International Journal of Arts and Social Science www.ijassjournal.com
ISSN: 2581-7922,
Volume 9 Issue 7, July 2026

The Relationship Between Frequencies of Use of Learner-Generated Drawings and Word Problem-Solving Performance: Basis for Learner-Generated Drawing-Based Instructional Framework for Grade 9 Mathematics at Nibras International School

Ferdinand Alcantara Valdez, MAEd[1], Diosdado Vinluan Jr., Ph.D.[2]

[1]*(Graduate School of Education, St. Paul University Manila, Philippines)*
[2]*(Professor, Graduate School of Education, St. Paul University Manila, Philippines)*

ABSTRACT: *This study examined the relationship between the frequency with which Grade 9 students used learner-generated drawings and their performance in solving mathematical word problems at an international school in Dubai, United Arab Emirates. Using a quantitative, non-experimental, explanatory correlational design, data were gathered from 65 students selected through stratified random sampling. Two validated instruments, a Drawing Frequency Questionnaire and a Word Problem-Solving Performance measure, were administered, and responses were analyzed using descriptive statistics, Spearman rank-order correlation, and content analysis of open-ended responses. Results showed that students used learner-generated drawings moderately ($M = 3.13$, $SD = 0.53$) and reported generally favorable perceptions of their problem-solving performance ($M = 3.12$, $SD = 0.52$). A statistically significant, very strong positive correlation was found between drawing frequency and performance ($r = .90$, $p = .01$), leading to rejection of the null hypothesis. Students also reported challenges related to time constraints, limited drawing skill, and difficulty translating text into visuals. These findings informed the development of the "DRAW and BUILD Math: SEE Approach," an instructional framework designed to guide teachers in embedding structured, reflective drawing practices into mathematics instruction.*

KEYWORDS: *drawing frequency, instructional framework, learner-generated drawings, mathematics education, word problem-solving performance*

I. INTRODUCTION

Mathematical word problem-solving remains a persistent challenge for many secondary school students. At the researcher's school, an international private institution in Dubai, United Arab Emirates, Grade 9 students recorded a class average of 65.58% on recent mathematics assessments, falling short of the 75% benchmark set by the Knowledge and Human Development Authority (KHDA). Classroom observation suggested that students relied heavily on memorized procedures and struggled once a problem departed from a familiar pattern, raising questions about whether current instructional strategies adequately cultivated flexible, conceptual problem-solving.

A growing body of research has argued that effective mathematics instruction must move beyond rote memorization toward conceptual understanding and active engagement. Dweck [1] found that students with a growth mindset persevered more readily through academic difficulty, Yoon, D'Souza, and Jacobson [2] showed that embedding real-world context improved motivation and comprehension, and Hattie and Timperley [3] demonstrated that formative feedback helped identify misconceptions early. Yet much classroom practice, particularly in test-oriented systems, continues to emphasize a single prescribed solution method, leaving little space for multiple problem-solving paths [4].

One underused strategy with promise for bridging this gap is learner-generated drawing. Ainsworth, Prain, and Tytler [5] argued that drawing is not merely representational but is itself a means of reasoning, while Schukajlow, Achmetli, and Rakoczy [6] cautioned that the benefits of drawing depend on adequate structure and guidance. Cox [7] similarly described children's drawings as cognitive tools that reveal how learners make sense of mathematical ideas, and Hatisaru [8] found that students who generated their own visuals showed stronger comprehension and retention than those who relied solely on verbal instruction. Despite this evidence, few studies have examined how often secondary students spontaneously use drawing when solving word problems, or how this frequency relates to their performance, particularly within international school settings.

This study addressed that gap by investigating (a) the frequency with which Grade 9 students used learner-generated drawings to solve word problems, (b) their word problem-solving performance in relation to that frequency, (c) whether a statistically significant relationship existed between the two variables, (d) the challenges students encountered when using drawing strategies, and (e) how these findings could inform a drawing-based instructional framework. It was hypothesized that a statistically significant positive relationship would exist between the frequency of learner-generated drawing use and word problem-solving performance.

The study was grounded in three complementary theoretical perspectives. Constructivist Learning Theory [9] framed learner-generated drawing as an active process through which students construct mathematical understanding. Dual Coding Theory [10] proposed that engaging both visual and verbal cognitive channels strengthens comprehension and memory. Metacognitive Theory [11] explained how the act of drawing externalizes student thinking, supporting self-monitoring and reflection during problem-solving. Together, these perspectives informed the study's Input-Process-Output model, in which drawing frequency (input) shapes visualization and metacognitive reflection (process), which in turn affects word problem-solving performance (output).

II. METHODOLOGY

2.1 Research Design

This study employed a quantitative, non-experimental, explanatory correlational design to examine the naturally occurring relationship between the frequency of learner-generated drawing use and word problem-solving performance, without manipulating classroom instruction [12]. A correlational approach was considered appropriate and ethically sound, since withholding a potentially beneficial strategy such as drawing from a control group would have disadvantaged those students.

2.2 Participants and Sampling

The target population consisted of 78 Grade 9 students across three sections at the participating school. Using Slovin's formula with a 5% margin of error, and rounding up to account for non-response, a sample of 65 students (31 male, 34 female) was drawn through stratified random sampling proportionate to each section, ensuring representation across gender, academic ability, and the school's broader cultural and linguistic diversity (more than 25 nationalities represented).

Students with diagnosed learning conditions affecting visual-spatial processing, those anticipated to withdraw or be frequently absent during data collection, and those receiving extensive individualized instruction outside the regular curriculum were excluded to preserve the reliability of the findings.

2.3 Research Instruments

Two researcher-developed, validated instruments were used. The Drawing Frequency Questionnaire consisted of 10 items on a 4-point Likert scale (Always = 4 to Never = 1), yielding scores classified as high (40–50), moderate (25–39), or low (10–24) frequency of drawing use. The Word Problem-Solving Performance measure consisted of 10 items covering algebra, geometry, and number sense drawn from the Grade 9 curriculum, with responses classified as high (8–10), moderate (5–7), or low (0–4) performance. An open-ended item was also included to capture the challenges students experienced when using drawing strategies.

2.4 Data Collection Procedure

Data were collected over four weeks during the second term of the school year, following institutional and ethics committee approval. Week 1 involved administration of the Drawing Frequency Questionnaire; Week 2 involved administration of the Word Problem-Solving Performance measure under standardized, supervised conditions without calculators; and Weeks 3–4 involved classroom observation to corroborate self-reported drawing behavior. All responses were coded to protect anonymity and entered into SPSS Version 25 for analysis.

2.5 Data Analysis

Descriptive statistics (means, standard deviations, frequency and percentage distributions) summarized drawing frequency and performance scores. A Shapiro-Wilk test indicated that the data violated the assumption of normality ($p < .05$); consequently, the nonparametric Spearman rank-order correlation coefficient was used to test the hypothesized relationship between the two variables, with significance evaluated at $\alpha = 0.05$. Open-ended responses regarding challenges were examined through content analysis [13], in which responses were read, coded, and grouped into categories reflecting recurring themes.

2.6 Ethical Considerations

The study was reviewed and approved by the Research Ethics Committee of St. Paul University Manila prior to data collection. Written informed consent was obtained from parents or guardians, and written assent was obtained from student participants. Participation was entirely voluntary, with the right to withdraw at any time without academic consequence. Coded identifiers protected participant anonymity, and all data were stored securely and reported only in aggregate form.

III. RESULTS AND DISCUSSION

3.1 Frequency of Learner-Generated Drawing Use

Table 1 presents the mean frequency scores for learner-generated drawing use. Overall, students reported using drawings "Sometimes" ($M = 3.13$, $SD = 0.53$). The highest-rated item, "I find it easier to solve problems after creating a visual representation" ($M = 3.32$, $SD = 0.64$), was interpreted as "Always," indicating strong belief in the value of visualization. The lowest-rated item, "I often use sketches to reorganize information in word problems" ($M = 3.02$, $SD = 0.82$), remained in the "Sometimes" range.

Table 1. Mean Scores for Frequency of Drawing Usage

Item	M	SD	V.I.
I find it easier to solve problems after creating a visual representation.	3.32	0.64	Always
I use visual aids (graphs/charts) to clarify my understanding of concepts.	3.17	0.72	Sometimes
Drawing helps me remember the details of a word problem.	3.15	0.78	Sometimes

I sketch pictures/shapes or create visuals to explain my reasoning.	3.14	0.92	Sometimes
I use sketches to reorganize information in word problems.	3.02	0.82	Sometimes
Overall	3.13	0.53	Sometimes

Note. SD = Standard Deviation; V.I. = Verbal Interpretation. Legend: 1.00–1.75 Never, 1.76–2.50 Rarely, 2.51–3.25 Sometimes, 3.26–4.00 Always.

This pattern points to a belief-practice gap: students recognize the cognitive value of drawing yet apply it inconsistently. This is consistent with Dual Coding Theory [10] and with Ainsworth et al.'s [5] contention that drawing functions as a means of reasoning rather than mere illustration. The gap likely reflects a pedagogical vacuum rather than disinterest—Lapinid [4] and Hembree [14] both note that assessment-driven instruction favors procedural fluency over exploratory strategies such as drawing, so that even students who value visualization are rarely taught to use it systematically.

3.2 Word Problem-Solving Performance

Table 2 presents students' perceptions of how learner-generated drawings supported their word problem-solving performance, which yielded an overall mean of 3.12 (SD = 0.52), interpreted as "Agree." The highest-rated item, "Using drawings encourages me to think more creatively when solving math problems" (M = 3.29, SD = 0.79), was interpreted as "Strongly Agree," while the lowest-rated item, "I feel confident in solving word problems when I use drawings" (M = 2.98, SD = 0.72), remained positive but comparatively lower.

Table 2. Mean Scores for Word Problem-Solving Performance

Item	M	SD	V.I.
Using drawings encourages me to think more creatively when solving problems.	3.29	0.79	Strongly Agree
Drawings help me identify important information in the problem.	3.26	0.71	Strongly Agree
Drawing helps me check for errors in my solution.	3.20	0.69	Agree
Drawings improve my understanding and make abstract concepts easier.	3.15	0.67	Agree
Using drawings reduces my anxiety when solving word problems.	3.00	0.83	Agree
I feel confident in solving word problems when I use drawings.	2.98	0.72	Agree
Overall	3.12	0.52	Agree

Note. SD = Standard Deviation; V.I. = Verbal Interpretation. Legend: 1.00–1.75 Strongly Disagree, 1.76–2.50 Disagree, 2.51–3.25 Agree, 3.26–4.00 Strongly Agree.

The gap between students' cognitive recognition of drawing's benefits and their comparatively lower confidence suggests that awareness alone does not guarantee assured application. Structured modeling and guided practice, particularly in transforming text into accurate visual representations, may help close this gap. The pattern also reflects Flavell's [11] account of metacognition and Uesaka and Manalo's [15] observation that externalizing thinking through drawing makes it easier for students to monitor and refine their own reasoning.

3.3 Relationship Between Drawing Frequency and Performance

Table 3. Spearman Correlation Between Frequency of Drawing Usage and Word Problem-Solving Performance

Variables	r	p	Interpretation
Drawing Frequency – Problem-Solving Performance	.90	.01	Very high positive; significant

Note. Tested at the 0.05 level of significance.

A Spearman rank-order correlation revealed a statistically significant, very strong positive relationship between the frequency of learner-generated drawing use and word problem-solving performance, $r = .90$, $p = .01$. Since $p < .05$, the null hypothesis was rejected, indicating that more frequent drawing use was associated with higher problem-solving performance. This finding is consistent with Hatisaru [8], who found that students generating their own visuals achieved better comprehension and retention, and with Ainsworth et al. [5], who argued that drawing supports active processing and meaningful conceptual connections. It also offers an evidentiary counterpoint to procedure-centered instructional models critiqued by Hembree [14] and Lapinid [4].

3.4 Challenges Encountered in Using Learner-Generated Drawings

Content analysis of open-ended responses identified several recurring challenges. Time constraints were the most frequently cited concern, with students describing the process as slow under timed conditions, consistent with Schukajlow et al.'s [6] observation that learners often abandon drawing under time pressure. Limited drawing skill and low self-efficacy (e.g., "I'm bad at drawing") discouraged some students from attempting the strategy, echoing Ivens' [16] findings on drawing-related confidence. Others struggled with technical accuracy and proportionality, or reported that comprehension difficulties preceded visualization difficulties—consistent with Cox [7] and Uesaka and Manalo [15], who argued that understanding a problem's structure must precede its visual representation. A smaller group described drawing itself as a source of confusion, while others reported minimal or no difficulty, underscoring that the strategy's effectiveness depends heavily on guidance and individual differences in representational fluency.

Table 4. Categories of Challenges in Using Learner-Generated Drawings

Category	Illustrative Response
Time constraints	"It is time consuming"
Limited drawing skill / low self-efficacy	"I'm bad at drawing"
Technical accuracy / scaling	"Trying to get the exact measurement"
Problem comprehension and visualization	"I face confusion from the questions"
Drawing-induced confusion	"Sometimes they confuse me instead of helping me"
Minimal or no difficulty	"Almost none"

3.5 Proposed Instructional Framework

Drawing on these findings, the researcher developed the "DRAW and BUILD Math: SEE Approach," an instructional framework intended to transform students' use of drawing into a deliberate, guided, and reflective practice. The SEE component (Sketch Smart, Embed Drawing, Evaluate Visuals) equips teachers to model effective drawing, integrate it purposefully into lessons, and give feedback on the accuracy and clarity of student visuals. The DRAW component (Design the Visual, Represent Relationships, Analyze the Drawing, Work through the Solution Visually) guides students through externalizing, annotating, checking, and applying their visual representations. The complementary BUILD component (Break It Down, Use Drawing Rules, Integrate into Solving, Look Back and Refine, Develop Habits) supports the habitual, rule-governed use of drawing across problem types. Together, these components respond directly to the challenges identified in Section 3.4 while building on the demonstrated relationship between drawing frequency and performance.

IV. CONCLUSION

This study found that Grade 9 students used learner-generated drawings moderately and perceived them as beneficial to word problem-solving, with a statistically significant, very strong positive correlation between drawing frequency and performance ($r = .90$, $p = .01$). Students nonetheless encountered practical, skill-based, and cognitive challenges that limited more consistent use of the strategy. These findings support the value of learner-generated drawing as an evidence-based instructional strategy and provide the empirical basis for the "DRAW and BUILD Math: SEE Approach," which offers teachers a structured way to embed drawing, reflection, and feedback into mathematics instruction.

The study was limited to one academic term and one international school, and the proposed framework was developed but not experimentally tested. Future research should pilot the framework's effectiveness across grade levels, content areas, and school contexts, and examine whether structured drawing instruction narrows the belief-practice and confidence gaps identified in this study.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the members of the oral examination committee at the Graduate School of Education, St. Paul University Manila, as well as the administration, teachers, and Grade 9 students of the participating school for their cooperation during data collection.

REFERENCES

[1] C.S. Dweck, Mindset: The new psychology of success (New York, NY: Ballantine Books, 2020).

[2] H. Yoon, N. D'Souza, and J. Jacobson, Contextual learning in math: Bridging instruction with real-world application, Journal of Mathematics Education, 54(2), 2021, 211-228.

[3] J. Hattie and H. Timperley, The power of feedback in learning mathematics, Mathematics Education Research Journal, 32(4), 2020, 613-630.

[4] M. Lapinid, From procedure to process: A critique of Philippine mathematics instruction, Journal of Southeast Asian Education, 28(2), 2022, 145-159.

[5] S. Ainsworth, V. Prain, and R. Tytler, Drawing to learn science and mathematics (Abingdon, UK: Routledge, 2020).

[6] S. Schukajlow, K. Achmetli, and K. Rakoczy, Drawing to solve word problems: The role of teacher prompts, ZDM–Mathematics Education, 53(4), 2021, 839-854.

[7] M.V. Cox, Children's drawings of science and mathematics: Cognitive development and curriculum, Educational Studies in Mathematics, 104(3), 2020, 325-341.

[8] V. Hatisaru, Student-generated drawings in mathematics education: Analysis of representational and cognitive levels, International Journal of Mathematical Education in Science and Technology, 51(5), 2020, 678-695.

[9] L.S. Vygotsky, Mind in society: The development of higher psychological processes (Cambridge, MA: Harvard University Press, 1978).

[10] A. Paivio, Mental representations: A dual coding approach (Oxford, UK: Oxford University Press, 1986).

[11] J.H. Flavell, Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry, American Psychologist, 34(10), 1979, 906-911.

[12] J.W. Creswell and J.D. Creswell, Research design: Qualitative, quantitative, and mixed methods approaches, 5th ed. (Thousand Oaks, CA: Sage Publications, 2020).

[13] M. Nicmanis, Reflexive content analysis: An approach to qualitative data analysis, reduction, and description, International Journal of Qualitative Methods, 23, 2024.

[14] R. Hembree, The impact of high stakes testing on mathematical problem-solving, Journal of Educational Measurement, 59(1), 2022, 29-46.

[15] Y. Uesaka and E. Manalo, Metacognition and drawing: How visual representation supports reflective mathematical problem-solving, Contemporary Educational Psychology, 72, 2023, 102119.

[16] S. Ivens, Emotional and cognitive interpretations in children's mathematical drawings, Educational Psychology in Practice, 37(3), 2021, 267-281.