GAME-BASED CARD-BOARD MANIPULATIVE FOR BASIC NUMERACY OPERATIONS: EXPERT TEACHERS' EVALUATION

[1]April Velasco, [2]Shannen Lou Hernandez, [3]Aixanth Villaverde, [4]Aivee Macabuhay, and [5]Jesus Santillan*

Abstract

This study developed a game-based instructional material, the MDAS Card-Board Manipulative, for learning basic operations in numeracy education, determined its significant features and assessed its level of acceptability by selected experts in the field. Utilizing a convergent mixed method approach integrating the ADDIE Model, the study found excellent rating scores in the quality of the content, instructional, and technical aspects of the proposed material. The experts highly recommended the implementation of the game-based learning innovation at the primary and secondary levels. The findings suggest that game-based instructional materials and manipulative learning devices can boost learners' interest in a particular topic or context in Mathematics courses. Based on teachers' experiences and perspectives, game-based learning innovations in foundation topics, particularly basic operations, can enhance students' mastery level in the subject; thus, there are potential benefits of using game-based learning and manipulative devices in mathematics education.

Keywords: *game-based innovations, instructional tools, Math games, Math manipulatives, non-digital games*

Corresponding Author: Jesus Santillan, jesussantillan@cnsc.edu.ph

1.0 Introduction

Game-based learning is an instructional approach that utilizes games as a teaching tool and has gained increasing attention from researchers and educators in recent years. Trybus (2015) defines game-based learning as an instructional method that borrows certain gaming principles and applies them to real-life settings. This method has been proven to promote students' 21st-century skills and enhance their learning experience.

Mathematics is often viewed as a difficult subject by students, and their attitudes have a significant impact on their success in the subject (Yasar, 2016). To enhance students' interest and engagement in mathematics, educators can incorporate game-based learning activities into their teaching. Glavaš and Staščik (2017) noted that integrating educational games into teaching can increase students' learning interest in mathematics.

Basic operations in mathematics, such as addition, subtraction, multiplication, and division, are fundamental topics that students must master to succeed in more advanced mathematics (Khalid & Embong, 2020). However, many students struggle with these concepts, particularly those involving directed numbers or integers (Abdul Raof & Zakaria, 2019; Abidin *et al.,* 2016; Yousef & Chatti, 2017). Game-based learning can help students understand these concepts better, as they can learn through interactive, engaging activities that allow them to apply what they have learned in real-world scenarios.

Several studies have investigated the impact of game-based learning on students' attitudes toward mathematics and algebra. For instance, Erickson (2015) found that game-based math learning activities enhanced students' enthusiasm and interest in algebra, leading to a positive impact on their views toward mathematics and algebra. Ezeugwu *et al.* (2016) reported that the use of game-based learning in teaching algebra improved students' performance and reduced their anxiety about the subject. Similarly, Kebritchi (2008) noted that using educational games in teaching mathematics improved students' critical thinking skills and motivated them to learn more. Game-based learning activities that help students construct basic mathematical concepts themselves have also been found to be effective. For example, Gürbüz and Toprak (2014) reported that a game-based learning activity designed to teach fractions enhanced students' conceptual understanding of the topic. Rondina and Roble (2019) found that a game-based learning activity involving students in developing a carnival game improved their understanding of probability concepts.

Additionally, there are already game-based instructional materials to teach MDAS that have been found effective. "Prodigy" is a popular online math game designed to teach mathematical concepts to children in grades 1–8 through game-based learning (Prodigy Education, n.d.). Another game-based learning tool is "Math Quest," a multiplayer online game that teaches basic math concepts through an interactive storyline (Cohen, 2015); and "Math Blaster," an educational game that teaches arithmetic and problem-solving skills to children in grades 1–8 through interactive gameplay (Knowledge Adventure, 2021). These games provide students with an engaging and interactive learning experience that can help them develop a deeper understanding of basic mathematical concepts.

Likewise, according to Khalid *et al.* (2018), who developed a game-based learning tool for teaching fractions to primary school students, the use of the said tools enhanced students' conceptual understanding of fractions and improved their performance in related tasks. Similarly, Makonye and Fakude (2016), who developed a game-based learning tool for teaching basic arithmetic operations to primary school students in South Africa, noted that the tool was effective in enhancing students' engagement and understanding of the concepts.

Drawing insights from the existing tools and research, the present study introduces another game-based learning material that has been developed to address student's difficulties in learning basic operations in numeracy education. This is an effective instructional approach for enhancing students' interest, engagement, and understanding of mathematics, particularly in basic operations. Educators can incorporate game-based learning activities to provide students with interactive and engaging learning experiences that enhance their mathematical skills and knowledge. With the increasing availability of digital technology, there is an opportunity to develop innovative game-based learning tools tailored to meet students' learning needs and preferences.

The proposed game-based instructional material of the study was focused on solving equations involving the basic operations (application of MDAS) along with negative and non-negative integers. The target users of this material are students in grades 4–8. One basis for the proposed material is the learning contents and skills under the K–12 Mathematics curriculum in the Philippines. The said material was evaluated by five (5) selected mathematics teachers at Sta. Elena, Camarines Norte.

To determine the level of acceptability of the developed

supplementary game-based instructional material, which aims to address student's difficulties in learning basic operations in numeracy education, this study aimed to (1) determine the significant features of the developed MDAS card-board manipulative as supplement game-based instructional material in teaching and learning basic operations in numeracy education; (2) determine the level of acceptability of the developed MDAS card-board manipulative as a supplement to game-based instructional material in teaching and learning basic operations in numeracy education according to the selected experts, aligned with the DepEd Evaluation Rating Sheet, along with its content, instructional and technical quality; and lastly (3) identify the comments, suggestions, and recommendations of the selected teacher experts to enhance the developed MDAS card-board manipulative as a supplement to game-based instructional material in teaching and learning basic operations in numeracy education.

2.0 Methodology

The convergent mixed methods research design, integrating the ADDIE Model, was used as an approach for this study. The quantitative component (Analysis) was used to evaluate the acceptability of the instructional material, while the qualitative component (Design, Development, Implementation, Evaluation) was used to examine the perceptions of the teacher experts regarding the significant features of the game-based instructional material.

An in-depth analysis of existing game-based instructional material and related articles was conducted as part of the qualitative procedures to determine the significant features of the game-based instructional material for the study. The ADDIE model's Design phase was used to analyze the existing games by breaking down their components and looking at apparent similarities and differences to the game of the study. The Development phase involved formulating the thesis statement that describes the components of the developed game and conducting research to find proof and support for the thesis statement. The Implementation phase involved creating and modifying the instructional material to enhance its effectiveness in teaching and learning basic operations in numeracy education. The Evaluation phase involved assessing the level of acceptability of the developed MDAS card-board manipulative as a supplement to game-based instructional material, along with the content quality, instructional quality, and technical quality, using the Department of Education's adapted evaluation instrument for instructional and educational materials.

The researchers purposively selected five (5) teacher experts or evaluators using the following criteria: at least three years of teaching experience as a mathematics teacher in a private or public secondary, elementary, or tertiary school (Table 1). The evaluators' inputs for the developed game-based material of the study were obtained through survey interviews. The ADDIE model's Evaluation phase was used to gather all of the comments and feedback from the evaluators, organize and connect the data gathered, and code the data thematically.

The researchers introduced the developed game to the evaluators and explained the game mechanics (instruction handout). Then, the evaluators tried out the game based on the given mechanics. A survey interview was conducted to gather data regarding their comments, recommendations, and suggestions

Table 1. Respondents profile (n=5)

Respondents	Profile
A	16 years of teaching mathematics, Science Coordinator and hold a master's degree
B	34 years of teaching mathematics, mathematics coordinator, MAED
C	27 years of teaching mathematics, MAED
D	4 years of teaching mathematics, masters of Arts and Education
E	5 years of teaching mathematics

for the proposed material. The researchers used the following guide questions to obtain qualitative data for the study:

Content Quality: (*1) How can we make the instructional material more effective in catering to the needs of both advanced and slow learners? (2) How can we modify the cards to make them more suitable for different learning levels? (3) Can you suggest specific topics or concepts that should be included in the separate cards for advanced and slow learners?*

Instructional Quality: (1) *How can we ensure that the game-based instructional material is implemented properly for the learners? (2) What are the possible challenges that may arise in implementing the game-based instructional material? (3) Can you suggest strategies to address the challenges in implementing the game-based instructional material?*

Technical Quality: *(1) How can we improve the prototype sizes to make them more user-friendly? (2) How can we make the cards and the written notes inside them more visible and legible? (3) What materials can we use to make the instructional material more durable?*

Regarding the ethical considerations of the study, a request letter asking permission to conduct this research was sent to the respondents for their cooperation and honest response in this undertaking. The researchers also discussed with the respondents their rights to confidentiality and the exclusivity of data usage for the sole purpose of this research.

3.0 Results and Discussion

Features of the Proposed MDAS Card-Board Manipulative as Supplement Instructional Material in the Mathematics Fundamental Operations.

The significant features of the proposed MDAS card-board manipulative as a supplementary game-based instructional material in teaching and learning basic operations in numeracy education were adapted from some existing educational games and findings from related studies that focus on game-based teaching materials development. Table 2 summarizes the adopted features from reviewed articles and existing educational materials. Figure 1 on the other hand, shows the actual output of the proposed game-based material, integrating the adapted features, including features which are unique to this material. As illustrated, it shows the important components of the proposed game-based instructional materials as follows:

1. *Board:* This is a portable surface marked for playing a game

Table 2. Adapted features of the developed instructional material from other existing games

Game	Definition	Adapted Features
Scrabble	Scrabble is a word game in which two to four players score points by placing tiles.	Placing tiles onto the game board
Chess	A game played by two people on a square board, in which each player has 16 pieces.	Chess Board
Playing Cards	Playing cards, set of cards that are numbered or illustrated (or both) and are used for playing games, for education, for divination, and for conjuring	52 cards

Figure 1. Features of MDAS Card-Board Manipulative

on which the counters or other pieces are placed or moved. The chess board inspired the design of the developed game board; however, the game board for this particular material is significantly larger than the standard chess board. A game with a board is entertaining and challenging since it limits the players' space. Board games create connections with their peers because they bring them together to connect, strategize, compete, and have fun (Stemmle, 2020). Board games also increase brain function because they stimulate brain areas that are responsible for memory formation (Pat, 2019).

2. *Cards:* It is a piece of thin pasteboard. The 52 cards in the game-based educational material and how the game is continuously played were inspired by the game in a deck of cards. The researchers made the design pattern with each card containing two basic operations between two integers. Having cards in a game requires patience, which teaches the player to concentrate on weighing every choice, calculating every risk, waiting for that one card you want, and making important moves (Somashekar, 2022). Studies show that aside from being fun, card games have many cognitive benefits for players, i.e., they require players to order numbers, add and subtract, learn strategies for categorizing, sequence and sort numbers and suits, encourage turn-taking, communication, problem-solving, and teamwork, develop quick thinking skills, and encourage risk-taking and strategic thinking (Anglia, 2015).

3. *Game Mechanics:* The rules that govern and steer the player's actions, including the game's response, are known as game mechanics. In addition to the developed material, an instructional handout containing the game mechanics is given to the players so they can comprehend how it works. The mechanics explain the rules, scoring, how to play, how the game will end, and how to determine the winner. Game mechanics are an integral part of the game because it is the easiest way to determine if the game is a good fit for the learners (Eng, 2021). Game mechanics can also help foster repetitive play, fairness, motivation, and exploration because they determine how they will align with instruction and assessment strategies (Arnab *et al.,* 2014).

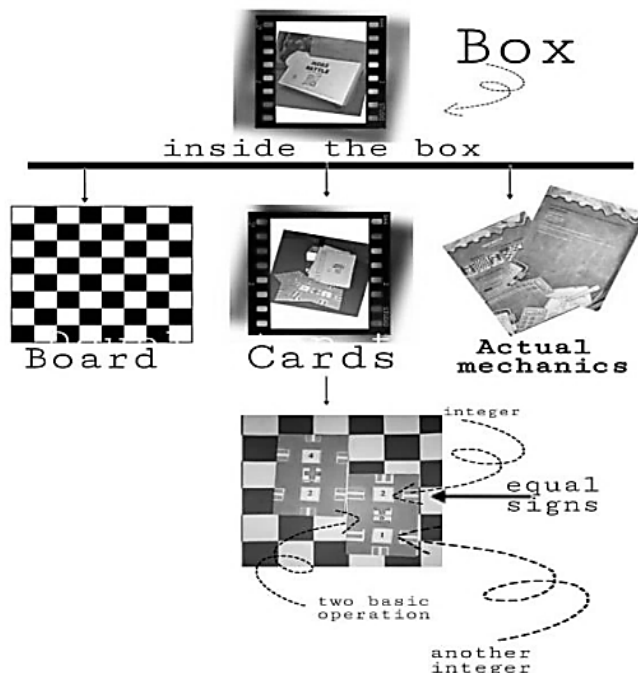4. *Scoring:* It refers to a gain (a point, goal, etc.) in a competitive

game. The MDAS card-board manipulative uses the earning points system. Whenever the player solves an equation and can place it on the board, they will be rewarded with a point value. The point system indicates the degree of the players' intent on achieving the game's objectives (Schell, 2008). It also influences satisfaction during gameplay (Lee *et al.*, 2017).

5. *Placement of Cards:* The MDAS card-board manipulative is inspired by the game of Scrabble, but instead of letters being placed on the board to complete a word, the cards are placed to complete a mathematical equation (Morales, 2017). The game revolves around solving equations involving basic mathematical operations, including negative and non-negative integers. This process of learning gives students opportunities to explore fundamental number concepts such as the counting sequence, one-to-one correspondence, and computation strategies (Rutherford, 2017). Solving equations in a game-based method will allow them to fully engage in mathematical activities since one of the studies shows that it improves learners' math fluency (Brezovsky *et al.*, 2019).

There are three (3) ways to place the card in the game. Figure 2 illustrates the procedures in terms of placing the cards on the game board. The instructor will explain how negative and non-negative integers in multiplication, division, addition, and subtraction are solved before the game begins. A fundamental comprehension of the principles required to play a specific game will enable the student to apply the game's mechanisms quickly. It also helps learners apply their knowledge in the future (Theall *et al.*, 2022). In addition, the game-based instructional material gives much importance to the fundamentals of mathematics. This is based on Bloom's hierarchy for cognition and learning objectives (2001), which includes math formulas in Bloom's taxonomies at the cognitive level (Forehand, 2010). In terms of content quality, the researchers focused on solving basic operations in mathematics. In terms of instructional quality, the researchers used challenging and stimulating mechanics, while

3 Points
The results of the equation of the two cards are equal.

2 Points
The equation on the one card-board is answered by its

1 Point
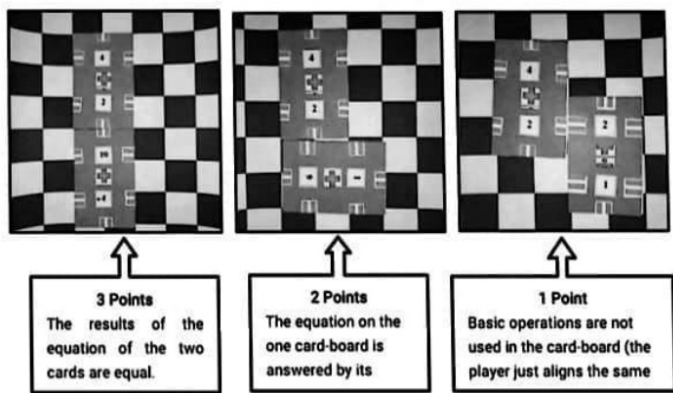Basic operations are not used in the card-board (the player just aligns the same

Figure 2. Ways to place the card-board.

a durable prototype designed specifically for the expected learning outcome was used for instructional quality.

The creation of game-based instructional materials is essential because they have the potential to support and improve mathematics learning outcomes. It also plays a successful role in creating an exciting learning environment that increases students' engagement (Nisbet, 2021). Following the principles of collaborativelearning, which is found to be the most effective form of learning (Panitz, 1999), this proposed game features the collaborative learning strategy (ter Vrugte *et al.,* 2015) because the game intends to help students who encounter difficulty in solving integers and allow them to improve their performance (Fakomogbon & Bolaji, 2017). With these features and the kind of manipulative instructionalmaterial in mathematics education, the learners are more motivated to learn when the mode of instruction is a game because they are challenged while having fun in the game. They can also work together and compete in a friendly manner. The following are the significant features of the game-based instructional material. As an initial and ideal process before any utilization process (Study II), the DepEd standard rating instrument was used to validate the proposed game-based instructional material. The proposed material was evaluated according to its content quality, instructional quality, and technical quality.

Table 3 shows the evaluators' level of acceptance in terms of the content quality of the developed game-based instructional material. Based on the results, all indicators under content quality are highly accepted (G.W.M. = 3.92). It indicates the accuracy of the proposed MDAS card-board manipulative is to enrich, reinforce, and achieve mastery of solving basic mathematical operations. It was also logically developed to promote critical thinking.

Table 4 shows the evaluators' high level of acceptance in terms of instructional quality of the developed game-based instructional material (G.W.M. = 4.00). Based on the rating, the result suggests that the instructions and mechanics of the game are clear and easy to follow. Ease in the game's procedures can ensure that the students will learn and attain mastery of the fundamentals of mathematics while playing. Thus, the assumption that the MDAS card-board manipulative will be enjoyable and challenging as it enhances the student's creativity in using the basic operations while playing the game is probable.

Finally, Table 5 shows the evaluators' high level of acceptance in terms of the technical quality of the developed game-based instructional material, based on the general weighted mean of 3.92.

Thus, based on the evaluation, it implies that the materials used

Table 3. Level of acceptability in terms of content quality of the developed game-based instructional material (n=5)

Content Quality	Weighted Mean	Rank	Interpretation
Content is consistent with topics/skills found in the Dep-Ed Learning Competencies for the subject and grade/year level.	4	3.5	Highly Accepted
Concepts developed contribute to enrich, reinforcement, or mastery of the identified learning objectives.	4	3.5	Highly Accepted
Content is accurate	3.8	8	Highly Accepted
Content is up-to-date.	4	3.5	Highly Accepted
Content is logically developed and organized.	3.8	8	Highly Accepted
Content stimulates and promotes critical thinking	4	3.5	Highly Accepted
Content is relevant to real-life situations	3.8	8	Highly Accepted
Language (including vocabulary) is appropriate to the target user level.	4	3.5	Highly Accepted
Content promotes positive values that support formative growth.	4	3.5	Highly Accepted
General Weighted Mean:	3.93		Highly Accepted

Legend: *(3.25-3.99/4.00)- Highly Accepted (2.50-3.24)- Accepted; (1.75- 2.49)- Less Accepted; (1.00-1.74) – Not Accepted*

Table 4. Level of acceptability in terms of instructional quality of the developed game-based instructional material (n=5)

Instructional Quality	W.M	Rank	Interpretation
Purpose of the material is well-defined.	4	5.5	Highly Accepted
Material achieves its defined purpose.	4	5.5	Highly Accepted
Learning objectives are clearly stated and measurable.	4	5.5	Highly Accepted
Level of difficulty is appropriate for the intended target user.	4	5.5	Highly Accepted
Graphics/colors/sounds are used for appropriate intended target user.	4	5.5	Highly Accepted
Material is enjoyable, stimulating, challenging, and engaging.	4	5.5	Highly Accepted
Material effectively stimulates creativity of target user.	4	5.5	Highly Accepted
Feedback on target user's responses is effectively employed.	4	5.5	Highly Accepted
Target user can control the rate and sequence of presentation and review.	4	5.5	Highly Accepted
Instruction is integrated with target user's previous experience.	4	5.5	Highly Accepted
General Weighted Mean:	4.00		Highly Accepted

Legend: *(3.25-3.99/4.00)- Highly Accepted (2.50-3.24)- Accepted; (1.75- 2.49)- Less Accepted; (1.00-1.74) – Not Accepted*

to create the prototype of the game are durable, the graphics and design are creative and do not distract the players attention, and it provides an accurate representation of the concept of the game. After conducting a validation of the game-based instructional material, feedback was utilized as a basis to improve the content and features of the created material. Table 6 summarizes the specified changes integrated into the developed material, which are categorized according to content quality, instructional quality, and technical quality (Fluet, 2021).

Table 5. Level of acceptability in terms of technical quality of the developed game-based instructional material (n=5)

Technical Quality	W.M	Rank	Interpretation
Visuals sustain interest and do not distract user's attention.	3.8	4.5	Highly Accepted
Visuals provide accurate representation of the concept discussed.	4	2	Highly Accepted
The user support materials (if any) are effective.	4	2	Highly Accepted
The design allows the target user to navigate freely through the material.	4	2	Highly Accepted
The material can easily and independently be used.	3.8	4.5	Highly Accepted
General Weighted Mean:	3.92		Highly Accepted

Legend: *(3.25-3.99/4.00)- Highly Accepted (2.50-3.24)- Accepted; (1.75- 2.49)- Less Accepted; (1.00-1.74) – Not Accepted*

Table 6. Modifications integrated into the developed game-based instructional material.

Criteria	Modification
Content Quality	Separate cards should be provided for advanced and slow learners.
Instructional Quality	The game should be implemented to the learners.
Technical Quality	Improved prototype sizes, both the size of the cards and the written note inside it and utilized much more durable materials.

Under the content quality criterion, the evaluators recommended providing separate cards for advanced and slow learners to avoid confusion in the game's mechanism. This modification aims to enhance the learning experience of slow learners by ensuring that they understand the game's concept (Wiggins & McTighe, 2005).

In terms of instructional quality, the material was considered effective in achieving its objectives and was logically developed. However, the evaluators recommended further research and deeper study by implementing the material with the learners to determine its effectiveness in the actual learning environment (Creswell, 2014).

In terms of technical quality, the evaluators suggested improving the prototype sizes—both the size of the cards and the written notes inside them—and utilizing more durable materials. Specifically, the evaluators recommended making the cards more prominent than the existing size to ensure that the text and visuals are easily visible and legible (Schmidt & Ralph, 2016). Finally, the feedback from the evaluators provided valuable insights that can be used to modify and improve the game-based instructional material. The modifications made based on the inputs can enhance the material's effectiveness and improve students' learning experiences (McLeod, 2022).

4.0 Conclusion

Card and board games about certain topics in mathematics can improve social skills, which makes them fun, challenging, and motivating. It also promotes critical thinking and problem-solving skills. It encourages friendly competition among students because it can be played collaboratively with their peers, who have the same goal, which is to answer the equations given on the card correctly. Therefore, the proposed game-based instructional material in this study has the potential to address learners' difficulty in basic mathematical operations. It enhances the skills of learners in solving basic equations. Furthermore, teachers should use game-based learning instruction throughout their mathematics courses (Erickson, 2015) and use it as supplemental learning material during the teaching-learning process.

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