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USING MANIPULATIVE TEACHING AIDS IN PRIMARY MATHEMATICS: A QUALITATIVE STUDY IN A GRADE 2 CLASSROOM

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Abstract

This study examines how manipulative teaching aids were used in Grade 2 mathematics learning at SDN Sidotopo Wetan I Surabaya and how pupils responded to their use. The study was motivated by the difficulty young learners often experience when abstract mathematical ideas are introduced mainly through verbal explanation, textbook exercises, and symbolic procedures. Using a qualitative descriptive design, data were collected through classroom observation, semi-structured interviews with the classroom teacher and pupils, and documentation of lesson materials, pupil work, and classroom activities. The analysis focused on the ways fraction boards, multiplication pouches, and TERKA boards supported pupils' movement from concrete activity to mathematical representation. The findings suggest that the teaching aids made mathematical ideas more visible and discussable, encouraged participation and peer interaction, and gave the teacher a concrete basis for questioning and guided explanation. However, the value of the aids depended strongly on teacher mediation, especially in modelling, prompting, managing group work, and connecting hands-on activity to mathematical language and symbols. Implementation was constrained by limited availability of teaching aids, uneven teacher confidence in media integration, inadequate classroom facilities, and classroom-management demands. The study concludes that simple, locally available teaching aids can support meaningful lower-primary mathematics learning when they are deliberately selected, carefully facilitated, and connected to clear conceptual goals. The study does not claim measurable achievement gains, but offers a contextual account of how manipulative-based instruction can be strengthened in resource-limited primary classrooms.

Keywords: manipulative teaching aids; mathematics learning; primary school; student engagement; TERKA board

INTRODUCTION

Mathematics in the early years of schooling is not only a matter of remembering procedures. Young pupils need to build meanings for number, quantity, shape, relation, and operation before these ideas are expressed through formal notation. This process becomes difficult when teaching moves too quickly from explanation to written exercises without sufficient concrete or visual support. Concepts such as fractions, multiplication, place value, and measurement are not always visible in pupils' everyday experience, and lower-primary pupils often need opportunities to see, touch, arrange, compare, and talk about mathematical relationships before they can represent them symbolically. Recent studies show that spatial, visual, and embodied experiences are closely related to mathematics learning, especially when pupils are guided to connect physical activity with formal mathematical representation (Hawes et al., 2022; Wilkie & Hopkins, 2024). The affective dimension is also important. When mathematics feels inaccessible, pupils may withdraw from participation; when it feels meaningful and manageable, they are more willing to explain their thinking and take intellectual risks (Quane, 2025).

Manipulative teaching aids are frequently used to make mathematical ideas more accessible in primary classrooms. However, contemporary research gives a cautious view of their value. Manipulatives do not improve learning simply because they are concrete. They become educationally meaningful when pupils are helped to connect action, image, language, and symbol. Research on concreteness fading argues that learners often need guided movement from concrete objects to pictorial or iconic forms and then to symbolic notation (Fyfe & Nathan, 2019). Donovan and Alibali (2021) also warn that pupils may treat manipulatives as toys unless teachers frame them explicitly as mathematical tools. This caution is important because many classrooms use of teaching aids remain decorative or episodic. If pupils only handle objects without being asked to notice patterns, justify answers, or translate their activity into mathematical language, the aids may increase activity without deepening understanding.

The teacher's role is therefore central. Manipulative-based learning requires teachers to select appropriate materials, pose questions, manage exploration, invite pupils to verbalise what they see, and guide them towards more formal representations. Indonesian studies also point to this issue. Problem-based learning assisted by manipulative media has been reported to strengthen conceptual understanding when hands-on media are embedded in structured mathematical tasks (Dewanti et al., 2024). Research on Realistic Mathematics Education similarly shows the importance of connecting mathematical ideas to familiar and meaningful situations (Fauzan et al., 2024; Listiawati et al., 2023). Studies on physical and virtual manipulatives further suggest that media effectiveness depends on task design, teacher modelling, feedback, and repeated opportunities to connect representations (Ahmad & Siller, 2024; Park & Bouck, 2022; Shin et al., 2023). In other words, the key issue is not whether a teacher uses an aid, but how the aid is positioned within the lesson.

In many Indonesian primary schools, these issues are practical rather than merely theoretical. Teachers are expected to promote numeracy, active learning, and differentiated instruction, yet they often work with limited resources, large classes, uneven pupil readiness, and classroom facilities that do not always support media-rich learning. For schools with limited digital equipment, locally available teaching aids may offer a feasible route to more meaningful mathematics instruction. A fraction board, multiplication pouch, or recycled counting board can create opportunities for pupils to explore mathematical ideas, but its value still depends on planning and facilitation. The present study addresses this issue through a qualitative descriptive study of manipulative teaching aids in a Grade 2 mathematics classroom at SDN Sidotopo Wetan I Surabaya. It asks: (1) how are manipulative teaching aids used in Grade 2 mathematics learning? (2) how do pupils respond to their use?

and (3) what constraints shape their implementation? By focusing on everyday classroom practice, the study aims to offer a grounded account of how simple teaching aids can support more accessible lower-primary mathematics learning without overstating their effects as measured achievement gains.

LITERATURE REVIEW

Manipulatives, representation, and early mathematics

Manipulative teaching aids occupy an important place in primary mathematics because they provide visible and touchable forms for ideas that are otherwise abstract. Physical objects such as fraction boards, counters, pouches, and number boards can help pupils compare quantities, identify part-whole relationships, model repeated addition, and test emerging ideas. Byrne et al. (2023), in a scoping review of educational interventions involving physical manipulatives, show that such tools are widely used in pre-primary and primary education, especially in mathematics. Yet their presence alone is insufficient. Manipulatives need to be embedded in meaningful tasks so that pupils understand what the object represents and how it relates to the target concept.

Several theoretical and empirical studies clarify this point. Fyfe and Nathan (2019) explain that concrete experiences become stronger instructional resources when they are gradually connected to abstract representations. Prosser and Bismarck (2023) similarly emphasise the concrete-representational-abstract approach, in which pupils move from objects to images and then to symbols. Research on physical and virtual manipulatives also suggests that different representational forms may support learning when they are aligned with the concept and with pupils' readiness (Ahmad & Siller, 2024; Masitoh & Prasetyawan, 2025). For pupils who need additional support, manipulative-based instruction may provide structure and access, but it still requires explicit modelling and repeated practice (Antara et al., 2024; Bone et al., 2023; Peltier et al., 2020; Shurr et al., 2021).

Teacher mediation and classroom feasibility

The literature also shows that manipulative-based mathematics learning is mediated by teacher judgement. Teachers need to decide which aid is appropriate, what mathematical relationship it represents, how pupils should interact with it, and when the lesson should move from concrete handling to explanation or notation. Donovan and Alibali (2021) show that children's views of manipulatives can affect their learning; if children perceive objects mainly as toys, the mathematical purpose may be weakened. Shin et al. (2023) and Park and Bouck (2022) also show that modelling, feedback, and teacher-delivered guidance are important when manipulatives are used to support learners with different needs.

In the Indonesian context, the use of manipulatives is connected to numeracy development, meaningful learning, and resource feasibility. Listiawati et al. (2023) show that Realistic Mathematics Education can support pupils, including slow learners, when mathematical ideas are connected to familiar situations. Fauzan et al. (2024) similarly found that RME supported elementary pupils' literacy and numeracy through everyday problem solving. Dewanti et al. (2024) reported that problem-based learning assisted by manipulative media strengthened elementary pupils' conceptual understanding in area and volume. Media-based studies also point to the importance of representation; Firdaus et al. (2024), for example, found that an interactive e-module supported fourth-grade pupils' understanding of equivalent fractions. Although some of these studies use digital tools, their shared implication is that pupils need representations that make mathematical relationships visible enough to discuss. The present study builds on this literature by examining how simple physical aids are used, how pupils respond, and what constraints appear in one lower-primary classroom.

METHOD

This study used a qualitative descriptive design to examine how manipulative teaching aids were used in Grade 2 mathematics learning, how pupils responded to their use, and what constraints shaped their classroom implementation. A qualitative descriptive design was considered appropriate because the study aimed to provide a direct, practice-oriented account of classroom events and participants' experiences rather than to measure the statistical effect of an intervention (Bradshaw et al., 2017). The study was conducted at SDN Sidotopo Wetan I Surabaya, Indonesia, in a Grade 2 mathematics classroom where the teacher had begun using simple manipulative aids to support pupils' understanding of early mathematical concepts. The classroom was selected because it represented a common lower-primary learning context in which mathematics instruction had previously relied mainly on teacher explanation, textbook exercises, and limited visual support.

The participants were one Grade 2 classroom teacher and 28 Grade 2 pupils who were directly involved in mathematics lessons using manipulative teaching aids. The classroom teacher was included because she planned and facilitated the mathematics lessons, while the pupils were included because they experienced the learning activities and responded to the use of the aids. Four pupils were selected for brief follow-up interviews and were coded as S1, S2, S3, and S4 in the reporting of findings. The pupils were selected to represent varied classroom responses, including pupils who were active during the activities and pupils who needed more support. The study focused on three locally available teaching aids: fraction boards, multiplication pouches, and TERKA boards. The TERKA board was a locally made counting board used to support basic addition and subtraction activities. It consisted of a simple board with movable number or object markers that pupils could arrange, count, remove, and compare. In this study, the TERKA board was used to help pupils see addition and subtraction as concrete actions before representing them in written number sentences. These aids were selected because they represented different areas of lower-primary mathematics learning, namely part-whole relationships, repeated grouping, and basic number operations.

Data were collected through classroom observation, semi-structured interviews, and documentation. The classroom observation focused on how the teacher introduced the teaching aids, how pupils handled and discussed the materials, how peer interaction occurred, and how the lesson moved from hands-on activity to mathematical explanation and written representation. The teacher interview explored lesson planning, reasons for using manipulative aids, perceived benefits, classroom management issues, and implementation constraints. Brief pupil interviews explored pupils' learning experiences, perceived ease or difficulty, peer interaction, and their understanding of the mathematical ideas represented by the aids. The interviews were conducted in Indonesian. The pupil quotations were translated from Indonesian into English and lightly edited for clarity without changing the meaning of the pupils' responses. Because the participants were young learners, the excerpts are presented briefly to preserve the substance of their responses while avoiding unnecessary linguistic elaboration. Documentation included lesson materials, worksheets, examples of pupil work, classroom photographs, and field notes. These documents were used to support and cross-check the observation and interview data.

Table 1. Data Sources and Analytical Focus

Data source	**Participants/materials**	**Analytical focus**	**Use in interpretation**
Classroom observation	Grade 2 mathematics lessons using fraction boards, multiplication pouches, and TERKA boards	Teacher modelling, pupil handling of aids, peer interaction, movement	Used to identify how manipulative aids were introduced, used, and

		from concrete activity to mathematical symbols, and classroom management	connected to mathematical meaning
Teacher interview	One Grade 2 classroom teacher	Planning decisions, perceived usefulness, facilitation strategies, and implementation constraints	Used to understand the teacher's pedagogical reasoning and challenges
Pupil interviews	Four Grade 2 pupils coded as S1–S4	Pupils' learning experiences, perceived understanding, participation, and difficulties	Used to include pupils' perspectives on the learning process
Documentation	Lesson materials, worksheets, pupil work, photographs, and field notes	Evidence of learning activities and links between manipulative use and written mathematical work	Used to support the interpretation of classroom processes and pupil responses

Data were analysed thematically. The researchers first read the observation notes, interview transcripts or summaries, and documentation records repeatedly to become familiar with the data. Meaningful segments related to the research questions were then coded. Initial codes included, for example, hands-on comparison, repeated grouping, teacher prompting, pupil explanation, peer assistance, transition to symbols, limited materials, noisy group work, and facility constraints. These initial codes were compared across observation, interview, and documentation data, then grouped into broader themes. The final themes were: (1) the use of manipulative teaching aids in moving pupils from concrete activity to mathematical meaning; (2) pupil participation, peer interaction, and emerging conceptual explanation; and (3) teacher facilitation and classroom constraints. Thematic analysis was used because it allows researchers to identify patterned meanings across qualitative data while remaining close to participants' words and observed classroom events (Braun & Clarke, 2021; Kiger & Varpio, 2020).

Trustworthiness was strengthened through triangulation, member checking, and an audit trail. Triangulation was conducted by comparing evidence from classroom observation, teacher interview, pupil interviews, and documentation. Member checking was carried out with the classroom teacher to confirm that the researchers' interpretations of the observed lessons and interview meanings were reasonable. An audit trail was maintained through field notes, interview summaries, documentation records, coding notes, and theme development. These procedures were used to support credibility, dependability, and transparency in the qualitative analysis (Nowell et al., 2017). Ethical attention was given by seeking permission from the school and the classroom teacher, explaining the purpose of the study, and protecting pupils' identities through the use of codes. Because the study involved young pupils, interview questions were kept brief, non-threatening, and focused only on their classroom learning experiences. The study did not aim to produce statistical generalisation or claim measurable achievement gains; instead, it sought to provide a contextual account of how simple manipulative teaching aids were used and experienced in one lower-primary mathematics classroom

FINDINGS AND DISCUSSION

The use of manipulative teaching aids in moving pupils from concrete activity to mathematical meaning

The findings show that manipulative teaching aids changed the character of Grade 2 mathematics learning in the observed classroom. Before the use of fraction boards, multiplication pouches, and TERKA boards, mathematics instruction was largely organised through teacher explanation, examples on the board, textbook exercises, and individual written tasks. This pattern allowed the teacher to deliver content efficiently, but it gave pupils limited opportunities to observe mathematical relationships directly, test ideas through action, or explain their reasoning before moving to written symbols. In a lower-primary classroom, this limitation is important because pupils are still developing the ability to connect concrete experience with formal mathematical notation. The introduction of manipulative teaching aids therefore created a more accessible learning pathway: pupils could see, touch, arrange, compare, group, and discuss mathematical ideas before representing them symbolically.

The teacher described this shift clearly during the interview:

> When I just explain from the textbook or write examples on the board, many children can copy the answer. But honestly, I do not know if they really understand it. They can write the right number, yet when I ask what it means, some of them struggle to explain it. That is why I like using the board or the pouch. The moment they can see it and touch it, things start to click. I let them play with it first, then I ask questions. Their explanations are not always correct, but at least I can see they are trying to make sense of the number instead of just copying what I wrote. *(Teacher interview)*

This statement suggests that the teaching aids functioned not merely as classroom media, but as mediating tools between action and mathematical meaning. The teacher's concern was not simply whether pupils could produce correct answers, but whether they could understand the relationships represented by those answers. This finding is consistent with research showing that young pupils benefit when mathematical ideas are connected to spatial, visual, and embodied experiences (Hawes et al., 2022; Wilkie & Hopkins, 2024). In this study, the aids helped pupils approach mathematics as something that could be explored and explained, rather than only memorised or copied.

The fraction board was used to introduce part-whole relationships and simple comparison of fractions. Through movable pieces, pupils could observe how parts related to a whole and how different pieces could represent different fractional sizes. This was important because fractions are often difficult for young learners when introduced only through notation. In the observed lesson, the teacher first demonstrated how the fraction pieces represented parts of a whole, then invited pupils to compare pieces and explain which part was larger or smaller. This helped pupils recognise that a fraction was not simply a pair of numbers separated by a line, but a relationship between a whole and its parts. This process reflects the principle of concreteness fading, in which learners need guided movement from concrete experience to more abstract representation (Fyfe & Nathan, 2019). It also supports Wilkie and Hopkins's (2024) argument that concrete-to-symbolic representation can strengthen pupils' relational thinking when teachers help learners connect physical models to symbolic ideas.

A pupil's response illustrates how the board supported this movement:

> Before, the numbers confused me. When I used the pieces, I could see which part was bigger. It was easier because I could move them first. *(Student interview, S1)*

The quotation indicates that the fraction board helped the pupil make sense of comparison through visual and tactile experience. The pupil did not only state an answer, but began to explain why the answer made sense. This is a valuable form of early conceptual development. However, the finding should be interpreted cautiously. The study does not prove that the fraction board improved achievement in a measurable sense; rather, it shows that the board made the concept more visible and discussable during classroom interaction.

The multiplication pouch served a different instructional purpose. It helped pupils experience multiplication as repeated grouping before moving towards formal multiplication sentences. Instead of presenting multiplication as a table to memorise, the teacher asked pupils to place objects into pouches, count groups, and then connect the repeated groups to symbolic expressions. This approach helped pupils see multiplication as structure. The teacher explained that this was useful because several pupils could recite multiplication facts but still struggled to explain what multiplication meant.

> Some pupils can say that two times three is six because they remember it. But when I ask why it is six, many of them get stuck. That is what worries me. I do not want them to only remember the answer. With the pouch, I ask them to make two groups of three first. Once they see the groups with their own eyes, the idea starts to make sense. After that, "two times three is six" is not just something to memorise. They can actually see where the answer comes from. *(Teacher interview)*

This finding is consistent with Byrne et al. (2023), who note that physical manipulatives remain relevant in primary mathematics when embedded in meaningful activity. The value of the multiplication pouch did not lie in the object itself, but in how it supported grouping, counting, verbal explanation, and symbolic representation. The TERKA board showed a similar function in addition and subtraction activities. Made from accessible materials, it demonstrated that useful teaching aids do not always need to be expensive or technologically advanced. In a classroom with limited facilities, locally made aids offered a practical route to more active mathematics learning. This supports the argument that the usefulness of a manipulative depends less on its sophistication and more on the clarity of the mathematical relationship it helps pupils see.

The teaching process generally moved through three stages: demonstration, exploration, and reflection. In the demonstration stage, the teacher introduced the aid and modelled how it should be used. In the exploration stage, pupils handled the aid individually or in small groups. In the reflection stage, the teacher asked pupils to explain what they had done and guided them towards mathematical notation. This sequence was important because it prevented the use of manipulatives from stopping at play. Donovan and Alibali (2021) warn that children may treat manipulatives as toys unless teachers frame them as mathematical tools. The present finding supports this warning. The aids became productive when the teacher repeatedly returned pupils' attention to the mathematical idea represented by the object. Table 2 summarises the main classroom evidence from the observation, interviews, and documentation.

Table 2. Summary of themes, classroom evidence, and interpretation

Theme	Classroom evidence	Interview evidence	Interpretation
Concrete representation of abstract ideas	Pupils used fraction boards to compare parts of a whole and multiplication pouches to form repeated groups.	Teacher stated that pupils understood better after touching and moving the aids.	Manipulatives helped pupils access mathematical relationships before writing symbols.
Movement from action to explanation	Pupils were asked to explain what they had arranged before completing worksheets.	Pupils reported that the pieces and pouches helped them explain answers.	The aids supported early conceptual explanation, not merely task completion.
Increased participation and peer interaction	Pupils worked in groups, took turns, checked answers, and discussed arrangements.	Pupils said they enjoyed trying the aids with friends.	Manipulatives created more opportunities for active and social learning.
Teacher mediation	Teacher modelled the use of the aids, asked questions, and guided reflection.	Teacher stressed the need to remind pupils that the aids were for learning, not playing.	The aids were useful only when guided by clear pedagogical direction.
Implementation constraints	Limited number of aids, classroom noise, unequal turn-taking, and limited facilities were observed.	Teacher and pupils mentioned limited materials and classroom management difficulties.	Practical constraints affected the consistency and depth of manipulative-based learning.

Student responses: participation, peer interaction, and emerging conceptual explanation

Pupils responded positively to the use of manipulative teaching aids. Their responses appeared in greater willingness to participate, more visible attention during learning, stronger peer interaction, and more attempts to explain mathematical ideas in their own words. During conventional explanation, some pupils tended to remain quiet, wait for the teacher's answer, or copy examples from the board. When the aids were introduced, more pupils became involved because the tasks required action. They had something to hold, move, compare, arrange, and show to others. This changed participation from merely listening to doing, discussing, and explaining.

One pupil explained:

> I like using the board because I can try first. If I only write in the book, I do not always know why the answer is right. *(Student interview, S2)*

This response indicates that the manipulative provided a bridge between activity and understanding. The pupil's comment also reveals a weakness of textbook-centred learning: written exercises may produce answers, but they do not always make reasoning visible. With manipulative aids, pupils had a chance to test ideas before recording them. Ahmad and Siller (2024) found that concrete and virtual manipulatives can support mathematics achievement across different achievement groups, suggesting that manipulatives may provide multiple entry points for learners with varied readiness. The present qualitative finding provides a classroom-level explanation for that possibility: pupils who were not ready to respond through symbols could still participate through handling, arranging, and explaining objects.

Peer interaction also became more active. During group activities, pupils discussed how to arrange the fraction pieces, how to place objects in the multiplication pouch, and how to check answers on the TERKA board. These interactions were sometimes noisy, but they also showed that pupils were not learning only from teacher explanation. They were testing ideas with classmates, correcting one another, and negotiating answers. One student described this experience as follows:

> At first I put the piece in the wrong place. My friend showed me, then I tried again. After that I could do it by myself. *(Student interview, S3)*

This quotation shows that manipulative-based learning created space for peer-supported understanding. Pupils who were unsure could observe classmates' strategies, while pupils who understood earlier could explain their reasoning. This finding is relevant to Dewanti et al. (2024), who found that problem-based learning assisted by manipulative media supported elementary students' conceptual understanding when pupils actively worked through tasks. Although the tasks in this study were simpler, they still opened opportunities for shared reasoning. Pupils were not only completing exercises; they were comparing, correcting, and explaining.

This finding also resonates with Fauzan et al. (2024), whose work on Realistic Mathematics Education emphasises the importance of connecting mathematical ideas to meaningful classroom activity and learner experience. In this study, the activities were meaningful not because they replicated everyday life perfectly, but because they allowed pupils to construct mathematical ideas through visible relationships. The fraction board made part-whole relationships visible, the multiplication pouch made repeated grouping visible, and the TERKA board made addition and subtraction actions visible. These tools helped pupils approach mathematics through experience before abstraction.

The documentation of pupils' work supported the observation data. Worksheets completed after manipulative-based activities showed attempts to represent thinking through drawings, grouping marks, and short written explanations. This does not by itself prove deep understanding, but it indicates that some pupils were beginning to connect hands-on activity with written mathematical work. Firdaus et al. (2024), in their study of equivalent fractions using interactive e-modules, also show that representation is important in helping primary pupils grasp mathematical relationships. Although their study focused on digital media, the principle is relevant here: pupils need representations that make relationships visible enough to discuss and record.

A small but important observation also showed that manipulative-based learning did not run perfectly from the beginning. During one group activity using the multiplication pouch, several pupils became more interested in touching and moving the objects than in explaining the mathematical idea. Two pupils competed for turns, while another pupil waited passively and did not immediately take part in the discussion. The teacher had to stop the activity briefly, redistribute turns, and remind pupils that each group member needed to explain the grouping before writing the multiplication sentence. The field note recorded this moment as follows:

> During the group activity with the multiplication pouch, pupils became excited as soon as the materials were distributed. Several pupils immediately touched and moved the objects before the teacher had finished repeating the instructions. Two pupils competed for turns, while one pupil waited without taking part in the counting activity. The teacher paused the group work, redistributed turns, and asked each pupil to explain what the groups represented before they continued with the worksheet. After this redirection, the group became more focused and the pupils were better able to connect the objects with the multiplication sentence. *(Classroom observation field note)*

This episode is important because it shows that pupil enthusiasm did not automatically produce mathematical understanding. The teaching aid created opportunities for participation, but the activity still required clear rules, turn-taking, teacher prompts, and reflection. Without this guidance, the manipulative could easily become an object of play rather than a mathematical representation. This finding strengthens the argument that the value of manipulatives depends not only on their availability, but also on the teacher's ability to manage classroom interaction and redirect pupils from handling objects towards explaining mathematical relationships.

Teacher facilitation and classroom constraints

A central finding of this study is that the teacher's role shaped the quality of manipulative-based learning. The teaching aids were helpful, but they did not work independently. Their use depended on how the teacher selected the aid, introduced it, connected it to the lesson objective, organised group work, and returned pupils' attention to the mathematical concept. This finding challenges the assumption that the main problem in media-based learning is simply the lack of materials. Materials matter, but teacher mediation matters just as much.

The teacher acknowledged that manipulative-based learning required more preparation and stronger classroom management than conventional explanation:

> The children are much more excited when I use the media, and I like seeing that. At the same time, it makes the class harder to manage. They want to touch everything as soon as they get it. Sometimes they get so interested in the objects that they forget what we are supposed to be learning. Because of that, I have to set clear rules, give them turns, and keep reminding them that the media is there to help them learn, not just to play with. *(Teacher interview)*

This statement highlights a common tension in active learning. A quiet classroom may appear orderly, but it does not always indicate meaningful thinking. At the same time, active learning without structure can become distraction. The teacher therefore had to manage the balance between freedom and direction. Group size, turn-taking, time allocation, and whole-class reflection became important parts of the lesson design. In this sense, classroom management was not separate from manipulative use; it was part of the pedagogy.

The first constraint was limited availability of teaching aids. The school did not have enough ready-made mathematics manipulatives, so the teacher relied on simple or self-made materials. This was both a limitation and a strength. It limited consistency because not all topics had suitable aids and not every pupil could handle the materials for the same amount of time. However, it also showed that useful mathematics media can be made from local and low-cost materials. The TERKA board was an example of this practical creativity. A pupil mentioned the limitation directly:

> I wanted to try again, but I had to give the tool to my friend. If there were more tools, I could practise longer. *(Student interview, S4)*

This comment shows that access to materials affected the quality of participation. Group work encouraged peer interaction, but insufficient materials could also create unequal hands-on experience. Pupils who handled the materials longer had more opportunities to test ideas, while others sometimes became observers. For manipulative-based learning to work well, pupils need enough time and access to interact directly with the aids.

The second constraint concerned teacher confidence in selecting and integrating manipulatives. The teacher was able to use the fraction board, multiplication pouch, and TERKA board, but still faced uncertainty about which aid best suited each concept, how long pupils should explore, and how to move them from concrete activity to symbolic reasoning. This is a serious pedagogical issue because manipulative use requires pedagogical content knowledge. Teachers need to understand not only how to use the object, but also how the mathematical concept develops, where pupils are likely to misunderstand, and which representation can help them move forward. Shin et al. (2023) argue that manipulative-based instruction, including virtual manipulative use, requires explicit modelling and teacher guidance. Bassette and Bouck (2023) similarly stress that maintenance of learning requires repeated opportunities to connect manipulative use with independent mathematical reasoning. The present study supports these arguments in a physical classroom context.

The third constraint was the condition of classroom facilities. The damaged projector limited the teacher's ability to combine concrete aids with digital or visual representations. Although this study supports the value of physical manipulatives, it does not suggest that digital tools are unnecessary. A balanced use of physical and digital representations may enrich learning when both are available and purposeful. Shurr et al. (2021) found that virtual manipulatives could support mathematics learning for elementary pupils with autism, while Masitoh and Prasetyawan (2025) reported positive effects of virtual manipulatives on mathematics achievement. These findings are relevant because they show that representation can take different forms. For the observed classroom, physical aids were practical because digital resources were limited. However, when digital facilities are available, teachers may benefit from combining concrete, visual, and symbolic representations.

The fourth constraint was classroom management. Manipulative-based activities made pupils more active, but also created noise, movement, and moments of distraction. This condition should not be interpreted simply as a failure. In lower-primary classrooms, active mathematical learning often involves talk, movement, and negotiation. However, activity needs structure. The teacher needed to establish rules for handling materials, organise roles within groups, monitor turn-taking, and create reflection routines. Without these routines, pupils could remain at the level of play. With guidance, however, activity could become a route towards explanation.

There is also an inclusive dimension to the findings. Manipulative aids appeared to give pupils with different readiness levels a more accessible way to join the lesson. Pupils who were less confident with written mathematics could begin by handling objects, while more confident pupils could move more quickly towards explanation. This does not mean the same aid met all needs equally, but it offered a shared object around which different pupils could participate. Antara et al. (2024) show that mathematics manipulatives can function as assistive tools for pupils with disabilities, while Peltier et al. (2020) report positive evidence for manipulative use among students at risk or identified with disabilities. Although the present study was not conducted in a special education setting, the finding is still relevant because ordinary primary classrooms also contain pupils with varied confidence, attention, prior knowledge, and speed of understanding.

Overall, the findings indicate that manipulative teaching aids supported more accessible and participatory mathematics learning in the observed Grade 2 classroom. Their contribution was not that they automatically improved achievement, but that they made mathematical relationships more visible, encouraged pupils to take part in classroom activity, and gave the teacher concrete objects for questioning and explanation. This distinction is important for the scientific strength of the study. The qualitative evidence supports claims about classroom process, pupil response, and instructional meaning-making, but it does not support causal claims about measurable learning gains. Nurjanah et al. (2021) remind us that hands-on and computer-based learning activities can produce different conceptual experiences depending on how they are structured. The present study reinforces this point: manipulatives are valuable when they are deliberately selected, actively used by pupils, connected to mathematical language, and followed by guided movement towards symbolic work.

CONCLUSION

This study concludes that manipulative teaching aids can support more accessible primary mathematics learning when they are used purposefully within classroom instruction. In the Grade 2 classroom observed, fraction boards, multiplication pouches, and TERKA boards helped make mathematical relationships more visible and discussable. Pupils were more willing to participate, interact with peers, and attempt explanations when they could first work with concrete materials before moving towards mathematical symbols. However, the study also shows that manipulatives do not work automatically. Their value depended on the teacher's ability to model their use, ask guiding questions, manage group work, and connect hands-on activity to mathematical language and notation.

The findings should be interpreted within the limits of a qualitative classroom-based study. The study does not provide statistical evidence that manipulative teaching aids improved achievement, nor does it claim generalisability beyond the observed classroom. Its contribution lies in showing how simple, locally available aids can be integrated into lower-primary mathematics learning and what practical constraints shape their use. Future research should examine manipulative-based instruction across more classrooms, include clearer documentation of pupil work over time, and combine qualitative observation with direct assessment of conceptual understanding. For practice, schools should support teachers not only by providing teaching aids, but also by giving time, training, and collaborative opportunities to design tasks that move pupils from concrete exploration to mathematical reasoning.

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