End Analysis confirmed a significant gap between the need for mastery of basic numeracy literacy in early childhood and the limitations of conventional, abstract learning methods. This creates a high urgency to develop technology-based learning media (mobile games) that bridge numeracy with real-world, contextual applications. Second, this research validated the need for explicit integration of two main variables: Basic Numeracy Literacy (recognition of numbers 1–20, addition, subtraction, quantity comparison) and Simple Entrepreneurship Education (through social arithmetic context such as buying/selling and profit/loss). This integration is recommended to cultivate an entrepreneurial mindset while strengthening children's functional numeracy abilities. Third, the Learner Analysis revealed that ECE children prefer bright colors (40%), cute characters (35%), and instant rewards (25%), which must inform UI/UX design. The Task Analysis produced a simplification matrix that transformed real business concepts (COGS, strategic profit optimization, accounts receivable risk) into game missions that teach addition, subtraction, and comparison. Fourth, the main output of the Define stage is a comprehensive Product Specification Blueprint including functional requirements (Simple Store, Inventory, Change Calculator, Coin Leaderboard) and non-functional requirements (Android platform, 2D animation, inclusive characters, difficulty progression levels). The Blueprint serves as the technical guide for subsequent Design, Development, and Dissemination phases. To optimize the results of this Define stage, it is strongly recommended that the research continue to follow the established R&D 4D model consistently. Subsequent research must immediately focus on the Design stage, translating the Blueprint into a detailed prototype (visual design, storyboard, UI/UX) that is attractive and appropriate for ECE characteristics, followed by the Development stage to produce a valid and practical game. Additionally, future researchers should conduct extensive testing, including quantitative effectiveness trials with ECE groups, to empirically prove the extent to which the "NumBiz Kidz" educational mobile game improves children's numeracy literacy and entrepreneurship awareness compared to conventional learning methods. Collaboration with game developers, ECE teacher associations, and local MSME communities is recommended to ensure the game remains contextually relevant and sustainable.

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