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Effects of Digital Manipulative Activities on the Foundational Literacy Skills of SPED Learners

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Abstract

Background and Aim: In Special Education (SPED), learners often require tangible and multisensory teaching methods to acquire foundational skills. This quasi-experimental study aimed to determine the effects of digital manipulative activities on the foundational literacy skills—letter recognition, letter-sound association, and color recognition—of SPED learners.

Materials and Methods: A quasi-experimental pretest-posttest design with a control group was employed. Fifty SPED learners from a public school SPED Center in Cagayan de Oro City, Philippines, participated in the study. They were divided into an experimental group ($n = 25$) and a control group ($n = 25$). The experimental group received instruction using digital manipulatives, while the control group received traditional instruction using flashcards, worksheets, and teacher-directed activities. A teacher-validated 30-item test was administered as a pretest and posttest to both groups. Data were analyzed using descriptive statistics, paired-sample t-tests, and independent samples t-tests.

Results: Both groups had comparable pretest scores (experimental: $M = 11.3$, $SD = 2.39$; control: $M = 10.7$, $SD = 3.68$), both falling under "Needs Improvement." After the six-week intervention, the experimental group achieved a mean score of 23.0 ($SD = 2.87$), corresponding to "Very Good," while the control group obtained a mean score of 16.8 ($SD = 4.03$), corresponding to "Fair." Both groups showed significant within-group improvements (experimental: $t = -12.19$, $p < .001$; control: $t = -6.69$, $p < .001$). More importantly, the experimental group significantly outperformed the control group at posttest ($t = 6.23$, $p < .001$), with a mean difference of 6.16 points.

Conclusion: Digital manipulatives are significantly more effective than traditional instruction in improving foundational literacy skills of SPED learners. These findings support integrating digital tools into SPED curricula and inform inclusive education policy in the Philippines.

Keywords: Digital Manipulatives, SPED Learners, Letters, Sounds, Inclusive Education

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Introduction

The advent of technology has greatly revolutionized teaching and learning in modern-day education, owing to the rapid pace of technology. The emergence of digital manipulatives could be seen as one such development, as they are virtual technology used as an instructional tool, imitating the real-life hands-on learning aid. With the help of these tools, learners can engage with concepts in dynamic and interactive ways that make learning easier and meaningful (Dutta Banerjee & Mete, 2024; Siller and Ahmad, 2024). In the case of learners with special educational needs (SPED), digital manipulatives provide individual and multisensory learning experiences, which can be used to help them achieve better academic results (Oyedokun, 2024; Varella et al., 2024).

The potential effectiveness of digital manipulatives for SPED learners is supported by established learning theories. Cognitive Load Theory (Sweller, 1988) suggests that instructional materials should optimize working memory capacity; digital manipulatives can reduce extraneous cognitive load by presenting information in segmented, interactive formats. Similarly, Multisensory Integration Theory (Shams & Seitz, 2008) posits that learning is strengthened when multiple sensory pathways are engaged simultaneously—a feature inherent in digital tools that combine visual, auditory, and tactile feedback.

SPED learners often have difficulties in learning basic academic skills like letter recognition, letter-sound association, and color identification. Conventional teaching methods might not meet the varied learning requirements of such students, leading to poor advancement (Carvalho et al., 2025; Junior et al., 2024). Specifically, static worksheets and rote memorization require abstract symbolic reasoning that many SPED learners find challenging; for example, associating a printed letter with its sound provides no concrete reference point or interactive feedback. In addition, studies indicate that traditional learning approaches do not always work with highly engaging or concrete learning approaches since students need to be engaged more actively (Ismuni et al., 2024; Sumilat Margareta, & Mochtar, 2024). In this regard, digital manipulatives can be seen as a potentially viable solution since it provides an interactive and tangible learning experience that facilitates learning and interest (Kumari, 2025; Wahyuni & Ariyanto, 2024).

Regardless of the possible advantages, there are a number of problems that restrict the application of digital tools in SPED classrooms. These are the lack of device access, poor access to the internet, lack of teacher training, and the digital divide (Asgarov & Badalova, 2024; Arsyad et al., 2024; Tariq, 2024). Moreover, negative attitudes or inappropriate use of digital tools are also identified as the reason for the slow adoption of technology in SPED (Oyedokun, 2024). However, under appropriate conditions, digital manipulatives have the potential to contribute to the motivation, engagement, and self-advocacy of learners and support academic and socio-emotional growth (Agusnaya et al., 2024; Hunt et al., 2025; Varella et al., 2024).

Despite the evidence on the benefits of manipulative and digital tools in education, minimal empirical research on the direct effect of manipulatives and computer technologies on the academic achievement of learners with SPED is presented. In the majority of research, engagement, motivation, and inclusion are considered, and the quantifiable learning outcomes remain a relatively uncharted area (Carvalho et al., 2025; Junior et al., 2024). Furthermore, few studies have directly compared the effectiveness of digital manipulatives against traditional instructional methods using a controlled design. This gap explains the necessity of research that explores how digital manipulative activities can not only enhance the aspect of learning but also academic achievement in the core skills among students with special educational needs.

This quasi-experimental study aimed to address this gap by comparing the effects of digital manipulative activities and traditional instruction on the foundational literacy skills—specifically letter recognition, letter-sound association, and color recognition—of SPED learners in Cagayan de Oro City, Philippines. The research results facilitated evidence-based teaching methods to teachers, school leaders, and policymakers that will encourage effective and inclusive learning measures to learners with special needs (Dutta Banerjee & Mete, 2024; Varella et al., 2024).

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Objectives

This study aimed to determine the effects of the digital manipulative activities on the academic performance of the learners with special educational needs in the school year 2025 – 2026. Specifically, it answers the following questions: (1) What is the pretest performance of SPED learners in the experimental group (exposed to digital manipulatives) and the control group (exposed to traditional instruction)? (2) What is the posttest performance of SPED learners in the experimental group and the control group? (3) Is there a significant difference between the pretest and posttest performance within the experimental group and within the control group? And (4) Is there a significant difference between the posttest performance of the experimental group and the control group?

Literature Review

The use of manipulatives in the classroom setting has always been applied in mathematics lessons in aid of learning abstract concepts. Learners can be given concrete manipulatives, like blocks, tiles, and counters, as a tangible method of exploration to make the learning process more exciting and significant (Siller & Ahmad, 2024; Sumilat Margareta, & Mochtar, 2024). Studies have shown that students who studied with the help of manipulatives had better academic performance than students who studied using conventional means only. Siller and Ahmad (2024) discovered that students in the fifth grade who received mathematics instruction based on the use of manipulatives showed improvement in mathematics skills compared to those who received instruction without the manipulatives.

On the same note, Abrahan et al. (2024) found that Grade 3 students who worked with square tiles and counters performed well in multiplication tasks, indicating that manipulatives are effective in enhancing conceptual knowledge and precision. Manipulatives not only help with developing an understanding but also problem-solving skills. Cueva and Susada (2024) noted that working with Lego pieces enhanced the skills of learners in solving problems associated with areas, which means that practical and hands-on activities also help in mastering concepts as well as cognitive abilities. Nevertheless, other teachers complain of the overuse of manipulatives, which can negatively affect the advancement of abstract thinking. To overcome this, it has been suggested that a balance between instruction abilities of manipulation and conventional approaches to teaching should be encouraged, which allows learners to move on to the stage of higher levels of reasoning based on the concrete experience (Sumilat Margareta, & Mochtar, 2024).

The use of digital versions of conventional manipulatives has become more common in classrooms with the improvement of technology. Digital manipulatives enable the interactivity, engagement, and academic development of learners through dynamic, visually rich, and personalized learning with concepts (Ismuni et al., 2024). Students who utilize digital tools have been reported to have a higher academic performance than those who rely on only traditional approaches (Dutta Banerjee & Mete, 2024). Motivation, autonomy, and agency are the other areas that digital manipulatives improve when it comes to learning. Hunt et al. (2025) showed that digital activities in the form of games helped students to become more interested and understand concepts like fractions better. In the same manner, Wahyuni and Ariyanto (2024) and Agusnaya et al. (2024) identified that learners were more motivated and persistent when they could control their learning with the help of digital tools. Kumari (2025) and Hu et al. (2024) noted that the successful implementation of digital manipulatives into the right learning processes and pedagogies brings substantial positive changes to the results of learning, confirming the idea that the technology should be integrated into the teaching process and not seen as an addition to it.

Digital manipulatives represent a strength and a weakness in Special Education (SPED). They ensure the flexibility of learning, encourage multisensory involvement, as well as independence and

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self-advocacy among learners with disabilities (Oyedokun, 2024; Varella et. al., 2024). Research shows that interactive and customized experiences can help SPED learners to increase engagement and acquisition of fundamental skills (Carvalho et al, 2025; Junior et al, 2024). Nevertheless, the lack of infrastructure, teacher training, and the digital divide are the common barriers that rarely permit the digitization of SPED classes (Arsyad et al., 2024; Asgarov & Badalova, 2024; Tariq, 2024). Both negative attitudes and misuse of digital tools can also impact the slow adoption of technology (Oyedokun, 2024). Nevertheless, digital manipulatives have proven beneficial to academic performance, confidence, and engagement in SPED learners (Varella et al., 2024; Hunt et al., 2025). They provide the possibility to provide inclusive learning that can meet the needs of different types of learners, so that SPED learners can obtain more significant improvement in literacy and numeracy skills development, as well as in the development of other basic skills.

Whereas many studies highlight the advantages of manipulative and digital technologies overall and special education, in particular, there is little empirical research that specifically addresses the direct effect on the quantifiable academic achievement of learners with SPED. The impact on the actual acquisition of skills and learning outcomes has hardly been studied before, as most of the previous studies are concerned with engagement, motivation, and inclusion (Carvalho et al., 2025; Junior et al., 2024). This gap creates the necessity of research that examines whether digital manipulative activities not only result in the interactive nature of learning but also enhance the academic performance of students with special educational needs.

Conceptual Framework

The framework of this research depicts the impact of digital manipulatives on the foundational literacy of learners with special educational needs using a quasi-experimental design with a control group. The framework begins with a pretest administered to both the experimental and control groups to determine their initial performance in letter recognition, letter-sound association, and color identification. After the pretest, the experimental group was exposed to digital manipulative activities as the intervention, while the control group received traditional instruction using conventional methods such as worksheets, flashcards, and teacher-directed activities. Both groups received the same duration and frequency of instruction, with the only difference being the medium of delivery.

After the intervention period, both groups took the posttest to measure their performance in the same three skill areas. The framework allows for two types of comparison: (1) within-group comparison (pretest versus posttest scores for each group separately), and (2) between-group comparison (experimental group posttest scores versus control group posttest scores). This design assumes that any significantly greater improvement in the experimental group's posttest results compared to the control group can be attributed to the implementation of digital manipulatives.

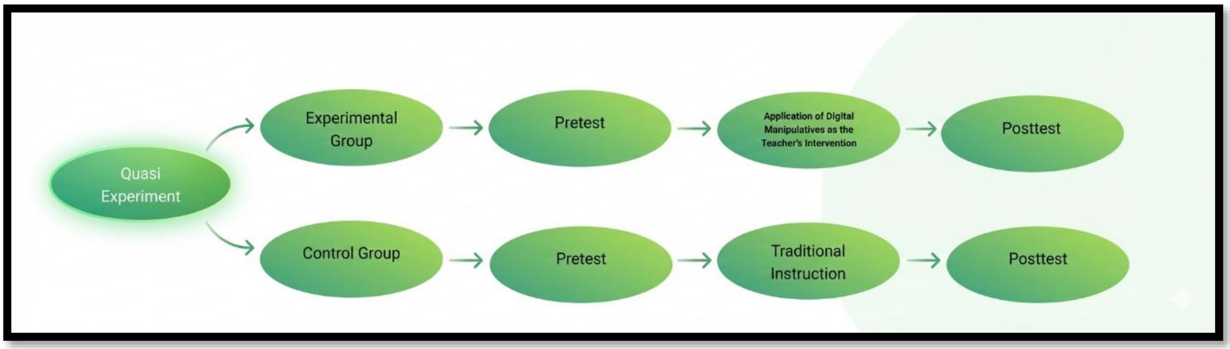

Figure 1. Conceptual Framework of the Study

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Methodology

1. Research Design

This study employed a quasi-experimental pretest-posttest design with a control group. This design was chosen to compare the effectiveness of digital manipulative activities against traditional instruction in improving the foundational literacy skills of SPED learners.

In a quasi-experimental design, participants are not randomly assigned to groups due to practical constraints in educational settings. Instead, existing class sections were assigned as the experimental group and control group. While this design is stronger than a one-group pretest-posttest design, it does not eliminate all threats to internal validity. Possible confounding factors such as history, maturation, and testing effects are partially controlled by the presence of a comparison group, but cannot be ruled out completely. The findings should therefore be interpreted with this limitation in mind.

Both groups took a pretest at the beginning of the study. The experimental group then received the intervention—digital manipulative activities—while the control group continued with traditional instruction. After the intervention period, both groups took a posttest to measure changes in their performance.

2. Research Participants

The participants of this study were 50 learners enrolled in the SPED Center of a public school in Cagayan de Oro City, Philippines. They were divided into two groups: an experimental group (n = 25) and a control group (n = 25). The groups were composed of existing class sections to avoid disrupting the school's regular programming.

Participants were included in the study based on the following criteria: (1) officially enrolled in the SPED Center, (2) currently receiving instruction in foundational literacy skills (letter recognition, letter-sound association, and color recognition), and (3) no severe physical or sensory impairments that would prevent interaction with digital tools or traditional materials.

Table 1. *Demographic Profile of Participants by Group and Diagnosis*

Diagnosis	Experimental Group (n = 25)	Control Group (n = 25)	Total (N = 50)
Autism Spectrum Disorder	9	8	17
Speech Disability	5	6	11
Learning Disability	5	5	10
Attention Deficit Hyperactivity Disorder (ADHD)	4	4	8
Hearing Impairment	2	2	4

3. Research Instrument

The main instrument used in this study was a teacher-constructed 30-item multiple-choice test designed to assess learners' knowledge in three areas: letter recognition, letter-sound association, and color recognition. For each item, learners were required to select the correct response from among the given options. To establish content validity, the test was reviewed by three specialists: a SPED coordinator with over 10 years of experience, a literacy specialist from the school's reading program, and a measurement expert. These specialists evaluated the test for alignment with the SPED curriculum, appropriateness of language for the learners' cognitive levels, and clarity of instructions. Based on their feedback, five items were rephrased for clarity, and two items were replaced to better match the skills being assessed.

A pilot test was conducted with 20 SPED learners from a nearby school who were not part of the main study. The pilot data yielded a Cronbach's alpha reliability coefficient of 0.82, which indicates good internal consistency and is acceptable for researcher-developed instruments. The same instrument was used for both pretest and posttest. To minimize recall bias, the sequence of questions was randomized in the posttest administration.

Description of the Intervention

The independent variable in this study was the type of instruction received by each group.

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Experimental Group (Digital Manipulatives)

The experimental group was exposed to digital manipulative activities using tablet devices provided by the school. The following applications were used during the intervention:

a. Letter School – an interactive app that teaches letter formation, letter names, and letter sounds through tracing and audio feedback
b. ABC Kids – Tracing & Phonics – a gamified app focusing on letter recognition and letter-sound correspondence
c. Colors Learning Games for Kids – an app that teaches color identification through matching and sorting activities

The intervention was conducted over a period of six weeks. Learners used the applications three times per week, with each session lasting approximately 30 minutes. Sessions were integrated into the regular classroom schedule and facilitated by the SPED teacher, who provided guidance and support as needed. In addition to classroom use, learners were encouraged to practice at home using the same applications on family devices or school tablets made available for home.

Control Group (Traditional Instruction)

The control group received traditional instruction using conventional methods commonly employed in SPED classrooms. These included:

a. Letter flashcards – used for drill and practice of letter names and sounds
b. Worksheets – for letter tracing, matching letters to pictures, and coloring activities
c. Teacher-directed instruction – whole-class and small-group lessons on letters, sounds, and colors
d. Physical manipulatives – such as magnetic letters, color tiles, and picture cards

The control group received instruction for the same duration and frequency as the experimental group: three times per week for 30 minutes per session over six weeks. The only difference between the two groups was the medium of instruction—digital versus traditional.

4. Data Gathering Procedure

The data gathering procedure began with obtaining official approval from the school administration to conduct the study in the SPED Center. Informed consent forms were then distributed to parents and guardians of all potential participants, explaining the purpose of the study, the procedures involved, and the voluntary nature of participation. Only learners with signed consent forms were included in the study. The pretest was administered to both the experimental and control groups during the same week. The test was conducted in small groups with the SPED teacher present to aid as needed, such as reading instructions aloud or clarifying directions, and learners were given ample time to complete the test. Over the next six weeks, the experimental group received instruction using digital manipulatives while the control group received traditional instruction. Fidelity of implementation was monitored through weekly check-ins with the SPED teacher and review of activity logs for the digital applications. Immediately after the six-week intervention, the posttest was administered to both groups using the same test items, but with the sequence randomized to reduce recall bias. Administration procedures were identical to the pretest. Finally, test scores were encoded in Microsoft Excel, verified for accuracy, and imported into JAMOVI for statistical analysis.

5. Data Analysis

The following statistical analyses were conducted to answer the research questions. Descriptive statistics, including mean, standard deviation, minimum, and maximum, were computed for pretest and posttest scores of both groups to summarize their performance levels. Paired-sample t-tests were conducted to determine whether there were significant differences between pretest and posttest scores within each group, separately for the experimental and control groups. An independent samples t-test was conducted to compare the posttest scores of the experimental group and control group, determining whether the digital intervention led to significantly better performance than traditional instruction. Before this analysis, pretest scores were compared using an independent samples t-test to establish baseline equivalence between groups. Effect sizes (Cohen's d) were computed to determine the practical significance of any significant differences. All analyses were performed using JAMOVI and Microsoft Excel, with statistical significance set at $\alpha = .05$.

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6. Ethical Considerations

This study was conducted in accordance with ethical standards to ensure the protection of participants' rights and welfare. Permissions were obtained from the school administration, and informed consent was secured from the parents or guardians of all participants. Participation was voluntary, and learners were informed that they could withdraw at any time without consequences.

Both groups received instruction throughout the study period; no learner was denied educational opportunities. The control group continued to receive the standard instruction provided by the school, which was appropriate for their learning needs.

Personal information and test scores were kept confidential and used solely for research purposes. All data were anonymized before analysis. The digital applications used in the intervention were reviewed by the SPED teacher to ensure they were safe, age-appropriate, and educationally effective for the learners.

Results and Discussions

1. **What is the pretest performance of SPED learners in the experimental group (exposed to digital manipulatives) and the control group (exposed to traditional instruction)?**

Table 2. Pretest Performance of Experimental and Control Groups

	Group	N	Mean	SD
Pretest	Experimental	25	11.3	2.39
	Traditional	25	10.7	3.68

Note. *Descriptive Equivalent Range: 27–30 = Excellent, 23–26 = Very Good, 19–22 = Good, 15–18 = Fair, 1–14 = Needs Improvement*

Table 2 presents the pretest scores of both groups before the intervention. The experimental group obtained a mean score of 11.3 (SD = 2.39), while the control group obtained a mean score of 10.7 (SD = 3.68). Both mean scores fall within the "Needs Improvement" descriptive equivalent range (1–14), indicating that learners in both groups had limited foundational literacy skills in letter recognition, letter-sound association, and color recognition at the start of the study. An independent samples t-test confirmed that there was no significant difference between the two groups at pretest ($p > .05$), establishing baseline equivalence.

The low pretest scores reflect the challenges that SPED learners commonly face in acquiring basic academic skills. Siller and Ahmad (2024) noted that learners with special needs often require concrete and multisensory experiences to grasp abstract concepts. Similarly, Sumilat Margareta & Mochtar (2024) emphasized that instructional aids help students visualize and understand concepts more effectively. The absence of such supports in the learners' prior instruction may explain their low initial performance.

From the perspective of Cognitive Load Theory (Sweller, 1988), the low pretest scores suggest that learners may have experienced high extraneous cognitive load when attempting to learn abstract letter-sound correspondences through conventional methods. The practical implication is that SPED learners need instructional approaches that reduce unnecessary cognitive demands by presenting information in more accessible, segmented formats. This finding justifies the need for interventions like digital manipulatives that can provide such support.

2. **What is the posttest performance of SPED learners in the experimental group and the control group?**

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Table 3. Posttest Performance of Experimental and Control Groups

	Group	N	Mean	SD
Posttest	Experimental	25	23.0	2.87
	Traditional	25	16.8	4.03

Note. *Descriptive Equivalent Range: 27–30 = Excellent, 23–26 = Very Good, 19–22 = Good, 15–18 = Fair, 1–14 = Needs Improvement*

Table 3 shows the posttest scores of both groups after the six-week intervention. The experimental group achieved a mean score of 23.0 (SD = 2.87), which falls within the "Very Good" descriptive equivalent range (23–26). The control group obtained a mean score of 16.8 (SD = 4.03), which falls within the "Fair" descriptive equivalent range (15–18). These results indicate that while both groups improved from their pretest scores, the experimental group demonstrated a substantially higher level of performance after instruction using digital manipulatives.

This finding aligns with the observations of Dutta Banerjee & Mete (2024), who reported that students using digital tools tend to achieve higher academic performance compared to those relying solely on traditional approaches. Kumari (2025) also emphasized that digital tools promote active participation and improve learning outcomes through personalized and engaging experiences. The interactive and multisensory nature of digital manipulatives appears to have facilitated deeper learning for the experimental group.

The superior performance of the experimental group can be explained by Multisensory Integration Theory (Shams & Seitz, 2008), which posits that learning is strengthened when multiple sensory pathways are engaged simultaneously. The digital applications used in this study combined visual, auditory, and tactile feedback, allowing learners to see letters, hear their sounds, and trace their shapes. The practical implication is that SPED teachers should consider incorporating digital tools that leverage multisensory features to enhance foundational literacy instruction.

3. **Is there a significant difference between the pretest and posttest performance within the experimental group and within the control group?**

Table 4. Within-Group Comparison of Pretest and Posttest Scores

	statistic	df	p
Pretest – Posttest (Traditional)	-6.69	24.0	<.001
Pretest – Posttest (Experimental)	-12.19	24.0	<.001

Note. H_a $\mu_{\text{Measure 1 - Measure 2}} \neq 0$

Table 4 presents the results of paired-sample t-tests conducted for each group. The experimental group showed a highly significant improvement from pretest to posttest ($t = -12.19$, $df = 24$, $p < .001$). The control group also showed a highly significant improvement ($t = -6.69$, $df = 24$, $p < .001$). These findings indicate that both instructional approaches were effective in improving the foundational literacy skills of SPED learners over the six weeks.

These results are consistent with the broader literature on manipulatives in education. Abrahan et al. (2024) found that students who worked with manipulatives performed higher in academic tasks, indicating that hands-on learning enhances conceptual knowledge. Cueva and Susada (2024) similarly noted that practical activities help learners master concepts and develop cognitive abilities. Both groups in this study received some form of manipulative-based instruction—digital for the experimental group and physical for the control group—which likely contributed to their significant improvements.

From a theoretical standpoint, the significant improvements in both groups demonstrate that structured, intentional instruction—regardless of medium—can reduce cognitive load and support

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learning. However, the larger t-value in the experimental group (-12.19 vs. -6.69) suggests that digital manipulatives may be more efficient at reducing extraneous cognitive load by providing immediate feedback and allowing self-paced exploration. The practical implication is that while traditional methods remain effective, digital tools may accelerate learning gains for SPED learners.

4. Is there a significant difference between the posttest performance of the experimental group and the control group?

Table 5. Between-Group Comparison of Posttest Scores

	Statistic	df	p	Mean Difference	SE Difference
Posttest	6.23	48.0	<.001	6.16	0.989

Note. H_a $\mu_{Experimental} \neq \mu_{Traditional}$

Table 5 displays the results of an independent samples t-test comparing the posttest scores of the two groups. The experimental group significantly outperformed the control group ($t = 6.23$, $df = 48$, $p < .001$), with a mean difference of 6.16 points. This difference is both statistically significant and practically meaningful, providing evidence that digital manipulatives are more effective than traditional instruction for teaching foundational literacy skills to SPED learners.

This finding is supported by previous research. Hunt et al. (2025) found that game-based digital activities enhanced student engagement and understanding of foundational concepts compared to traditional methods. Wahyuni and Ariyanto (2024) and Agusnaya et al. (2024) identified that learners were more motivated and persistent when they could control their learning with digital tools. Varella et al. (2024) specifically noted that digital manipulatives offer individualized and multisensory experiences that are particularly beneficial for SPED learners.

The results also address the research gap identified in the literature. While previous studies focused primarily on engagement and motivation (Carvalho et al., 2025; Junior et al., 2024), this study provides empirical evidence of quantifiable learning outcomes. From the perspective of Cognitive Load Theory, digital manipulatives likely reduced extraneous cognitive load by presenting information in segmented, interactive formats with immediate feedback, allowing learners to focus their working memory on essential learning tasks. The practical implication for SPED teachers, school administrators, and policymakers is clear: investing in digital tools and integrating them into SPED instruction can lead to significantly better academic outcomes for learners with special educational needs.

Knowledge Contribution

At the core of this study is the finding that digital manipulatives significantly improved the foundational literacy skills of SPED learners, with the experimental group substantially outperforming the control group. This evidence addresses a critical gap in the literature by providing quantifiable learning outcomes rather than solely focusing on engagement or motivation.

The second tier of the framework—Enhanced Learner Engagement and Motivation—reveals that digital manipulatives address the affective domain of learning, which is often a barrier for SPED learners. The interactive and multisensory nature of the applications used in this study (Letter School, ABC Kids, Colors Learning Games) kept learners engaged despite the challenges of their disabilities. For policymakers, this suggests that investments in digital resources should not be viewed merely as technological upgrades but as tools for fostering inclusion by meeting learners where they are developmentally.

The third tier—Improved Academic Performance in Literacy—provides empirical validation that digital manipulatives produce measurable gains in letter recognition, letter-sound association, and

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color identification. These are foundational skills that determine future academic success. For the Department of Education, this finding supports the allocation of resources toward digital infrastructure in SPED centers, particularly in regions where this study was conducted. It also justifies the development of teacher training programs focused on integrating technology into special education instruction.

Finally, the framework leads to Practical Implications for SPED Teaching, which directly inform the implementation of Inclusive Education policy. The significant difference between groups demonstrates that digital manipulatives are not merely an alternative to traditional instruction but a superior approach for teaching foundational literacy to SPED learners. This has concrete implications for curriculum design: SPED teachers should be encouraged to adopt a blended approach that prioritizes digital tools for skills that require multisensory reinforcement, while using traditional methods for other instructional purposes.

In the Philippine context, where inclusive education aims to provide quality education to all learners regardless of ability, these findings offer evidence-based direction. The study suggests that:

- Policy development should mandate the inclusion of digital manipulatives in SPED curriculum guidelines.
- Budget allocation should prioritize tablets and educational software for SPED centers nationwide.
- Teacher preparation programs should integrate training on digital tool selection and implementation.
- Monitoring and evaluation frameworks should include measurable literacy outcomes as indicators of inclusive education success.

In general, this study moves beyond theoretical advocacy for technology in SPED by providing empirical evidence from a Philippine public school context. The knowledge contribution lies in demonstrating that digital manipulatives are not just engaging but demonstrably effective in producing superior academic outcomes, thereby strengthening the evidence base for inclusive education policy and practice in the Philippines.

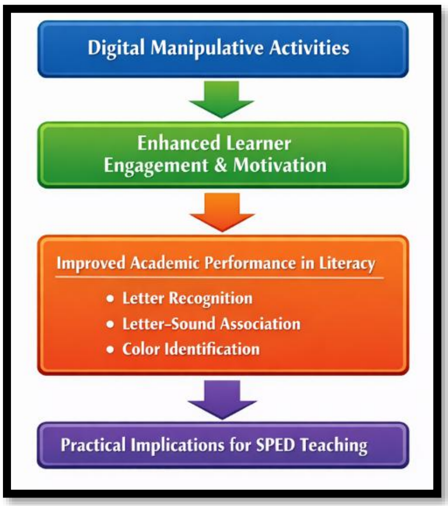

Figure 2. Knowledge Contribution of the Study

Recommendation

According to the results of the study, it is advised that teachers and SPED centers should include digital manipulative activities in the daily education to develop the basic literacy proficiency, i.e., letter recognition, letter-sound association, and color identification. Teachers should give well-organized and

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interactive online assignments, which match the capabilities of learners, so that they can be accessible in both the classroom and at home to aid learning. School administrators are advised to assist teachers by supplying them with the required digital equipment, internet services, and training so as to be able to use the mentioned tools. In addition, parents and guardians would be required to participate in the direction of the use of digital manipulatives at home so that the practice can continue. These strategies will help SPED learners have better engagement, motivation, and academic performance in a sustainable and practicable way.

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