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Beyond arithmetic skills: integrating interactive learning, gradual practice, and reward systems to foster children's numeracy development

Nadia Rahmadani[1]*, Difa'ul Fikri Jayyid[2], Abubakar Siddiq Uba[3]

[1] Universitas Islam Negeri Sunan Kudus, Kudus, Indonesia

[2] IIM Surakarta, Surakarta, Indonesia

[3] National Board for Arabic and Islamic Studies (NBAIS), Kano, Nigeria

*Corresponding Author: 055nadiarahmadani@gmail.com

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Abstract

Mathematics learning continues to face challenges related to low student engagement, motivation, and conceptual understanding of basic arithmetic operations. This study aims to analyze the implementation of an integrated numeracy learning approach combining interactive learning, gradual practice activities, and a reward system to improve children's numeracy skills and learning motivation. This study employed a descriptive qualitative approach supported by simple quantitative data obtained through participant observation, initial and final assessments, and documentation involving 18 children aged 5–12 years in Peganjaran Village. The findings revealed that the implemented learning approach contributed to improvements in learning engagement, self-confidence, numeracy skills, and learning persistence. These improvements were reflected in children's increased willingness to participate, shifts in problem-solving strategies from procedural approaches toward conceptual understanding, and the development of learning motivation through an effort-oriented reward system. These findings indicate that integrating interactive learning, gradual practice, and a proportional reward system can establish a more active, enjoyable, and developmentally appropriate numeracy learning environment.

Keywords: Numeracy skills; Interactive learning; Gradual practice; Reward system; Learning motivation

Abstrak

Pembelajaran matematika masih sering menghadapi tantangan berupa rendahnya keterlibatan, motivasi, dan pemahaman konseptual peserta didik terhadap operasi hitung dasar. Penelitian ini bertujuan untuk menganalisis implementasi pembelajaran numerasi berbasis pembelajaran interaktif, latihan bertahap, dan *reward system* dalam meningkatkan kemampuan numerasi serta motivasi belajar anak. Penelitian ini menggunakan pendekatan kualitatif deskriptif dengan dukungan data kuantitatif sederhana yang diperoleh melalui observasi partisipatif, asesmen awal dan akhir, serta dokumentasi terhadap 18 anak usia 5–12 tahun di Desa Peganjaran. Hasil penelitian menunjukkan bahwa pendekatan pembelajaran yang diterapkan mampu meningkatkan keterlibatan belajar, kepercayaan diri, kemampuan numerasi, dan ketekunan anak. Peningkatan tersebut terlihat dari keberanian anak dalam berpartisipasi, perubahan strategi penyelesaian masalah dari prosedural menuju pemahaman konseptual, serta berkembangnya motivasi belajar melalui *reward system* yang berorientasi pada usaha dan perkembangan individu. Temuan ini menunjukkan bahwa integrasi pembelajaran interaktif, latihan bertahap, dan *reward system* mampu menciptakan lingkungan belajar numerasi yang lebih aktif, menyenangkan, dan sesuai dengan kebutuhan perkembangan anak.

Kata Kunci: Kemampuan numerasi, Pembelajaran interaktif, Latihan bertahap, Sistem Berhadiah, Motivasi belajar

Introduction

Numeracy skills are fundamental competencies that play a crucial role in children's cognitive development and their ability to solve problems in everyday life (Chen, 2024). Numeracy is not merely related to the ability to perform arithmetic calculations, but also involves conceptual understanding, numerical reasoning, and the ability to apply mathematical knowledge in various contexts. Strong numeracy skills during childhood provide an important foundation for future academic achievement, particularly in mathematics and science-related subjects. However, many children continue to experience difficulties in mastering basic arithmetic concepts, especially when mathematical learning is introduced only as procedural activities without helping children understand the relationships between numerical operations (Verschaffel et al., 2020). Therefore, effective numeracy learning should facilitate children in developing both procedural fluency and deeper conceptual understanding through meaningful learning experiences.

The challenges in developing children's numeracy skills are influenced not only by cognitive factors but also by motivational and emotional aspects during the learning process. Conventional mathematics instruction often emphasizes correct answers and repetitive exercises, causing some children to perceive mathematics as difficult and intimidating (Schoenfeld, 2022). This condition can reduce students' learning engagement, self-confidence, and willingness to explore various problem-solving strategies. From a constructivist perspective, children actively construct their knowledge through interactions, experiences, and meaningful learning activities (Zajda, 2021). Therefore, numeracy learning requires student-centered approaches that provide opportunities for children to communicate, collaborate, experiment, and gradually develop their mathematical understanding according to their developmental stages.

Various learning strategies have been developed to overcome difficulties in numeracy learning. Interactive learning approaches have been widely recognized for increasing student engagement by creating two-way communication and active participation in the classroom (Thwin & Lwin, 2018). In addition, educational games and storytelling activities can transform abstract mathematical concepts into more concrete and enjoyable learning experiences for children (McFeetors & Palfy, 2018). Gradual practice activities also contribute to improving mathematical fluency because children are given opportunities to master simple concepts before moving to more complex problems. Furthermore, positive reinforcement through reward systems has been found to improve children's learning motivation by appreciating their efforts and achievements during the learning process. These findings indicate that effective

numeracy learning should involve cognitive, social, and motivational dimensions simultaneously.

However, several previous studies still show limitations in addressing numeracy learning comprehensively. Research Lin et al. (2018) examined the implementation of interactive learning in mathematics education and reported improvements in student engagement; however, the study mainly focused on classroom interaction without exploring its influence on the gradual development of numeracy concepts. Research Yeh et al. (2019) investigated the use of educational games to increase students' interest in mathematics, but the findings were limited to motivational aspects without analyzing changes in children's conceptual understanding of arithmetic operations. Research Murayama (2022) analyzed the effectiveness of reward systems in improving learning participation; however, the study emphasized extrinsic motivation and paid less attention to the transition toward intrinsic motivation and long-term learning persistence. These limitations indicate the need for a more integrated numeracy learning strategy that combines cognitive, interactive, and motivational dimensions.

Based on these gaps, this study implements an integrated numeracy learning program that combines interactive learning, gradual practice activities, and an effort-oriented reward system among children aged 5–12 years in Peganjaran Village, Bae District, Kudus Regency. Interactive learning was implemented through two-way communication, educational games, and storytelling activities to encourage active participation and meaningful learning experiences. Meanwhile, gradual practice activities were designed to help children understand arithmetic concepts from simple to more complex levels, while the reward system was applied to appreciate children's effort, courage, discipline, and individual learning progress. This integrated approach aims to address not only children's numeracy achievement but also their engagement, confidence, and learning persistence.

Therefore, this study contributes to the development of child-centered numeracy learning by offering a more comprehensive approach that integrates cognitive, social, and motivational aspects within a single learning framework. Unlike previous studies that tended to examine learning strategies separately, this study highlights how interactive learning, structured gradual practice, and proportional reward systems work together in supporting children's numeracy development. The findings are expected to provide practical implications for educators, tutors, and parents in designing numeracy learning environments that are not only effective in improving mathematical abilities but also capable of fostering confidence, motivation, and sustainable interest in learning mathematics.

Method

This study employed a descriptive qualitative approach supported by simple quantitative descriptive data to examine the implementation of an interactive

numeracy learning program among children in Peganjaran Village, Bae District, Kudus Regency (Creswell, 2014). The qualitative approach was utilized to explore changes in children's learning engagement, self-confidence, motivation, and learning behaviors during the implementation of the learning activities. Meanwhile, quantitative descriptive data were used to present changes in children's numeracy skills based on initial and final assessments. The study was conducted from August 2 to August 30, 2025, with a focus on understanding how the integration of interactive learning, gradual practice, and a proportional reward system contributed to children's cognitive and affective development in numeracy learning.

The participants of this study consisted of 18 children aged between 5 and 12 years who voluntarily participated in the learning program. The activities were conducted twice a week with a total of eight learning sessions, and each session lasted approximately 60 minutes. The numeracy learning activities focused on basic arithmetic operations, including addition, subtraction, multiplication, and division. The learning process integrated several strategies, such as two-way communication, educational games, storytelling, gradual practice activities, and a reward system that emphasized appreciation for children's effort, courage, discipline, and individual progress. These strategies were designed to create a supportive learning environment that encouraged active participation and allowed children to develop their numeracy skills according to their individual learning needs.

Data were collected through participant observation, initial and final numeracy assessments, and learning documentation. Observations were conducted throughout the learning sessions to identify changes in children's engagement, self-confidence, motivation, persistence, and problem-solving strategies. The initial and final assessments were used to examine the development of children's abilities in performing basic arithmetic operations and understanding mathematical concepts. The collected data were analyzed using descriptive analysis techniques. Qualitative data were interpreted through data reduction, categorization, and interpretation to identify patterns of behavioral and cognitive changes, while quantitative data were analyzed by comparing the children's performance before and after the learning program to provide a comprehensive understanding of the effectiveness of the implemented learning strategies.

Results and Discussion

Implementation of interactive learning in the tutoring program

The results of the observations indicated that the implementation of interactive learning brought changes in children's participation and self-confidence during the numeracy learning process. At the initial stage, most participants tended to be passive, particularly in asking questions and expressing their answers in front of their peers. The initial and final observation data demonstrated considerable changes after the

implementation of interactive learning across eight learning sessions. These changes were reflected in the children's increased willingness to participate in discussions, solve problems directly, and demonstrate their abilities without fear of making mistakes. This improvement suggests that a learning environment that encourages active participation can help children develop a greater sense of comfort and confidence in engaging with learning activities.

Table 1. Development of Children's Engagement and Self-Confidence in Interactive Learning

Indicator	**Initial Observation**	**Final Observation**	**Change**
Children actively asking or answering questions during learning	7 children (38.9%)	16 children (88.9%)	+50 percentage points
Children confidently solving problems in front of their peers	6 children (33.3%)	15 children (83.3%)	+50 percentage points

Source: Researchers' observation results (2025).

Based on Table 1, the most notable improvement was observed in children's active engagement during the learning process. The proportion of participants who actively asked or answered questions increased from 38.9% to 88.9%, while the proportion of children who confidently solved problems in front of their peers increased from 33.3% to 83.3%. These findings indicate that interactive learning does not merely provide children with opportunities to receive information, but also creates a space for them to explore their abilities and express their thoughts openly. However, the observations also revealed that two children remained less active in discussions, and three children still lacked full confidence when asked to solve mathematical problems in front of their peers. This indicates that the development of children's social and academic abilities progresses at different rates depending on individual characteristics.

The increased level of engagement demonstrates that interactive learning has a broader function beyond simply providing variation in teaching methods. Educational games, storytelling activities, and two-way communication served as stimuli that helped children reduce anxiety toward mathematics learning. When children experience a safe and enjoyable learning environment, they become more willing to try, make mistakes, and improve their understanding through direct learning experiences. This finding is consistent with the study conducted by Researcher Tsai et al. (2020) which reported that activity-based interactive learning could improve students' engagement and their confidence in expressing opinions. Likewise, the study by Researcher Cheung and Ng (2021) found that the use of educational games enhanced learning motivation by providing a more contextual and enjoyable learning experience for children.

From a theoretical perspective, these findings can be explained through the constructivist approach, which views learners as active individuals who construct

knowledge through experiences and social interactions. In numeracy learning, opportunities to discuss, ask questions, and attempt problem-solving play an essential role in developing conceptual understanding. The present findings also support the results of Researcher Risyanto et al. (2024) who demonstrated that a student-centered learning approach can improve students' participation, self-confidence, and learning independence. Therefore, the success of interactive learning in this study was not only reflected in the increased level of children's engagement throughout the learning activities but also in the creation of a more positive learning environment that supports both cognitive and affective development.

Improvement of children's numeracy skills through gradual practice activities

The observation results revealed that the improvement of children's numeracy skills did not occur equally across all arithmetic operations. Addition showed the most rapid development because most children had prior experiences with counting simple objects in their daily lives. In contrast, greater difficulties were found in subtraction involving borrowing techniques, multiplication of numbers 6–10, and division, which require a deeper understanding of relationships between mathematical concepts. After participating in eight learning sessions, improvements were not only reflected in increased accuracy in solving problems but also in the development of children's thinking processes in understanding arithmetic operations. These findings indicate that numeracy improvement is not merely related to obtaining correct answers but also involves the development of conceptual understanding regarding the relationships among mathematical operations.

Table 2. Development of Children's Numeracy Skills Based on Learning Indicators

Numeracy Skill Indicators	**Initial Condition**	**Final Condition**
Solving one- and two-digit addition problems accurately	15 out of 18 children were able to solve the problems independently, while 3 children still required guidance during the calculation process	All children were able to solve the problems independently with more consistent accuracy
Solving subtraction problems involving borrowing techniques	Nine children still experienced difficulties in understanding the borrowing concept, especially when dealing with larger numbers	Only two children still required assistance when solving problems with higher levels of difficulty
Mastering and applying basic multiplication	Most children only mastered multiplication tables from 1–5, while 10 children frequently made errors when solving multiplication problems involving numbers 6–10	Fourteen children were able to solve multiplication tables from 1–10 fluently, while four children still required reinforcement through repeated practice

Understanding division as the inverse of multiplication	Twelve children experienced difficulties because they still relied on repeated subtraction strategies and had not understood the relationship between division and multiplication	Eleven children began to understand the relationship between multiplication and division and were able to solve simple division problems correctly

Source: Researchers' observation results (2025).

Based on Table 2, the most significant improvement in numeracy skills was observed in the quality of children's understanding of mathematical concepts. Addition developed relatively quickly because the concept is closely connected to children's concrete experiences, such as counting objects encountered in everyday situations. In contrast, multiplication and division require more complex thinking processes because children must understand numerical patterns and the relationships between mathematical operations. A particularly important finding was the change in children's strategies for solving division problems. At the beginning of the learning process, some children relied solely on repeated subtraction methods. However, after receiving gradual practice, they began to understand that division has a direct relationship with multiplication, enabling them to use more effective and efficient problem-solving strategies.

This shift in thinking strategies demonstrates that gradual practice not only improves children's mathematical fluency but also helps them achieve deeper conceptual understanding in numeracy learning. Organizing learning activities from simple to more complex levels provides children with opportunities to construct knowledge progressively and reduces cognitive load when encountering new concepts. Research Borji et al. (2021) demonstrated that a gradual practice approach could improve mastery of basic mathematical concepts because learners are given sufficient time to understand one concept before moving to the next level. Similarly, Research Fyfe and Brown (2018) explained that structured exercises accompanied by consistent feedback can enhance children's numerical reasoning and their ability to connect various mathematical concepts more comprehensively.

Although the findings indicate positive improvements, the development of numeracy skills was not achieved uniformly among all participants. At the end of the learning process, several children still required assistance, particularly in multiplication and division, which involve higher levels of abstraction. These differences in achievement may be influenced by the participants' age range (5–12 years), previous learning experiences, and individual levels of cognitive readiness. This finding aligns with Piaget's (2003) theory of cognitive development and Vygotsky's (1987) concept of scaffolding, which emphasize that children's learning develops gradually and requires instructional support tailored to their zone of proximal development. Therefore, gradual practice represents an appropriate strategy because it allows children to develop according to their individual learning needs and capacities.

In addition to demonstrating the effectiveness of the learning approach, these findings imply that the development of children's numeracy skills should consider the balance between procedural mastery and conceptual understanding. Children's success in solving arithmetic problems should not only be measured by their ability to produce correct answers but also by their capacity to explain the reasoning behind the strategies they use. However, this study has certain limitations because the observations were conducted over only eight learning sessions, meaning that it cannot fully represent the long-term development of children's numeracy skills. Therefore, future studies are recommended to investigate the effectiveness of gradual practice over longer periods and involve more comprehensive evaluations of children's numeracy development.

The role of reward system in enhancing children's learning motivation and persistence

The implementation of the *reward system* became one of the supporting strategies in numeracy learning to strengthen children's motivation and create a more positive learning experience (Miller, 2018). In this study, the *reward system* was implemented through two forms of appreciation, namely verbal rewards and simple tangible rewards. Verbal rewards were given throughout the learning process in the form of praise and positive responses when children showed constructive learning behaviors, such as actively asking questions, bravely attempting to answer problems despite making mistakes, trying to complete exercises independently, or demonstrating improvement compared to previous sessions. Meanwhile, simple tangible rewards, such as stickers, pencils, erasers, and small snacks, were provided at the end of each learning session to children who demonstrated categories such as the most active participation, the greatest improvement, discipline in attending learning activities, and courage in facing challenging tasks. This mechanism was designed to ensure that rewards were not only received by children with the highest academic achievement but also by those who showed positive progress and learning efforts.

Table 3. Changes in Children's Learning Motivation and Persistence After the Implementation of the Reward System

Learning Motivation Indicators	Initial Condition	Final Condition
Attendance and readiness to participate in learning activities	Several children arrived late and still needed encouragement to participate fully in the learning process	Most children attended on time, with some arriving earlier and preparing their learning materials independently
Enthusiasm in completing exercises	Some participants only completed tasks when instructed and easily lost focus during learning activities	Children became more focused on completing exercises, and several participants requested additional problems as a form of challenge

Courage to face difficult problems	Children were hesitant to attempt unfamiliar problems because they were afraid of making mistakes	Children became more willing to try solving problems even when they were not completely confident in their answers
Response toward appreciation	Children felt happy when receiving praise, but their learning motivation still depended on guidance from researchers	Children began to show learning initiative and a desire to achieve better outcomes

Source: Researchers' observation results (2025).

Based on Table 3, the implementation of the *reward system* contributed to changes in children's learning behavior, particularly in terms of discipline, enthusiasm, and willingness to engage in challenging learning activities. The improvement was evident from children's increased punctuality and preparation before learning sessions. Several children also showed greater persistence in completing numeracy exercises and no longer depended entirely on instructions from researchers. Instead, they demonstrated greater initiative by asking for additional problems and attempting more challenging tasks. These findings indicate that a well-designed reward system can foster learning engagement and persistence because children perceive their efforts and progress as being recognized and appreciated during the learning process.

From the perspective of educational psychology, these behavioral changes can be explained through Skinner's (1958) theory of behaviorism, particularly the concept of *positive reinforcement*. According to this theory, behaviors followed by positive consequences tend to be repeated in similar situations. In this context, praise for courage, appreciation of effort despite incorrect answers, and simple tangible rewards acted as positive reinforcements that encouraged children to maintain positive learning behaviors. Research Aulia and Jamilah (2024) demonstrated that the application of positive reinforcement in educational settings could improve students' participation and engagement because they felt that their efforts and achievements were acknowledged by their learning environment.

However, the effectiveness of the reward system in this study cannot be understood solely as an increase in extrinsic motivation resulting from praise or tangible rewards. Observations revealed that after several learning sessions, children gradually developed internal learning motivation, such as feeling proud when solving more difficult problems and voluntarily asking for additional exercises without expecting rewards. This transition indicates a shift from extrinsic motivation toward intrinsic motivation. This finding aligns with the Self-Determination Theory proposed by Deci and Ryan (2012), which explains that sustainable motivation develops when individuals experience a sense of competence, autonomy, and meaningful connections within their learning environment.

Furthermore, these findings suggest that the effectiveness of a reward system does not depend on the value or quantity of the rewards provided but rather on how the appreciation emphasizes children's efforts, progress, and learning processes. Research López-Ardao et al. (2026) explained that effort-oriented rewards are more effective in promoting long-term motivation than rewards solely focused on final performance. Therefore, appreciation for children's bravery in trying, persistence in solving problems, and continuous improvement became more meaningful than merely rewarding those who obtained the highest scores. Such an approach also created a more inclusive learning environment where every child had equal opportunities to receive recognition according to their individual development.

Despite its positive contributions, the implementation of a reward system should be conducted carefully to avoid creating excessive dependence on external rewards. Frequent or inappropriate use of rewards may shift children's orientation toward obtaining prizes rather than enjoying the learning process itself. Research Malek et al. (2020) showed that rewards that are not accompanied by meaningful learning experiences may hinder the development of intrinsic motivation. Therefore, the use of rewards in numeracy learning should gradually shift from external appreciation toward the development of internal satisfaction when children successfully understand concepts and overcome learning challenges.

Overall, the reward system implemented in this study contributed to improving children's motivation, discipline, persistence, and courage in engaging with numeracy activities. Its effectiveness was not merely caused by the provision of gifts or praise but by the creation of a supportive learning environment that recognized each child's effort and developmental progress. Therefore, a proportionally implemented reward system can serve as an effective complementary strategy in numeracy learning by bridging the transition from extrinsic motivation to more sustainable intrinsic motivation.

Conclusion

This study demonstrates that the implementation of an interactive numeracy learning program through gradual practice activities and a well-designed reward system contributed to improvements in children’s numeracy skills, learning engagement, self-confidence, and learning persistence. The findings reveal that the improvement was not only reflected in children’s ability to obtain correct answers but also in their shift from procedural strategies toward deeper conceptual understanding of mathematical operations. The effectiveness of the program was achieved through active interaction, structured exercises adjusted to children’s developmental levels, and an effort-oriented reward system that appreciated children’s participation, courage, and individual progress. Therefore, meaningful numeracy learning requires not only

repeated practice but also a supportive learning environment that accommodates children's cognitive and motivational needs.

This study contributes to the development of numeracy learning strategies by demonstrating that the integration of interactive learning, gradual practice, and proportional reward systems can create a more engaging and child-centered learning experience. However, this study was limited by its short implementation period of eight learning sessions and the broad age range of participants, which may influence variations in learning outcomes. Future research is recommended to conduct longer interventions, involve more homogeneous age groups, and utilize more comprehensive assessment methods to examine the long-term effectiveness of these strategies in improving children's numeracy development.

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