Int. J. Educ. Found. 03 (04) 2026. 824-830 DOI: 10.33687/ijef.003.04.00179

Available Online at EScience Press
International Journal of Education Foundations
ISSN: 3078-7866 (Online), 3078-7858 (Print)
https://ijef.esciencepress.net

RESEARCH ARTICLE

Improvised Learning Materials and Numeracy Skill Development Among Pre-Primary Pupils in Ubungo Municipality, Dar es Salaam, Tanzania

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Article History
Received: August 19, 2026 ; Accepted: September 13, 2026 ; Published: September 24, 2026.

ABSTRACT

This article examined how improvised learning materials help pre-primary pupils develop numeracy skills in selected pre-primary schools in Ubungo Municipality, Dar es Salaam, Tanzania. It was developed from the second objective of a broader mixed-methods study, which specifically examined how improvised learning materials help pupils learn numeracy skills. Guided by Piaget's Cognitive Development Theory and Vygotsky's Socio-Cultural Theory, the study employed an explanatory sequential mixed-methods design. Quantitative data were obtained from 28 pre-primary teachers and 58 pupils, while qualitative evidence was collected through semi-structured interviews, focus group discussions, classroom observations, and pupil assessment activities. Descriptive statistics were used to summarize teachers' responses and pupils' learning experiences, while qualitative evidence was thematically analysed and integrated with the quantitative results. The findings show strong teacher agreement that improvised learning materials support numeracy learning: 92.9% agreed or strongly agreed that the materials help pupils understand counting concepts, 92.9% reported greater pupil engagement, 92.9% associated the materials with counting forward and backward, 85.7% with one-to-one correspondence, 78.6% with sorting and grouping, and 71.4% with comparing quantities. In addition, 86.2% of pupils reported enjoying numeracy learning when improvised materials were used. Interview and focus-group evidence indicated that concrete materials allow children to touch, manipulate, compare, and organize objects, making abstract number concepts more understandable. Classroom observations similarly showed greater confidence during object-based counting activities. The findings support constructivist explanations of early numeracy learning while showing that the effectiveness of improvised materials depends on purposeful teacher guidance. The article concludes that improvised learning materials can meaningfully support foundational numeracy when intentionally linked to learning objectives and used through active, guided learning.

Keywords: Improvised learning materials; Numeracy skills; Pre-primary Education; Concrete materials; Constructivism; Tanzania

INTRODUCTION

Foundational numeracy is an important component of early childhood education because young children need opportunities to develop number recognition, counting, quantity, classification, comparison, pattern recognition, and simple operations. At the pre-primary level, these skills are strengthened when children connect mathematical ideas with concrete experiences in their immediate environment. Learning materials therefore serve not simply as classroom resources but as

mediating tools through which children can see, touch, organize, compare, and manipulate quantities.

Improvised learning materials are particularly relevant in resource-constrained settings because they can be made from objects that are Improvised available and familiar to children, including bottle tops, stones, sticks, seeds, recycled containers, paper, and clay. However, an object becomes an instructional material when a teacher intentionally selects and uses it to achieve a learning objective. Availability alone cannot guarantee learning; the educational value depends on the pedagogical purpose, activity, and teacher guidance.

Piaget's Cognitive Development Theory provides an important explanation for the use of concrete materials with young children. Piaget (1952) argued that children develop knowledge through active interaction with their environment. Vygotsky's Socio-Cultural Theory adds that learning is mediated by tools and social interaction, with teachers and peers helping children connect concrete experiences to new concepts (Vygotsky, 1978). Thus, bottle tops, stones, and seeds can become mediating tools when teachers use them to help children count, compare, sort, group, and recognize numbers.

International and African research has documented the contribution of concrete and culturally relevant materials to early mathematics learning. Studies have reported benefits from natural materials, counting tools, stones, sticks, seeds, bottle tops, traditional games, and recycled objects in developing number sense, counting, classification, spatial awareness, and learner participation (Bruce, 2021; Clements & Sarama, 2014; Habimana, 2020; Li & Zhang, 2020; Ng'asike, 2019). These studies suggest that Improvised available resources can function as legitimate pedagogical tools rather than merely substitutes for commercial materials.

In Tanzania, activity-based learning is encouraged in pre-primary education, yet schools continue to experience shortages of conventional instructional materials, overcrowded classrooms, limited time, and inadequate teacher preparation (Kitta & Tilya, 2019; Mligo, 2020). Teachers therefore rely on Improvised available resources. The important issue is not merely whether such resources are present but how they contribute to children's actual development of numeracy skills.

Ubungo Municipality provides a useful context for examining this issue because the broader study found that pre-primary teachers use a range of Improvised available materials under varying resource conditions. The present article focuses exclusively on the second objective of that study: to examine how improvised learning materials help pre-primary pupils learn numeracy skills in selected schools in Ubungo Municipality. The article therefore does not discuss the other objectives except where necessary to explain the second objective.

LITERATURE REVIEW AND THEORETICAL PERSPECTIVE

Early numeracy develops through children's interaction with quantities, objects, symbols, and mathematical language. Clements and Sarama (2014) emphasize that children progress through mathematical learning trajectories and need experiences connecting informal knowledge with formal mathematical concepts. Concrete materials can make number relationships visible and manipulable, allowing children to construct meanings rather than memorize symbols in isolation.

Piaget's theory is especially relevant because young children benefit from concrete experiences when developing numerical concepts (Piaget, 1952). In a numeracy lesson, bottle tops can represent quantities that children count and compare, while sticks or seeds can be organized into groups. Vygotsky (1978) adds that the educational value of a material is strengthened through social mediation. A bottle top does not teach counting independently; learning occurs when the teacher guides children to match, count, compare, explain, and reorganize objects.

Research from different contexts supports this position. Bruce (2021) reported that natural materials integrated into play-based mathematics supported counting fluency and spatial awareness. Li and Zhang (2020) found value in physical counting tools in kindergarten mathematics, while NCERT (2019) documented activity-based use of stones, sticks, seeds, and handmade number charts. In Africa, Ng'asike (2019), Kyeyune (2017), and Habimana (2020) similarly reported benefits associated with Improvised available and culturally relevant materials.

Tanzanian studies also indicate that environmental resources can support early numeracy. Kitta and Tilya (2019) reported the value of stones, sticks, and improvised abacuses in developing number sense and problem-solving, while Tandika (2020) found that bottle tops, stones, sticks, maize grains, and newspapers are commonly used in Tanzanian pre-primary settings. Nevertheless, Kitta and Tilya (2021) and Mligo (2020) highlight challenges in implementing learner-centred approaches, including limited teacher preparation, overcrowding, and restricted instructional time.

Recent evidence cautions that hands-on activity alone is insufficient. Purpura et al. (2022) found that combining hands-on activities with explicit teacher guidance produces stronger learning outcomes than hands-on activity without adequate instructional mediation. This is important for the present study because the findings show that materials can facilitate learning, but their effect depends on purposeful integration and teacher support.

Overall, the literature supports the proposition that improvised materials can facilitate early numeracy by making mathematical concepts concrete, increasing participation, and connecting learning with children's everyday experiences. At the same time, the literature

indicates that material availability must be combined with intentional teacher mediation and alignment with specific learning objectives. These principles guide the interpretation of the findings.

METHODOLOGY

This article draws exclusively on the second objective of a broader mixed-methods study conducted in selected pre-primary schools in Ubungo Municipality, Dar es Salaam, Tanzania. The broader study employed an explanatory sequential mixed-methods design, beginning with quantitative data collection and followed by qualitative inquiry to explain the quantitative patterns. For this article, quantitative information was obtained from 28 pre-primary teachers and 58 pre-primary pupils, while qualitative evidence was drawn from semi-structured interviews with head teachers, focus group discussions with teachers, classroom observations, and pupil assessment activities. Teachers participated because of their direct experience teaching numeracy, while pupils participated in activities concerning their experiences and responses to numeracy learning with improvised materials. The quantitative instrument included items concerning whether improvised materials support counting, engagement, number recognition, and understanding of quantity, while pupil responses captured enjoyment of numeracy learning. Qualitative instruments explored how teachers use materials, how pupils respond to them, and which numeracy skills are supported. Classroom observations were conducted in six pre-primary classrooms across three schools. Quantitative data were analysed using descriptive statistics, particularly frequencies and percentages, while qualitative data were analysed thematically and integrated with the quantitative findings. The qualitative evidence was used to explain the numerical patterns rather than to establish causal effects. Ethical procedures included institutional approval, permission from relevant authorities and schools, informed consent from adult participants, appropriate consent and assent procedures for children, confidentiality, voluntary participation, and the right to withdraw.

FINDINGS AND DISCUSSION

The findings address the second objective, which examined how improvised learning materials help pre-primary pupils learn numeracy skills. One consolidated quantitative table is presented first. The major numeracy outcomes are then presented, interpreted, analysed, and discussed separately, with interview, focus-group, observation, and pupil evidence integrated into each discussion.

Table 1. Quantitative evidence on how improvised learning materials support numeracy learning

Numeracy learning indicator	Frequency	Percentage	Evidence
Teachers agreeing materials help counting concepts	26/28	92.9%	Teacher questionnaire
Teachers reporting greater pupil engagement	26/28	92.9%	Teacher questionnaire
Teachers agreeing materials help number recognition	26/28	92.9%	Teacher questionnaire
Teachers agreeing materials improve understanding of quantity	26/28	92.9%	Teacher questionnaire
Counting forward and backward	26/28	92.9%	Teacher responses
One-to-one correspondence	24/28	85.7%	Teacher responses
Sorting and grouping	22/28	78.6%	Teacher responses
Comparing quantities	20/28	71.4%	Teacher responses
Basic concrete addition	15/28	53.6%	Teacher responses
Pattern recognition	12/28	42.9%	Teacher responses
Pupils enjoying numeracy with materials	50/58	86.2%	Pupil responses

Counting and Number Concepts

Counting was one of the strongest numeracy outcomes reported in the study. Twenty-six of the 28 teachers (92.9%) agreed or strongly agreed that improvised learning materials helped pupils understand counting concepts. The same proportion reported that the materials supported counting forward and backward. This finding suggests that improvised materials were particularly useful in helping pupils connect number words with actual quantities. Rather than learning numbers only as abstract symbols, pupils were able to interact with physical objects while counting.

The interview evidence helps explain why this finding was strongly reported. One teacher explained:

> *When I use bottle tops for counting, children understand better as compared to when I write numbers on the board. Children can touch the objects, can manipulate them and observe that five bottle tops are more than three.* (Teacher 3, Interview, July 2026).

The interview implies that bottle tops provide pupils with an opportunity to see and manipulate quantities physically. The researcher interprets this as an important explanation for the high quantitative response because counting becomes an activity involving objects, movement, observation, and comparison rather than memorization alone. This interpretation is consistent with Piaget's emphasis on concrete experience and manipulation in children's cognitive development (Piaget, 1952). It also reflects Vygotsky's view that learning can be mediated through tools and guided interaction (Vygotsky, 1978). The finding further agrees with research showing that concrete manipulatives can support early number sense and mathematical reasoning (Clements & Sarama, 2014; Li & Zhang, 2020) and with Tanzanian evidence concerning environmental resources and early numeracy (Kitta & Tilya, 2019). Teachers should continue using Improvised available objects such as bottle tops and seeds when teaching counting and should combine manipulation with guided questions so that pupils understand both the number and the quantity represented.

One-to-One Correspondence and Comparing Quantities

One-to-one correspondence was identified by 24 teachers (85.7%), while 20 teachers (71.4%) reported that improvised materials supported pupils in comparing quantities. These findings indicate that the materials supported pupils beyond simple number recitation by helping them establish relationships between numbers and objects and distinguish between larger and smaller quantities.

A teacher participating in the focus-group discussion explained:

> *Improvised learning materials are helpful when teaching children one-to-one correspondence. If a child places a bottle top on every number card, he or she realizes that each number stands for one item. This is difficult to teach without concrete materials. I also use stones to teach more or less. Children can see that a pile of five stones is bigger than a pile of three stones.* (Teacher FGD, July 2026).

The interview evidence implies that improvised materials make mathematical relationships visible and physically demonstrable. The researcher argues that the relatively high percentages for one-to-one correspondence and comparison of quantities can therefore be understood in terms of pupils' ability to match, separate, count, and compare real objects. The finding supports constructivist learning because pupils actively construct mathematical meaning through manipulation. It also agrees with Salandanan et al. (2021), who reported benefits of improvised materials for counting and grouping, and Akinoso (2022), who found advantages of materials such as maize seeds and matchsticks in sorting and matching activities. Teachers should use materials that allow pupils to physically match, separate and compare objects, particularly when introducing one-to-one correspondence and concepts such as more, fewer and equal.

Sorting, Grouping and Classification

Sorting and grouping were reported by 22 teachers (78.6%). This finding indicates that improvised materials were also useful for helping pupils identify similarities and differences and organize objects according to characteristics such as colour, type or size. These activities are important because they introduce children to classification and logical thinking that later support mathematical reasoning.

The qualitative evidence provides a clear explanation of this finding. One teacher reported:

> *For sorting and grouping, I use different colored bottle tops or different types of seeds. Children can group red bottle tops together, blue ones together, or group maize seeds separately from bean seeds. This builds the foundation for classification skills*.(Teacher FGD, July 2026).

The interview implies that the educational value of the materials comes from the characteristics that pupils can observe and manipulate. From the researcher's perspective, bottle tops and seeds function as meaningful mathematical tools because pupils can reorganize them according to observable attributes. Thus, their value is not simply that they are inexpensive materials, but that they provide concrete opportunities for classification. This supports Vygotsky's view of materials as mediating tools and agrees with evidence from India and Africa concerning the use of Improvised available objects to support classification and mathematical participation (NCERT, 2019; Ng'asike, 2019). Teachers should deliberately select materials with visible differences in colour, size, shape or type and provide sorting activities that require pupils to explain why objects belong in particular groups.

Number Recognition and Understanding of Quantity

Twenty-six teachers (92.9%) agreed or strongly agreed that improvised materials helped pupils recognize numbers, and the same proportion agreed that the materials improved understanding of quantity. Number recognition was also identified as a specific numeracy skill by teachers. These findings suggest that concrete materials helped pupils establish a connection between numerical symbols and the quantities represented by those symbols.

The interview evidence on counting and one-to-one correspondence provides an explanation for this relationship.

> *The teacher who used bottle tops reported that pupils could physically connect numbers with objects and observe differences between quantities* (Teacher 3, Interview, July 2026).

This evidence implies that pupils were not learning number symbols in isolation; instead, the symbols were being connected to quantities that pupils could see and manipulate. The researcher therefore interprets the high quantitative response as evidence of the importance of moving from concrete objects towards abstract numerical representations during early numeracy instruction.

This finding corresponds with Piaget's emphasis on concrete experience and with research showing that manipulatives can support mathematical reasoning when appropriately integrated (Clements & Sarama, 2014; NCTM, 2019). However, physical objects alone are not sufficient. Purpura et al. (2022) indicate that hands-on activities become more meaningful when combined with explicit teacher guidance. Therefore, the observed benefit should be understood as the result of the interaction between the material, pupil activity and teacher mediation. Teachers should connect concrete objects with number cards and symbols, gradually helping pupils move from manipulating objects to recognizing and using abstract numbers.

Pupil Engagement and Enjoyment

Pupil engagement was another strongly reported outcome. Twenty-six teachers (92.9%) reported greater pupil engagement when improvised materials were used, while 50 of 58 pupils (86.2%) reported enjoying numeracy learning through the materials. During pupil assessment activities, children were also reported to demonstrate greater confidence in counting when they were allowed to manipulate objects rather than relying only on worksheets.

A teacher explained:

> *Children get very excited when I use improvised learning materials. They want to touch everything. It becomes difficult sometimes to control the class but I see that they are learning. The pupils who are not able to understand abstract numbers find it easier to understand with the help of physical objects.* (Teacher 7, Interview, July 2026).

The interview implies that improvised materials influence both participation and accessibility. Pupils become interested in touching and manipulating the objects, while children who struggle with abstract numbers receive an additional concrete route to understanding. However, the interview also reveals a classroom-management challenge because high levels of enthusiasm can make classroom control more demanding. The researcher therefore interprets engagement as a potential pathway through which materials support learning, rather than treating enjoyment itself as proof of achievement.

This interpretation is consistent with Fernández-Santín and Feliu-Torruella (2022), who emphasize active methodologies and learner motivation, and Bruce (2021), who highlights the value of natural materials in play-based mathematics. Nevertheless, enjoyment should not automatically be equated with achievement. Purpura et al. (2022) emphasize that teacher guidance remains important in converting hands-on activity into meaningful learning.

Basic Concrete Addition

Basic concrete addition was reported by 15 of the 28 teachers (53.6%). Although this was lower than the percentages reported for counting, engagement, number recognition and quantity, more than half of the teachers still indicated that improvised materials supported pupils in learning basic addition. The finding suggests that concrete materials were beginning to support pupils in combining quantities, although this skill appeared less frequently than foundational counting and matching skills.

The qualitative evidence concerning bottle tops and stones provides a useful explanation for this finding. Teachers reported using these objects to represent and compare quantities, enabling children to physically manipulate groups of objects. The same principle can support basic addition because pupils can combine one group with another and determine the resulting quantity. The researcher interprets the lower percentage as an indication that addition may require a higher level of mathematical understanding than counting and recognition and therefore may demand more deliberate teacher guidance.

This interpretation is also consistent with the broader finding that concrete materials are most useful when teachers connect manipulation with explicit explanation and questioning. The evidence therefore suggests that improvised materials can provide a foundation for concrete addition, but their use needs to be closely

aligned with the mathematical objective. Teachers should introduce addition gradually by allowing pupils to physically combine small groups of objects before moving to numerical symbols and written calculations.

Pattern Recognition

Pattern recognition was reported by 12 teachers (42.9%), making it the least frequently reported numeracy outcome in the table. Although the proportion was lower than for the other indicators, the finding still shows that some teachers used improvised materials to support pupils' recognition of repeated arrangements and relationships.

The qualitative evidence available in the study emphasizes the use of materials such as coloured bottle tops and different types of seeds for sorting and grouping. Although the interview evidence does not contain a separate quotation specifically about pattern recognition, the sorting and grouping evidence provides a related explanation. When pupils arrange objects according to observable characteristics, they begin to attend to similarities, differences and sequences. The researcher therefore interprets the relatively low percentage cautiously: pattern recognition may require teachers to design more specific activities rather than assuming that any use of improvised materials will automatically develop the skill. This finding is important because the study shows that materials alone do not determine the learning outcome. Their effectiveness depends on the mathematical task, teacher explanation and the way pupils are guided to observe relationships. Thus, the lower percentage for pattern recognition may point to an area requiring more deliberate classroom practice rather than indicating that improvised materials cannot support the skill.

Integrated Interpretation of the Findings

Taken together, the quantitative and qualitative findings indicate that improvised learning materials supported numeracy learning through several interconnected mechanisms. The strongest reported outcomes were counting concepts, counting forward and backward, pupil engagement, number recognition and understanding of quantity, all of which were reported by 26 of the 28 teachers (92.9%). One-to-one correspondence was reported by 24 teachers (85.7%), sorting and grouping by 22 teachers (78.6%), and comparison of quantities by 20 teachers (71.4%). Basic concrete addition was reported by 15 teachers (53.6%), while pattern recognition was reported by 12 teachers (42.9%). In addition, 50 of 58 pupils (86.2%) reported enjoying numeracy learning when materials were used. The qualitative evidence helps explain these numerical patterns. Teachers described bottle tops, stones and seeds as objects that pupils could touch, count, match, separate, group and compare. The researcher interprets this convergence between the quantitative and qualitative evidence as suggesting that the principal contribution of improvised materials was to make abstract mathematical ideas more visible and manipulable. The evidence also indicates that the strongest benefits occurred in foundational skills that can be directly represented with physical objects, whereas more advanced skills such as addition and pattern recognition appeared less frequently.

Classroom observations further provide an important qualification. Materials were sometimes present but not used, or were used without a clear connection to the stated learning objective. This means that materials are not inherently instructional. Their educational value depends on purposeful selection, teacher explanation, questioning, guided manipulation and alignment with a specific numeracy outcome.

CONCLUSION

The overall evidence therefore supports a cautious conclusion that improvised learning materials can facilitate foundational numeracy learning in the observed context. The findings do not establish a causal effect because the study did not use an experimental comparison. Rather, the convergence of questionnaire responses, pupil evidence, interviews, focus-group discussions and observations indicates that purposeful use of concrete Improvised materials can make early numeracy more understandable, participatory and engaging. The study recommended that, The Ministry of Education, Science and Technology should establish systematic in-service training on the selection, preparation and pedagogical use of Improvised material in pre-primary numeracy, with practical session on managing large classes.

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