

## Development and Validation of Manipulatives in Teaching Mathematics 6

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### ABSTRACT

*This study focused on the development and validation of manipulatives as strategic intervention materials for teaching Mathematics 6 at Manapa I Elementary School. Grounded in the Constructivist Learning Theory, the research aimed to enhance learners' conceptual understanding by addressing their least-learned competencies through interactive learning tools. A descriptive-developmental research design was employed, involving the identification of learning gaps, creation of manipulatives, expert validation, and classroom implementation. The study identified key mathematical challenges among Grade 6 learners, particularly in differentiating expressions from equations. Manipulatives were designed to bridge these gaps by providing concrete representations of abstract concepts, fostering critical thinking and problem-solving skills. Experts evaluated the manipulatives based on content, format, presentation, organization, accuracy, and durability, confirming their suitability for instructional use. Findings revealed a significant improvement in learners' mathematical performance, with post-test scores demonstrating increased mastery levels compared to pretest assessments. The study highlights the effectiveness of manipulatives in promoting engagement, reinforcing conceptual understanding, and supporting struggling learners in mathematics. It contributes to the growing discourse on manipulative-based learning strategies, emphasizing the importance of integrating interactive materials into mathematics education to enhance student learning outcomes.*

### KEYWORDS

*Manipulatives; least-learned competencies; student performance; strategic intervention materials; descriptive developmental; Philippines*

### INTRODUCTION

The OECD average in mathematics dropped by 15 points, marking a concerning decline in learners' performance (OECD, 2023). However, high-performing nations such as Singapore, Japan, and Chinese Taipei maintained strong results, demonstrating resilience in their educational systems (OECD, 2023). In contrast, the Philippines continues to experience learning gaps, particularly among disadvantaged learners, who are seven times more likely to perform at lower levels compared to their advantaged peers (OECD, 2023). These findings reinforce the need for targeted interventions, such as manipulative-based learning strategies, to bridge conceptual gaps and improve learners' engagement in mathematics education.

Mathematics, often perceived as an intimidating subject, is pivotal for fostering critical thinking, problem-solving, and logical reasoning abilities. The use of manipulatives can bridge the gap between abstract mathematical concepts and tangible experiences, thereby augmenting learners' understanding and engagement. While research on the use of manipulatives in mathematics education has proliferated in recent years, there remains a paucity of studies that specifically investigate their effectiveness for struggling learners. Existing literature primarily focuses on the general benefits of manipulatives for enhancing mathematical understanding and engagement, with limited attention to their targeted use for addressing learning difficulties (Bartolini & Martignone, 2020).

The Department of Education (DepEd) has issued various policies and guidelines that support the use of innovative teaching approaches, including Strategic Intervention Materials (SIMs). DepEd Memorandum Order No. 8, s. 2015, "Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program," encourages teachers to utilize a variety of assessment tools and strategies that cater to diverse learning styles and needs. The integration of manipulatives in Mathematics 6 instruction resonates with this policy, as it provides an alternative avenue for learners to demonstrate their understanding and skills.

The latest Programme for International Student Assessment (PISA) 2022 results indicate that the Philippines continues to lag behind in mathematics, reading, and science, scoring well below the Organization for Economic Cooperation and Development (OECD) average. In mathematics, only 16% of Filipino learners attained at least Level 2 proficiency, compared to 69% of learners in OECD countries, meaning that a significant portion of Filipino learners' struggle with fundamental mathematical skills (OECD, 2023). Despite a slight improvement among low-achieving learners, the overall performance remained largely unchanged from the 2018 PISA results, highlighting persistent challenges in foundational learning (OECD, 2023).

Despite the DepEd's encouragement of innovative teaching approaches, the use of manipulatives in Mathematics 6 remains limited due to several factors such as lack of teacher training on the effective use of manipulatives the scarcity of readily available and affordable manipulatives, and the prevailing perception that manipulatives are merely "playthings" rather than valuable learning tools. This gap in practice requires research that investigates the feasibility and impact of integrating manipulatives in the Philippine context, considering the unique challenges and opportunities present in the local educational landscape.

The compelling need to enhance mathematical proficiency among Filipino learners, coupled with the existing gaps in research and practice, provides a strong justification for conducting this study. By investigating the effectiveness of manipulatives in teaching Mathematics 6, this research aimed to contribute to the development of evidence-based instructional practices that can empower teachers to address learning difficulties and create a more inclusive and engaging mathematics classroom.

At Manapa I Elementary School, a significant number of Grade 6 learners struggle to grasp fundamental mathematical concepts, as evidenced by their low performance in standardized tests and classroom assessments. Traditional teaching methods, which heavily relied on rote memorization and abstract explanations, proved ineffective in addressing these learning difficulties (Pokhrel & Poudel, 2024). Traditional activities such as repetitive drills of multiplication tables, or abstract explanations, like lengthy lectures on theoretical concepts. These methods may include worksheets focused solely on formula recall or problem-solving that lacks real-world context. Such approaches can hinder meaningful learning by neglecting conceptual understanding and active engagement. This

scenario stressed the urgent need for alternative instructional approaches, such as the use of manipulatives, to cater to the diverse learning needs of learners and provide them with opportunities for meaningful mathematical experiences. This study determined the efficacy of manipulatives in teaching Mathematics 6.

## **LITERATURE REVIEW**

This study was anchored on the Constructivist Learning Theory, primarily attributed to Piaget (1952) and further developed by Vygotsky (1978). Piaget's work in the mid-20th century laid the foundation for understanding how children constructed knowledge through active engagement and interaction with their environment. Vygotsky extended this theory by emphasizing the role of social interaction and cultural context in shaping learning and development.

In the realm of mathematics education, constructivism had profound implications for teaching and learning. It emphasized the importance of providing learners with opportunities to explore, experiment, and make sense of mathematical concepts through hands-on activities and problem-solving tasks. Rather than focusing on rote memorization and abstract procedures, constructivist approaches prioritized conceptual understanding and the development of problem-solving strategies.

Constructivism posited that learners are not passive recipients of knowledge but active participants in their own learning process. They construct meaning by connecting new information to their existing knowledge and experiences. This theory advocates for a learner-centered approach in mathematics education, encouraging learners to discover mathematical relationships and concepts through hands-on activities and problem-solving tasks.

The use of manipulatives aligned seamlessly with the constructivist approach. Manipulatives provide concrete representations of abstract mathematical concepts, allowing learners to manipulate and interact with them, thus facilitating the construction of meaning and understanding. By engaging in hands-on activities with manipulatives, learners bridge the gap between concrete experiences and abstract mathematical ideas, leading to deeper and more meaningful learning.

## **RESEARCH METHODS**

### ***Research Design***

The study employed a descriptive-developmental research design, which was essential in both identifying learning gaps and systematically developing manipulatives tailored to address learners' least-learned competencies. The descriptive aspect of the design allowed for an in-depth analysis of learners' difficulties in Mathematics 6, providing a clear understanding of their conceptual struggles. Through pretest assessments and item analysis, the researcher was able to pinpoint specific areas requiring intervention. Meanwhile, the developmental component facilitated the creation and refinement of manipulatives, ensuring that these instructional tools were designed based on empirical data rather than assumptions. This approach ensured that the developed materials were evidence-based, validated by experts, and effective in enhancing learners' learning outcomes. By integrating both descriptive and developmental processes, the study was able to bridge theoretical understanding with practical application, reinforcing the value of interactive learning tools in mathematics education. The descriptive-developmental research design was chosen because it provided a structured methodology to assess, develop, and refine intervention materials, ensuring their alignment with pedagogical standards and learners' learning needs.

### **Research Locale**

Manapa I Elementary School is one of the public schools in Buenavista, Division of Agusan del Norte. It is situated at Purok 4, Manapa, Buenavista, Agusan del Norte, approximately six kilometers away from the Municipality of Buenavista, and was established in 1940. In the school year 2024–2025, it had 284 enrollees, consisting of 152 males and 132 females, along with one school principal, 11 teachers, and 1 non-teaching personnel.

### **Research Instrument**

The researcher utilized a mathematics achievement test as the primary instrument in this study. The test encompassed mathematical domains in the third quarter. This test was given to the learners and served as a pretest. Afterward, item analysis was conducted to identify the least-learned competencies in Mathematics 6 in the third quarter.

The next instrument is the standard evaluation tool for print resources of the Department of Education. This evaluation tool is designed to assess the quality and effectiveness of print resources, using a structured approach that covers several key factors: content, format, presentation and organization, and accuracy and up-to-dateness. Evaluators rate each criterion within these factors on a scale from 1 (Not Satisfactory) to 4 (Very Satisfactory), providing comments to justify ratings below 4. This process ensures a thorough review of the material's educational value, physical attributes, and correctness, with specific guidelines and descriptors to aid in objective assessment. The tool includes pass/fail criteria for each factor, ensuring that only resources meeting the specified quality standards are recommended for use.

### **Data Gathering Procedure**

The data gathering procedure involved a series of systematic steps to ensure the collection of accurate and reliable data. Initially, the researcher sought approval from the school administration and obtained informed consent from the parents or guardians of the participating Grade 6 learners. Once ethical considerations were addressed, the study commenced with the administration of a pretest to the Grade 6 learners, developing manipulatives, and post-test to measure the effectiveness of the intervention. Initially, a pretest was administered to Grade 6 learners to pinpoint their least-learned competencies in Mathematics 6. Based on the results, manipulatives were designed and developed to specifically address these identified learning gaps. Subsequently, a post-test was conducted to evaluate the impact of the manipulatives on improving learners' performance in those targeted areas.

### **Data Analysis Plan**

#### **Statistical Treatment**

The following statistical tools were used in treating the problems in this study.

**Frequency Counts and Percentage.** It refers to the number of times a particular value, response, or category appears in a data set, while percentage expresses this count as a proportion out of 100, showing how much of the total each category represents.

**Weighted Mean.** This statistical tool was used to identify the scores given by the experts after evaluating the manipulatives.

**Mean Percentage Score.** This was used to identify the least-learned competencies after the implementation of item analysis

Arithmetic Mean. This was used to determine the average performance of learners in both pretest and posttest assessments, providing a central measure of their mathematical proficiency before and after the intervention.

Standard Deviation. This was used to assess the consistency or variability in learners' test scores, indicating whether the manipulatives contributed to more stable and uniform performance improvements among students.

Paired Sample t-Test. This was used to compare the means of the pretest and posttest scores to determine whether there was a statistically significant improvement in students' mathematical performance after utilizing the developed manipulatives.

## RESULTS AND DISCUSSION

**Table 1.** Least Learned Competencies in Mathematics 6 in the Third Quarter

No	Competencies	Mean percentage Scores (MPS)	Remarks
1	Differentiate solid figures from plane figures (M6GE-IIIa-28)	78.23%	Nearly Mastered
2	Identifies the face of a solid figure (M6GE-IIIb-30)	69.75%	Nearly Mastered
3	Visualize and describes the different solid figures (M6GE-IIIa-28)	66.50%	Nearly Mastered
4	Formulate the rule in finding the nth term using different strategies (M6AL-IIIId-7)	62.50%	Nearly Mastered
5	Differentiate expression from equation (M6AL-IIIId-15)	59.33%	Least Mastered

*Legend: 0-39- Not mastered; 40-59-Least Mastered; 60-79-Nearly Mastered; 80-100-Mastered*

### ***Design and Development of the Manipulatives on the Conceptual Understanding of the Least-Learned Lessons***

The developed manipulatives were designed based on the identified least learned competency to effectively address learners' learning gaps. Adhering to the evaluators' criteria, the instructional materials ensured relevance, clarity, and usability in educational settings. In terms of content, the developed manipulatives aligned with learners' cognitive development, fostering higher-order thinking skills such as critical reasoning and creativity. The format incorporated legible print, well-structured illustrations, and an aesthetically coherent layout to enhance comprehension. To ensure durability, high-quality materials were selected for paper and binding, making the developed manipulatives suitable for extensive classroom use. The cardboard was used for the thickness of the manipulative and layered with scotch tape for multiple uses. In this manner manipulative will not easily tear during the development phase.

Presentation and organization played a vital role in the structure of the developed manipulatives, maintaining logical sequencing of ideas, appropriate vocabulary for the Grade 6 learners, and varied sentence structures that sustained engagement. These elements contributed to the clarity and accessibility of the instructional materials, making the developed manipulatives effective learning tools for learners. Furthermore, accuracy and up-to-dateness were prioritized through extensive reviews to eliminate conceptual, factual, and computational errors, ensuring that learners received reliable and relevant information. Practical considerations such as size, weight, and handling were also

addressed, making the developed manipulatives user-friendly, portable, and easy to manipulate during instruction.

The design highlights the value of the developed manipulatives as an instructional resource that enhances Grade 6 learners' comprehension, engagement, and mastery of previously challenging concepts. Addressing the least learned competency with reference to the evaluators' criteria allowed the developed manipulatives to provide meaningful hands-on learning experiences, bridging the gap between abstract theories and practical understanding. Alignment with pedagogical standards of the Department of Education reinforced the role of the developed manipulatives in fostering an interactive, dynamic, and effective learning environment.

The development of manipulatives to address least-learned competency in Mathematics 6 is rooted in constructivist learning principles. Literature extensively supports the notion that tactile and interactive learning experiences enhance conceptual understanding (Deevi & Sk, 2023). Research affirms that manipulatives bridge the gap between abstract reasoning and tangible experiences, particularly for struggling learners (Bungao-Abarquez, 2020). Furthermore, studies highlight the necessity of aligning manipulative-based interventions with curriculum standards to ensure instructional effectiveness (Cenita, 2024).

### ***Experts' Evaluation of the Developed Mathematical Manipulatives***

Table 2 presents an evaluation of the developed manipulatives based on the experts' assessment of its content. Additionally, it is found to significantly contribute to the attainment of identified least-learned competency in Mathematics 6. The assessment highlights the absence of partialities related to ideology, culture, religion, race, gender, and other prejudices.

Moreover, the experts observed that the materials are inclusive—they do not promote or reflect any form of bias or discrimination based on ideology, culture, religion, race, or gender. Because of this fairness and relevance, the content received the highest possible rating of 4.00, which falls under the qualitative description of "Very Satisfactory."

Creating educational materials that are free from biases is essential for building a learning environment where every learner feels respected and valued. The fact that the developed manipulatives received the highest rating in this area shows a strong commitment to inclusivity. It means the materials are designed to support all learners—regardless of their background—without promoting stereotypes or exclusion. When learning tools are inclusive, learners can engage with the content confidently, knowing they are in a safe and welcoming space. This not only supports their academic growth but also helps build mutual respect and understanding among classmates from diverse walks of life. This top rating also signals that the materials meet both educational and ethical standards. Today's classrooms call for fairness, representation, and sensitivity—and this aspect of the manipulatives reflects those values clearly. With a weighted mean of 4.00, this area stands out as a key strength of the material. It sets the bar for other criteria, demonstrating just how thoughtfully these tools were designed—especially when it comes to addressing delicate or potentially divisive topics.

Additionally, the developed manipulatives helps develop desirable values such as national pride, scientific reasoning, and excellence, though it receives a slightly lower weighted mean of 3.40, indicating a satisfactory rating. The developed manipulatives capture interest of the Grade 6 learners as reflected in its 3.80 weighted mean. Safety and health precautions are sufficiently addressed, though the rating of 3.40 suggests room for improvement in explicitly guiding users in potentially hazardous activities. In educational

materials, especially those involving hands-on activities or experiments, clear safety instructions are critical to prevent accidents and ensure learners' well-being. While the current rating indicates that these precautions are present, their effectiveness may not be fully optimized. The "Satisfactory" rating implies that the warnings may lack detail or fail to address all possible risks associated with the activities. For example: Instructions might not specify proper handling techniques for hazardous materials, safety measures could be generalized rather than tailored to specific tasks, visual aids (e.g., diagrams or symbols) or step-by-step safety protocols might be missing. Insufficiently detailed safety notes could leave users uncertain about how to proceed safely, particularly in activities involving sharp tools, chemicals, or physical exertion. This could lead to potential risks for learners or educators.

The perfect score for Indicator 4 underscores experts' confidence in the material's fairness and inclusivity. This plays a vital role in the overall "Very Satisfactory" rating (3.71), confirming that the manipulatives are not only effective but also thoughtfully crafted for use in diverse educational settings.

The findings imply that the Developed Manipulatives are a high-quality educational tool in teaching Mathematics 6, demonstrating strong content validity and alignment with learning goals. Its ability to foster cognitive development and maintain an unbiased perspective ensures its appropriateness. However, the lower ratings in value formation and safety considerations indicate that these aspects had a comparatively lesser influence on learners' intellectual and ethical development. This reflects an area where the manipulatives had a more limited impact. While the overall instructional value remains strong, the data implies that the influence on fostering desirable values and ensuring safety precautions was not as pronounced as other evaluated aspects.

The evaluation of the developed manipulatives in terms of content aligns with educational theories advocating for learner-centered instruction. The constructivist approach emphasizes that learners must actively engage with mathematical concepts rather than passively receive information (Piaget, 1952; Vygotsky, 1978). Research supports the use of manipulatives in promoting higher-order thinking, problem-solving, and conceptual learning (Gunduz et.al., 2022). Additionally, studies highlight that manipulatives must be free from biases, culturally appropriate, and capable of fostering meaningful learning experiences (Garcia et al., 2024). By adhering to these principles, the developed manipulatives effectively align with best practices in mathematics education.

**Table 2.** Experts' Evaluation of the Developed Manipulatives in terms of Content

Indicators	Wtd mean	Descriptive Rating
1. <b>Content is suitable to the student's level of development.</b>	3.80	Very Satisfactory
2. <b>Material contributes to the achievement of specific objectives of the subject area and grade/year level for which it is intended.</b>	3.80	Very Satisfactory
3. <b>Material provides for the development of higher cognitive skills such as critical thinking, creativity, learning by doing inquiry,</b>	3.80	Very Satisfactory
4. <b>Material is free of ideological, cultural, religious, racial, gender biases and prejudices.</b>	4 .00	Very Satisfactory
5. <b>Material enhances the development of desirable value and traits such as:</b>	3.40	Satisfactory
√ 5.1 Pride in being a Filipino	3.40	Satisfactory

5.2 Scientific attitude and reasoning	3.40	Satisfactory
√ 5.3 Desire for excellence	3.40	Satisfactory
√ 5.4 Love for country	3.40	Satisfactory
√ 5.5 Helpfulness/Teamwork/Cooperation	3.40	Satisfactory
√ 5.6 Unity	3.40	Satisfactory
√ 5.7 Desire to learn new things	3.40	Satisfactory
√ 5.8 Honesty and trustworthiness	3.40	Satisfactory
√ 5.9 Ability to know right from wrong	3.40	Satisfactory
√ 5.10 Respect	3.40	Satisfactory
√ 5.11 Critical and creative thinking	3.40	Satisfactory
√ 5.12 Productive work	3.40	Satisfactory
<b>6. Material has the potential to arouse interest of target reader.</b>	<b>3.80</b>	<b>Very Satisfactory</b>
<b>7. Adequate warning/cautionary notes are provided in to and activities where safety and health are of concern.</b>	<b>3.40</b>	<b>Satisfactory</b>
<b>Overall Weighted Mean</b>	<b>3.71</b>	<b>Very Satisfactory</b>

*Legend: 0- Not Applicable; 1.00-1.49-Not Satisfactory; 1.50-2.49-Poor; 2.50-3.49-Satisfactory; 3.50-4.00-Very Satisfactory*

Table 2 reveals the experts' evaluation of the developed manipulatives in terms of Format. The evaluation of the developed manipulatives demonstrates their overall effectiveness in terms of format, as assessed through five key indicators: Print, Illustration, Design and Layout, Paper and Binding, and Size and Weight of Resource. Each of these indicators contributes to the usability and durability of the material, ensuring that it meets academic and practical standards for its intended users.

Print quality plays a crucial role in readability and comprehension, with letter size, spacing, font readability, and printing quality all receiving high ratings. Notably, the readability of the font and the quality of the printed text scored the highest at 4.00, affirming that the material is easy to read and free from defects.

Illustrations serve as a vital supplement to textual content, enhancing engagement and understanding. Simplicity and recognizability achieved the highest rating of 4.00, signifying that the images are clear and easily interpreted. Cultural relevance, while still within a Very Satisfactory range at 3.40, indicates a slight need for refinement to ensure inclusivity and broader applicability across diverse learner populations.

When it comes to learning materials, how something looks and feels can be just as important as what it says. A well-designed resource makes it easier for learners to focus, understand, and stay engaged. In this evaluation, the manipulatives earned an overall Very Satisfactory rating of ( $w=3.78$ ), which shows they are doing a great job in this area. A few small adjustments could take them from very good to excellent—but as they stand, they are already a valuable tool for both teachers and learners.

The format evaluation of the developed manipulatives underscores the importance of visual clarity, readability, and durability. Literature suggests that well-structured learning materials, including appropriate fonts, illustrations, and high-quality printing, contribute to better comprehension and engagement (Irvine, 2020). Additionally, the inclusion of culturally relevant illustrations ensures that learners can relate to the material, reinforcing the importance of context in education (Ramirez & Tabirao, 2023).

The inclusion of culturally relevant illustrations is important because it helps learners create connections between abstract mathematical concepts and their own lived experiences. By seeing familiar images and contexts, learners are more likely to engage

with the material and find it meaningful, which can enhance their understanding and retention. This approach acknowledges the diversity within the classroom and promotes a more inclusive learning environment, where all learners feel represented and valued.

**Table 3.** Experts' Evaluation of the Developed Manipulatives in terms of Format

Indicators	Wtd mean	Descriptive Rating
<i>Print</i>		
1. Size of letters is appropriate to the intended user.	3.80	Very Satisfactory
2. Spaces between letters and words facilitate reading.	3.80	Very Satisfactory
3. Font is easy to read.	4.00	Very Satisfactory
4. Printing is of good quality (i.e., no broken letters, even density, correct alignment, properly placed screen registration).	4.00	Very Satisfactory
<i>Illustration</i>		
1. Simple and easily recognizable.	4.00	Very Satisfactory
2. Clarify and supplement the text.	3.80	Very Satisfactory
3. Properly labelled or captioned (if applicable)	3.80	Very Satisfactory
4. Realistic / appropriate colors.	3.80	Very Satisfactory
5. Attractive and appealing.	3.80	Very Satisfactory
6. Culturally relevant.	3.40	Very Satisfactory
<i>Design and Layout</i>		
1. Attractive and pleasing to look at.	3.80	Very Satisfactory
2. Simple (i.e., does not distract the attention of the reader)	3.80	Very Satisfactory
3. Adequate illustration in relation to text.	3.80	Very Satisfactory
4. Harmonious blending of elements (e.g., illustrations and text).	3.80	Very Satisfactory
<i>Paper and Binding</i>		
1. Paper used contributes to easy reading.	3.60	Very Satisfactory
2. Durable binding to withstand frequent use.	3.60	Very Satisfactory
<i>Size and Weight of Resource</i>		
1. Easy to handle.	3.60	Very Satisfactory
2. Relatively light.	3.80	Very Satisfactory
<b>Overall Weighted Mean</b>	<b>3.78</b>	<b>Very Satisfactory</b>

*Legend: 0- Not Applicable; 1.00-1.49-Not Satisfactory; 1.50-2.49-Poor; 2.50-3.49-Satisfactory; 3.50-4.00-Very Satisfactory*

Table 3 reveals the experts' evaluation of the developed manipulatives in terms of Presentation and Organization. The assessment of the developed manipulatives highlights their effectiveness in terms of presentation and organization, demonstrating their ability to support comprehension and engagement. Among the indicators evaluated, length of sentences is suited to the comprehension level of the target reader received the highest weighted mean of 4.00, corresponding to a Very Satisfactory rating. This indicates that the developed manipulatives are highly effective in presenting sentence structures that are appropriate for the reading and comprehension levels of Grade 6 learners. On the other hand, the items with the lowest weighted mean of 3.60 were presentation is engaging, interesting, and understandable, there is logical and smooth flow of ideas, and vocabulary level is adapted to the target reader's likely experience and level of understanding. While these items still received a Very Satisfactory rating, the slightly lower scores suggest that there may be minor areas for improvement in enhancing the overall engagement, clarity of idea progression, and the appropriateness of vocabulary for the learners' level. Evaluations indicated that while the manipulatives were generally rated "Very Satisfactory," slightly

lower scores in engagement, clarity of idea progression, and vocabulary appropriateness suggest areas for refinement. Improving these aspects could enhance learner motivation, ensure clearer understanding of mathematical concepts, and make the materials more accessible to students of varying levels, ultimately leading to more effective instruction.

With consistently high ratings across key indicators, the materials are well-structured to maintain learner interest and facilitate understanding. The presentation’s clarity and appeal ensure that learners remain engaged, while the

logical flow of ideas enhances the accessibility of information. The appropriateness of vocabulary further supports readability, aligning with the comprehension levels of the target audience. Additionally, sentence length is optimally structured, ensuring that information is conveyed effectively without overwhelming learners, earning the highest rating. The variation in sentence and paragraph structures contributes to the overall readability and engagement of the content. The findings imply that the manipulatives are well-designed instructional tools that align with pedagogical standards, reinforcing their utility in educational settings. Although all indicators received favorable assessments, minor refinements in logical sequencing and vocabulary selection could further enhance their accessibility and effectiveness.

The findings in Table 3 emphasize the significance of structured sequencing, appropriate vocabulary, and varied sentence structures in educational materials. Literature supports the notion that logically organized content facilitates better learning outcomes (Johnson et al., 2021). The constructivist framework stresses that learners must actively interact with instructional materials that are accessible and engaging (Jerome, 1961). Research has shown that vocabulary and language complexity must be carefully tailored to the learners’ comprehension level to maximize accessibility (Mierluș-Mazilu & Yilmaz, 2023). The developed manipulatives adhere to these principles, ensuring structured and engaging content delivery.

**Table 4.** Experts’ Evaluation of the Developed Manipulatives in terms of Presentation and Organization

Indicators	Wtd mean	Descriptive Rating
1. Presentation is engaging, interesting, and understandable. .	3.60	Very Satisfactory
2. There is logical and smooth flow of ideas.	3.60	Very Satisfactory
3. Vocabulary level is adapted to target reader's likely experience and level of understanding.	3.60	Very Satisfactory
4. Length of sentences is suited to the comprehension level of the target reader.	4.00	Very Satisfactory
5. Sentences and paragraph structures are varied and interesting to the target reader.	3.80	Very Satisfactory
<b>Overall Weighted Mean</b>	<b>3.72</b>	<b>Very Satisfactory</b>

*Legend: 0- Not Applicable; 1.00-1.49-Not Satisfactory; 1.50-2.49-Poor; 2.50-3.49-Satisfactory; 3.50-4.00-Very Satisfactory*

Table 4 experts’ evaluation of the developed manipulatives in terms of Accuracy and Up-to-datedness. The evaluation of the developed manipulatives in terms of accuracy and up-to-datedness reflects their reliability and precision as instructional tools. With all indicators—including conceptual errors, factual errors, grammatical errors, computational errors, obsolete information, and typographical or minor errors—receiving a weighted mean of 4.00 and a descriptive rating of "Not present," the findings confirm that the

material is free from inaccuracies and out-dated content. This suggests that the developed manipulatives are well-reviewed and carefully curated to maintain their integrity, ensuring that learners receive correct and relevant information without the risk of

misinformation. The absence of errors enhances their credibility and usability in educational settings, reinforcing their role as a dependable resource for effective learning experiences.

To ensure the accuracy and up-to-datedness of developed manipulatives, the research emphasizes a process of rigorous review and careful curation. This involves multiple rounds of expert evaluation to identify and eliminate various errors, including conceptual, factual, grammatical, and computational inaccuracies. Furthermore, it necessitates verifying the information's currency and aligning the content with curriculum standards to prevent the inclusion of obsolete data or conceptual misunderstandings. By adhering to these practices, the manipulatives can serve as dependable resources that foster effective learning and mitigate the risk of misinformation.

The assessment of the manipulatives' accuracy highlights their reliability as instructional tools. Educational research underscores the importance of eliminating conceptual, factual, and computational errors to maintain content integrity (Iqbal et al., 2020). Studies affirm that validated learning materials significantly reduce misconceptions and enhance problem-solving skills (Justo et al., 2022). Ensuring up-to-date information is also critical for maintaining relevance in instruction, supporting the manipulatives' role in fostering precise and current mathematical knowledge (Roberts et al., 2020).

**Table 5.** Experts' Evaluation of the Developed Manipulatives in terms of Accuracy and Up datedness

Indicators	Wtd mean	Descriptive Rating
1. Conceptual errors	4.00	Not present
2. Factual errors	4.00	Not present
3. Grammatical errors	4.00	Not present
4. Computational errors	4.00	Not present
5. Obsolete information	4.00	Not present
6. Typographical and other minor errors (e.g., inappropriate or unclear illustrations, missing labels, wrong captions, etc)	4.00	Not present
<b>Overall Weighted Mean</b>	<b>4.00</b>	<b>Not present</b>

*Legend: 0- Not Applicable; 1.00-1.49-Poor; do not evaluate further; 1.50-2.49-Present and requires major revision; 2.50-3.49-Present but very minor and must be fixed; 3.50-4.00- Not present*

Table 5 presents the experts' evaluation of the developed manipulatives in terms of Durability. The evaluation, based on four key indicators, consistently points towards a high level of robustness and quality. Firstly, the experts agreed that the materials used are sturdy and appropriate for frequent handling, evidenced by a weighted mean of 3.8, which falls squarely within the "Very Satisfactory" range. This suggests that the foundational elements of the manipulatives are well-chosen to withstand regular use.

Secondly, this positive assessment is reinforced by the finding that the manipulatives can withstand wear and tear from repeated use, also scoring a weighted mean of 3.8 and a "Very Satisfactory" rating. This indicates that the construction and materials are likely resilient to the stresses of classroom activities. Furthermore, the experts believe that the manipulatives will maintain their form, color, and usability over time, achieving a weighted mean of 3.6, again categorized as "Very Satisfactory." This speaks to the longevity and sustained functionality of the learning tools.

Finally, the highest rating was given to the secureness of the components, with experts noting that components are securely attached or fastened to prevent damage, resulting in a perfect weighted mean of 4.0 and a "Very Satisfactory" rating. This is a critical aspect of durability, as loose or easily detached parts can significantly shorten the lifespan of manipulatives. Overall, the data in Table 5 strongly suggests that the developed manipulatives are well-designed and constructed to be durable and withstand the demands of regular educational use.

The durability of educational manipulatives plays a significant role in ensuring their effectiveness in classroom settings. Research emphasizes that well-constructed manipulatives enhance learner engagement and comprehension, particularly when they are resistant to wear and tear from regular use (Bartolini & Martignone, 2020). The findings presented in Table 5 align with this claim, as experts rated the manipulatives "Very Satisfactory" in terms of robustness, highlighting their ability to withstand frequent handling and classroom activities.

Additionally, manipulatives should be structurally sound and securely attached to prevent damage, ensuring prolonged usability (Byrne et al., 2023). The experts' evaluation confirmed this aspect, assigning a perfect weighted mean of 4.0 to the secureness of components. This suggests that the manipulatives were carefully designed to maintain their form, color, and usability over time, reinforcing their role as long-term instructional tools (Gunduz et al., 2022).

Moreover, research supports the notion that high-quality materials contribute to the sustained functionality of learning aids, allowing learners to repeatedly engage with them without degradation in quality (Irvine, 2020). The developed manipulatives met this criterion, earning strong ratings across all durability indicators. The integration of these findings underscores the importance of durability in manipulatives, ensuring that they remain effective educational resources for mathematics instruction (Roberts et al., 2020).

**Table 6.** Experts' Evaluation of the Developed Manipulatives in terms of Durability

Indicators	Wtd mean	Descriptive Rating
1. Materials used are sturdy and appropriate for frequent handling.	3.8	Very Satisfactory
2. Manipulatives withstand wear and tear from repeated use.	3.8	Very Satisfactory
3. Manipulatives maintain their form, color, and usability over time	3.6	Very Satisfactory
4. Components are securely attached or fastened to prevent damage	4.0	Very Satisfactory
<b>Overall Weighted Mean</b>	<b>3.8</b>	<b>Very Satisfactory</b>

*Legend: 0- Not Applicable; 1.00-1.49-Not Satisfactory; 1.50-2.49-Poor; 2.50-3.49-Satisfactory; 3.50-4.00-Very Satisfactory*

Table 6 presents the experts' evaluation of the developed manipulatives in terms of Durability. The evaluation, based on four key indicators, consistently points towards a high level of robustness and quality. Firstly, the experts agreed that the materials used are sturdy and appropriate for frequent handling, evidenced by a weighted mean of 3.8, which falls squarely within the "Very Satisfactory" range.

This positive assessment is reinforced by the finding that the manipulatives can withstand wear and tear from repeated use, also scoring a weighted mean of 3.8 and a "Very Satisfactory" rating. This indicates that the construction and materials are likely resilient to the stresses of classroom activities. Furthermore, the experts believe that the manipulatives will maintain their form, color, and usability over time, achieving a weighted mean of 3.6, again categorized as "Very Satisfactory." This speaks to the longevity and sustained functionality of the learning tools.

The highest rating was given to the secureness of the components, with experts noting that components are securely attached or fastened to prevent damage, resulting in a perfect weighted mean of 4.0 and a "Very Satisfactory" rating. This is a critical aspect of durability, as loose or easily detached parts can significantly shorten the lifespan of manipulatives. Overall, the data in Table 6 strongly suggests that the developed manipulatives are well-designed and constructed to be durable and withstand the demands of regular educational use.

### **Level of Performance of the Learners Before and After Utilization of the Developed Manipulatives**

Table 7 outlines the level of performance of learners both before and after the introduction of manipulatives in their learning process.

**Table 7.** Level of Performance of the Learners before and after utilization of the Manipulatives

Score Ranges	Before Utilization of Manipulatives		After Utilization of Manipulatives		Descriptive Level
	f	%	f	%	
17-20	3	10.7	23	82.1	High Mastery
12-16	14	50.0	5	17.9	Moderately High Mastery
8-11	10	35.7	0	0	Average Mastery
4-7	1	3.6	0	0	Low Mastery
0-3	0	0	0	0	No Mastery
<b>Total</b>	<b>28</b>	<b>100</b>			

Examining the "Before" utilization data, it has been observed a distribution where the largest group of learners, comprising 50.0% (n= 14), fell within the score range of 12-16, categorized as "Moderately High Mastery." Following this, 35.7% of the learners (n=10) achieved scores between 8-11, indicating "Average Mastery." A smaller portion, 10.7% (n= 3), demonstrated "High Mastery" with scores ranging from 17-20, while a minimal 3.6% (frequency of 1) scored between 4-7, classified as "Low Mastery." Notably, no learners fell into the "No Mastery" category before the use of manipulatives

The "After" utilization data, however, reveals a substantial shift in performance levels. A significant majority of the learners, 82.1% (n=23), now achieved scores within the 17-20 range, demonstrating "High Mastery." An additional 17.9% (n=5) scored between 12-16, obtaining a "Moderately High Mastery" level. Strikingly, after the integration of manipulatives, no learners were recorded below the moderately high mastery level. This stark contrast between the "Before" and "After" data strongly suggests a positive impact of the manipulatives on learner performance, indicating a clear progression towards higher levels of mastery. The data underscore a notable improvement in comprehension and knowledge acquisition following the use of these hands-on learning tools.

The increase in learners' performance observed in Table 3 supports the research findings on the effectiveness of manipulatives in improving mathematical comprehension (Ahmad & Siller, 2024). Studies have demonstrated that hands-on learning contributes to higher engagement and retention rates, particularly in complex topics such as algebra and geometry (Tessema et al., 2024). Additionally, constructivist theories affirm that learners develop deeper connections with mathematical concepts when actively engaging with manipulatives rather than relying solely on abstract instruction (Simon, 2022).

### **Significant Difference in the Level of Performance of the Learners Before and After Utilization of the Developed Manipulatives?**

**Table 8.** Paired t-test on the Level of Performance before and after utilization of the mathematical manipulatives

Test	Mean	Std. Deviation	Mean Difference	t-value	p-value	Decision on H <sub>0</sub>	Interpretation
Posttest	17.68	1.49	4.89	6.806**	.000	Reject H <sub>0</sub>	Significant
Pretest	12.79	3.36					

\*\*significant @  $p < .01$

Table 8 shows the result of the paired t-test on the pretest and posttest performances of the learners. The data show that the learners obtained higher mean score in the posttest ( $m=17.68$ ) than in the pretest ( $m=12.79$ ). The scores of the learners in the posttest are less diverged from the mean ( $SD=1.49$ ) which indicates that there are now a majority of the scores above the mean with only a few that are below the mean. On the other hand, the scores in the pretest are more diverse ( $SD=3.36$ ) because the majority of these scores are far from the mean compared to the majority of the posttest scores.

There is a significant difference between the levels of performance of the learners before and after the utilization of the manipulatives ( $t=6.806$ ;  $p=.000$ ) which led to the rejection of the null hypothesis. This is an indication that the utilization of the manipulatives was effective in improving the performances of the learners, thereby helping the majority of them to attain the desired mastery level.

#### **Proposed Enhancement of the Manipulatives**

The expert evaluation of the developed manipulatives indicates that they are highly effective educational tools, particularly in supporting mathematical comprehension and engagement among Grade 6 learners. However, certain aspects, such as value formation and safety considerations, received comparatively lower ratings, suggesting areas where enhancements could be made to strengthen their overall impact.

One area of improvement involves the reinforcement of value formation. While the manipulatives contribute to fostering desirable values such as pride in being Filipino, scientific reasoning, and teamwork, their lower ratings in this aspect indicate that their integration of character-building elements could be further refined. Strengthening activities within the manipulatives that explicitly connect mathematical concepts to real-life applications, ethical reasoning, and collaborative learning could enhance their role in value formation.

Additionally, safety and health considerations could be more prominently addressed within instructional guidelines and activities. Although adequate warning and cautionary notes were provided, their lower rating suggests that clearer instructions and explicit safety precautions in hands-on exercises may be necessary. Ensuring that manipulatives include structured guidelines for safe usage—particularly in interactive and experimental learning scenarios—could further minimize risks while enhancing their effectiveness.

In terms of format, while the overall design received strong ratings, cultural relevance within illustrations was identified as an area that may benefit from refinement. Ensuring greater inclusivity by incorporating diverse representations in visual materials can improve engagement among learners from varying backgrounds. Furthermore, the paper quality and binding durability could be reinforced to ensure the manipulatives withstand frequent handling and prolonged usage in classroom settings.

The findings imply that while the manipulatives effectively support mathematical learning, optimizing aspects related to value formation, safety precautions, cultural inclusivity, and durability could further enhance their instructional impact. Strengthening these elements would ensure that the manipulatives not only improve cognitive development but also contribute to ethical, collaborative, and safe learning experiences in mathematics education.

Here is a structured plan of action for enhancing the developed manipulatives based on the expert evaluations:

**Table 9.** Structured plan of action for enhancing the developed manipulatives based on the expert evaluations

<b>Area for Enhancement</b>	<b>Action Steps</b>	<b>Expected Outcome</b>	<b>Timeframe</b>
Value Formation	Integrate activities that explicitly promote desirable values such as cooperation, excellence, and integrity.	Strengthened incorporation of moral and ethical lessons within learning tasks.	1-2 months
Safety and Health Precautions	Improve instructions by including clearer warning labels and safety guidelines for interactive tasks.	Enhanced safety measures to ensure proper handling and minimize risks in usage.	1 month
Durability of Materials	Upgrade the quality of paper and binding to withstand frequent handling in classroom settings.	Improved longevity and usability of manipulatives for sustained instructional use.	3 months
Logical Sequencing & Vocabulary Refinement	Enhance text flow and adjust vocabulary to ensure accessibility for all learners.	Increased clarity and comprehension, making content easier to understand.	1-2 months
Ease of Handling	Modify manipulatives' size and weight for improved portability and usability.	Greater convenience in classroom applications, making them more effective tools.	1 month

This plan focuses on refining key areas to enhance the effectiveness of the manipulatives while ensuring they remain engaging, accessible, and aligned with best practices in mathematics instruction.

## CONCLUSION

Based on the findings presented in this study, the following conclusions are given:

1. The results of the study highlight the importance of tangible representations in understanding abstract mathematical concepts. Developing pattern recognition and arithmetic operation skills will support learners in formulating nth-term rules, enhancing their overall algebraic reasoning.
2. Manipulatives are more effective in addressing conceptual difficulties and enabling significant engagement and retention of mathematical knowledge when they are aligned to each student learning needs.
3. The significant improvement in learners' performance, with a clear shift towards higher mastery levels following the manipulatives' implementation, demonstrating their capacity to enhance learning outcomes.

4. The iterative development of the materials, guided by experts, improves the accessibility and usefulness of material to a diverse range of learners; this creates a more positive impact on learners learning outcomes.

### **Recommendations**

From the results and conclusions produced by this study, the researcher is able to make the following recommendations:

1. Curriculum Developers. Incorporate manipulatives into the Mathematics 6 curriculum to enhance conceptual understanding and learner engagement.
2. School Administrators. Allocate funds for manipulatives and provide teachers with training on their effective pedagogical use.
3. Mathematics Teachers. Employ hands-on manipulatives to develop learners' learning, problem-solving skills, and identification of least-learned competencies.
4. Learners. Actively use manipulatives to support mathematical learning, improve mastery, and increase engagement with various topics.
5. Researchers. Investigate the effectiveness of manipulatives across different grade levels, mathematical topics, and student demographics to broaden the understanding of their applications. The following research topics can be considered: Impact of Manipulative-Based Interventions on Algebraic Reasoning Skills of Grade 6 Learners, Enhancing Mathematical Proficiency Through Culturally Relevant Manipulatives: A Comparative Study, and The Role of Manipulatives in Developing Mathematical Competencies and Character Values in Grade School Children.

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