The International Review of Multidisciplinary Research
Volume 1, Issue 5, May 2026, pp. 250-257
https://doi.org/10.5281/zenodo.20094042

Development and Evaluation of Design Thinking Process (DTP)-Based Instructional Materials in Trigonometry

[1]Jeric C. Diño, [2]Jojim B. Cordova
[1]Paulba National High School, [2]SDO Ligao City
[1]jeric.di@deped.gov.ph, [2]jojim.cordova@deped.gov.ph

Article Details:

Received: 12 April 2026
Revised: 23 April 2026
Accepted: 30 April 2026
Published: 6 May 2026
Corresponding Email:
jeric.di@deped.gov.ph

Recommended Citation:

Diño, J. C., Cordova, J. B. (2026). Development and Evaluation of Design Thinking Process (DTP)-Based Instructional Materials in Trigonometry. The International Review of Multidisciplinary Research. 1 (5), 250-257. https://doi.org/10.5281/zenodo.20094042

Index Terms:

design thinking process, instructional materials development, trigonometry education, academic performance, student engagement, quasi-experimental design, mathematics pedagogy

Abstract. This study developed and evaluated Design Thinking Process (DTP)-based instructional materials in Trigonometry at Paulba National High School, Schools Division Office of Ligao City, for School Year 2025–2026, and determined their effectiveness in improving students' academic performance and engagement. Grounded in the Triadic Model of DT-Enhanced Mathematical Learning—integrating Constructivism, the Cognitive Theory of Multimedia Learning (CTML), and Self-Determination Theory (SDT)—six DTP-based worksheets with accompanying lesson plans were developed, covering all Most Essential Learning Competencies (MELCs) in Grade 9 Trigonometry. Each worksheet was structured around the five iterative stages of Design Thinking (Empathize, Define, Ideate, Prototype, and Test) and contextualized using locally relevant, real-world scenarios from the community of Paulba, Ligao City. A panel of ten expert evaluators assessed validity using the DepEd LRMDS Evaluation Rating Sheets across content quality, instructional design, and technical characteristics, yielding an overall validity rating of 3.97 (Very Satisfactory). A quasi-experimental pretest–posttest design with two intact Grade 9 sections measured effectiveness; the experimental group recorded a substantially higher mean gain of 23.72 points (T=22.2 at $\alpha = .05$) compared to 14.55 points in the control group (T=11.04 at $\alpha = .05$). Student engagement, measured via a researchers-developed 5-point Likert-scale survey (Cronbach's $\alpha = 0.979$), demonstrated a higher overall mean in the experimental group (4.11 vs. 3.94), with the most pronounced gains in cognitive and self-efficacy dimensions. Although the DTP-based instructional materials revealed several limitations along implementation, need for teacher scaffolding, scope and generalizability, and resource sensitivity, these findings confirm that DTP-based instructional materials are both valid and highly effective in improving trigonometry achievement and fostering multidimensional student engagement among Grade 9 learners.

Introduction

The twenty-first century has fundamentally reshaped the expectations placed upon educational systems worldwide. Global economic competition, rapid technological advancement, and complex societal challenges now demand a paradigm shift in pedagogy—from the mere transmission of knowledge to the cultivation of higher-order cognitive and non-cognitive skills.

Mathematics education serves not only as a cornerstone for STEM careers but also as a vital discipline for fostering critical thinking, logical reasoning, and informed decision-making in everyday life (OECD, 2021). Modern mathematics classrooms must therefore move beyond rote memorization of formulas and procedures, emphasizing instead the development of problem-solving, creativity, collaboration, and reflective thinking (Harding & Green, 2020).

One promising innovative instructional approach is Design Thinking (DT)—a human-centered, iterative process originally conceptualized in engineering and product development. Consisting of five stages—Empathize, Define, Ideate, Prototype, and Test—DT is structured to address complex or 'wicked' problems (Brown, 2019). When integrated into education, it fosters curiosity, resilience, and iterative refinement, enabling students to embrace challenges creatively and view failure as a necessary part of learning (Vianna et al., 2021).

In the Philippine context, the K to 12 Basic Education Program underscores the importance of producing holistically developed Filipino learners equipped with 21st-century skills. Despite these goals, the country's learning crisis remains deeply entrenched. The Second Congressional Commission on Education (EDCOM II, 2026) documents a severe 'proficiency collapse' that worsens as students advance: while 30.5% of Grade 3 learners meet proficiency standards, this figure plummets to just 1.36% by Grade 10 and 0.47% by Grade 12. This gap is especially pronounced in Mathematics 9, particularly in Trigonometry, where students must navigate concepts demanding both conceptual understanding and procedural fluency.

Recent data from the Division of Ligao City underscore this concern. The 2022–2023 NAT for Grade 10 showed that learners scored only 49.06% in Problem Solving, 49.12% in Information Literacy, and 48.45% in Critical Thinking—well below the 75% proficiency benchmark. At Paulba National High School, all Junior High School learners were classified under 'needs major support' in regional numeracy assessments for two consecutive school years (S.Y. 2023–2024 and S.Y. 2024–2025), with a mean of 35.07%. Furthermore, 831 out of 867 JHS students (approximately 96%) were classified as 'not proficient,' with no student reaching the 75% target.

Grounded in the Design Thinking framework, this study sought to: (1) develop Design Thinking Process (DTP)-based instructional materials in Grade 9 Trigonometry; (2) determine the extent of validity of these materials; (3) assess their effectiveness in improving students' academic performance and engagement; and (4) determine its limitations based on evaluation at Paulba National High School, Division of Ligao City, for School Year 2025–2026.

Theoretical Framework

This study is anchored on a complementary set of three core theories: Constructivism, the Cognitive Theory of Multimedia Learning (CTML), and Self-Determination Theory (SDT). These frameworks collectively justify the study's design methodology, pedagogical approach, and anticipated outcomes. Constructivism, as advocated by Piaget and Vygotsky, posits that learners actively construct knowledge through experience and social interaction. The Design Thinking Process operationalizes this through iterative, inquiry-driven stages where students construct and refine understanding. CTML (Mayer, 2009) explains that learning is optimized when verbal and visual information are presented in coordinated formats, which directly underpins the multi-modal design of the DTP-based worksheets. Self-Determination Theory (Deci & Ryan, 1985) identifies competence, autonomy, and relatedness as the three universal psychological needs for intrinsic motivation, each of which is addressed through distinct DTP stages. These three theories form the researchers' Triadic Model of DT-Enhanced Mathematical Learning, which positions Design Thinking as both a pedagogical scaffold and a psychological framework that addresses learners' cognitive, affective, and motivational dimensions simultaneously.

Methodology

Research Design

This study employed a developmental–experimental research design, combining elements of Research and Development (R&D) and a quasi-experimental pretest–posttest design. The developmental component involved the systematic design, creation, and expert validation of the DTP-based instructional materials following the ADDIE framework (Branch, 2009). The experimental component assessed the effectiveness of these materials through a pretest–posttest comparison between an experimental group (DTP-based instruction) and a control group (conventional instruction) at Paulba National High School, Division of Ligao City.

Participants

The study involved two intact sections of Grade 9 students at Paulba National High School for School Year 2025–2026, with 38 students per group (N = 76). The experimental group used DTP-based instructional materials, while the control group received conventional instruction over four weeks. For expert validation, a panel of ten mathematics educators and instructional materials specialists evaluated the developed materials using the standardized DepEd LRMDS Evaluation Rating Sheets for Printed Resources. A pilot test with 15 non-participant Grade 9 learners was conducted to validate test material consistency and the engagement survey instrument.

Development of Instructional Materials

Six DTP-based worksheets with accompanying lesson plans were developed targeting all Grade 9 Trigonometry Most Essential Learning Competencies (MELCs): (1) Illustrating the six trigonometric ratios; (2) Finding trigonometric ratios of special angles; (3) Illustrating angles of elevation and depression; (4) Using trigonometric ratios to solve real-life problems; (5) Illustrating laws of sines and cosines; and (6) Solving problems involving oblique triangles.

Each worksheet was structured around five iterative DTP stages: Empathize (The Human Story)—connecting abstract concepts to human contexts through locally relevant scenarios; Define (Strategic Problem Framing)—developing mathematical modeling skills; Ideate (Divergent Tool Selection)—fostering autonomy in problem-solving strategy selection; Prototype (Model Construction)—building procedural fluency and creative confidence; and Test (Iterative Evaluation)—reinforcing self-regulated evaluation. All scenarios were contextualized using community-based personas and real-world contexts from Paulba, Ligao City (e.g., designing a wheelchair ramp, calculating angles for a rescue mission on Mt. Masaraga).

Research Instruments

Three instruments were used: (1) a 50-item pretest–posttest measuring performance on Grade 9 Trigonometry competencies, validated through pilot testing (n = 15); (2) the DepEd LRMDS Evaluation Rating Sheets for Printed Resources, comprising a 4-point scale assessing content quality (Factors 1 and 4), instructional design (Factor 3), and technical characteristics (Factor 2); and (3) a researchers-developed 5-point Likert-scale Engagement Survey Questionnaire assessing affective, behavioral, cognitive, and self-efficacy dimensions.

Data Gathering Procedures

The study followed a systematic seven-step process: (1) group assignment of two intact Grade 9 sections as experimental and control; (2) pretest administration to both groups to establish baseline knowledge; (3) pre-intervention engagement survey administration; (4) intervention—four weeks of DTP-based instruction for the experimental group and conventional instruction for the control group; (5) posttest administration; (6) post-intervention engagement survey; and (7) data handling and analysis.

Statistical Tools

Descriptive statistics, including frequency count and weighted mean, were used to summarize validation and engagement data. For inferential analysis, paired-samples t-tests were conducted separately for both groups to assess within-group performance changes. The assumptions of interval-level measurement, normality of difference scores, and independence of observations were verified. Cohen's d was computed to assess effect size. Statistical significance was set at $\alpha = 0.05$. All analyses were performed using Jamovi.

Results and Discussion

Development of DTP-Based Instructional Materials

The researchers successfully developed a comprehensive set of six DTP-based worksheets with accompanying lesson plans targeting all Grade 9 Trigonometry MELCs. The materials employed a uniform five-stage Design Thinking template across all worksheets and were anchored in locally relevant 'Design Challenges' using community-based personas and real-world scenarios from Paulba, Ligao City.

Each DTP stage served a distinct pedagogical function grounded in the Triadic Model: the Empathize stage built Relatedness by connecting abstract concepts to human contexts; the Define stage developed mathematical modeling aligned with constructivist knowledge-building; the Ideate stage fostered Autonomy through divergent tool selection; the Prototype stage built procedural fluency and Creative Confidence; and the Test stage reinforced iterative, self-regulated evaluation.

The materials were systematically mapped to the six MELCs, ensuring full curricular alignment with the DepEd K–12 Mathematics Curriculum. A DTP-based Instructional Materials Design Plan, as shown in Table 1, guided the development process, incorporating competency codes, scenario titles, persona profiles, and stage-specific learning objectives.

The development of the DTP-based instructional materials was informed by an empirical analysis of the Region V Numeracy Assessment data from the 2024–2025 end-of-school-year (EOSY) cycle. Findings indicated that trigonometry constitutes a critical area of academic deficiency within the Grade 9 Geometry strand, as evidenced by a Mean Percentage Score (MPS) of 27.22. Diagnostic analysis further revealed significant learning gaps in higher-order cognitive skills, specifically "conjecturing and reasoning" and "proving and decision-making." Because these competencies are mapped to the Fourth Quarter of the Mathematics 9 curriculum, the researchers determined that the implementation of the study within this instructional period was both pedagogically relevant and logistically feasible.

WS	Competency (MELC)	Code	Design Challenge Scenario	DTP Stage Focus
W1	Illustrate the six trigonometric ratios (sine, cosine, tangent, secant, cosecant, and cotangent)	M9GE-IVa-1	Wheelchair ramp for Paulba NHS	Empathize: fairness/access Define: ratio labeling Ideate: ratio selection Prototype: solve ratios Test: test chosen method
W2	Finds trigonometric ratios of special angles (60° & 30°)	M9GE-IVb-c-1	Boradol Flying Contest at Tigbao Highlands	Empathize: confidence building Define: 30°-60°-90° special triangle Ideate: ratio selection Prototype: solve height h Test: alternate scenarios
W3	Finds trigonometric ratios of special angles (45°)	M9GE-IVb-c-1	Community Treehouse	Empathize: community safety Define: 45°-45°-90° triangle Ideate: exact value; select method Prototype: procedural fluency Test: alternate values
W4	Illustrates angles of elevation and depression; Solves problems involving right triangles	M9GE-IVd-1, M9GE-IV-e-1	Lighthouse-fisher scenario at Tambac, Ligao City	Empathize: fisher-lighthouse scenario Define: illustration and measure identification Ideate: appropriate trigonometric ratio Prototype: solve equation using tangent Test: alternate angle measure
W5	Illustrates the Law of Cosine; Solves problems involving oblique triangles	M9GE-IVf-g-1, M9GE-IV-h-j-1	Park Ranger in a community river	Empathize: park ranger duties Define: label triangle formed Ideate: appropriate law to use Prototype: computation using cosine law Test: test of method using different angle
W6	Illustrates the Law of Sine; Solves problems involving oblique triangles	M9GE-IVf-g-1, M9GE-IV-h-j-1	Rescue mission at Mt. Masaraga	Empathize: rescue a lost hiker Define: label triangle formed by stations Ideate: law selection Prototype: solve dimensions Test: evaluate accuracy

Table 1. DTP-Based Instructional Materials Design Plan

Extent of Validity of the DTP-Based Instructional Materials

Table 2 shows the summary of validity ratings of the DTP-based instructional materials in terms of Content Quality (LRMDS Factors 1 and 4), Instructional Design (LRMDS Factor 3) and Technical Characteristics (Factor 2).

Research Variable	LRMDS Factors	Weighted Mean	Verbal Interpretation
Content Quality	Factor 1: Content	3.94	Very Satisfactory
	Factor 2: Accuracy and Up-to-datedness	4.00	Very Satisfactory
Instructional Design	Factor 3: Presentation and Organization	3.98	Very Satisfactory
Technical Characteristics	Factor 2: Format	3.97	Very Satisfactory
Overall Validity		**3.97**	**Very Satisfactory**

Note: Ratings based on a 4-point scale: 3.50–4.00 (Very Satisfactory); 2.50–3.49 (Satisfactory); 1.50–2.49 (Poor); 1.00–1.49 (Not Satisfactory). Data processed from the summary of 10 expert Evaluation sheets.

Table 2. Summary of Expert Validation Results

The summary of expert Evaluation results provides a clear indication of the overall extent of validity of the DTP-based instructional materials for Grade 9 trigonometry. Across all LRMDS factors, such as content quality (Factors 1 and 4), instructional design (Factor 3), and technical specifications (Factor 2), the materials achieved Very Satisfactory ratings, with weighted means ranging from 3.94 to 4.00 and an overall validity of 3.97. These findings confirm that the developed materials meet high standards of educational quality, instructional coherence, and technical accuracy.

For content quality, Factor 1 (3.94) and Factor 4 (4.00) demonstrate that the materials are developmentally appropriate, aligned with learning objectives, cognitively engaging, inclusive, and free from conceptual, factual, grammatical, or computational errors. The high ratings across these indicators indicate that learners can access accurate, reliable, and pedagogically sound content that supports problem-solving, critical thinking, and iterative reasoning in trigonometry (Li & Zhan, 2022; Mehddi et al., 2025; Hidayat et al., 2023; Herianto et al., 2024).

The instructional design domain, reflected in Factor 3 (3.98), confirms that the materials are well-organized, logically sequenced, and visually clear, with vocabulary, sentence length, and paragraph structures adapted to learners' comprehension levels. Such a design promotes smooth cognitive processing and engagement throughout the Design Thinking Process stages, enabling students to construct, test, and refine solutions effectively (Maamin et al., 2022; Tytler et al., 2023).

Factor 2 (3.97) for technical characteristics highlights that the materials are professionally presented, durable, and physically accessible, with clear prints, illustrations, layout, and appropriate size and weight for classroom use. High-quality formatting ensures that learners can focus on reasoning and application without being hindered by technical or usability issues (Herianto et al., 2024; Hidayat et al., 2023).

Effects of the DTP-based Instructional Materials in Students' Performance

To determine whether the developed DTP-based instructional materials significantly impacted Grade 9 students' mastery in Trigonometry, the researchers conducted dependent t-tests on the pretest and posttest scores independently for both the control and experimental groups.

	Pretest Mean	Posttest Mean	df	α	T_{tab}	T_c	Effect size	Decision to Ho	Conclusion
Control	12.58	27.13	37	.05	2.026	11.04	1.79	Reject	Significant
Experimental	12.89	36.61	37	.05	2.026	22.2	3.61	Reject	Significant

Note: The results were obtained using a Paired Samples T-test. The null hypothesis (Ho) is rejected when Tc > Ttab; df – degrees of freedom; Tc – calculated t-value; Ttab – tabulated t-value at α=.05

Table 3. T-test Summary for Students' Performance in Grade 9 Trigonometry

As shown in Table 3, the paired-samples t-test for the control group revealed a pretest mean of 12.58 and a posttest mean of 27.13, with a calculated t-value (T = 11.04) exceeding the critical t-value (T = 2.026) at a significance level of $\alpha = 0.05$ with a large effect size of 1.79. This led to the rejection of the null hypothesis, indicating that the control group experienced a statistically significant improvement in performance despite receiving conventional instruction. The increase in mean scores suggests that standard instructional practices, while less targeted than DTP-based interventions, still contributed to measurable learning gains.

For the experimental group, the paired-samples t-test revealed a pretest mean of 12.89 and a posttest mean of 36.61, with a calculated t-value (T = 22.2) exceeding the critical t-value (T = 2.026) at $\alpha = 0.05$ with a large effect size of 3.61. This result indicates a statistically significant improvement in mastery after using the DTP-based instructional materials. The mean gain of 23.72 points is substantially higher than that observed in the control group, demonstrating the effectiveness of the DTP-based materials in promoting conceptual understanding, procedural fluency, and application of trigonometry skills.

The significant increase in performance reflects the impact of the Design Thinking Process, where learners actively engage in each stage—Empathize, Define, Ideate, Prototype, and Test—to construct and refine solutions iteratively. By incorporating real-world problem contexts, stepwise reasoning, and opportunities for reflection, the materials help students overcome difficulties in estimating values, visualizing relationships, and applying trigonometric concepts (Hidayat et al., 2023; Herianto et al., 2024). The results also suggest that integrating higher-order cognitive tasks into worksheets fosters student agency, problem-solving skills, and confidence, supporting both performance and engagement outcomes highlighted in the RRL (Mehddi et al., 2025; Li & Zhan, 2022).

Effects of the DTP-based Instructional Materials in Students' Engagement

The researchers also analyzed the data from the student engagement surveys administered before and after the four-week implementation to both groups. Engagement was treated as a multidimensional construct comprising affective, behavioral, cognitive, and self-efficacy components. Table 4 shows the comparison of the pre- and post-survey engagement surveys.

Engagement Dimensions	Control		Experimental	
	Pre-Mean	Post-Mean	Pre-Mean	Post-Mean
Affective	3.44	4.00	3.98	4.04
Behavioral	3.39	4.01	3.45	4.04
Cognitive	3.37	3.69	3.43	4.13
Self-Efficacy	4.08	4.26	4.13	4.45
Overall Mean Score	**3.47**	**3.94**	**3.52**	**4.11**

Table 4. Comparison of Pre- and Post-Survey Engagement Surveys

Based on the data, students who utilized the DTP-based instructional materials demonstrated a markedly higher final engagement level (4.11) compared to the control group (3.94). While both groups showed gains, the experimental group's trajectory toward higher levels of interest and participation was more pronounced, particularly in the cognitive and self-efficacy domains. Both the affective (emotional response) and behavioral (participation) dimensions in the experimental group reached a post-intervention mean of 4.04. This reflects a shift from "Neutral" to "Agree" regarding indicators such as finding trigonometry interesting and seeing its utility in the real world.

The implication of this improvement is tied to the Empathize stage of the DTP. By grounding abstract concepts in student context, the materials satisfied the students' psychological need for Relatedness, a core component of Self-Determination Theory (SDT). Research indicates that affective engagement is a key predictor of achievement; students who experience positive emotions toward mathematics are more likely to seek help and persist in difficult activities. By humanizing the subject, the DTP-based worksheets effectively countered the "dreaded" and "boring" perceptions typically associated with secondary trigonometry.

Limitations of the DTP-based Instructional Materials

Based on evaluation of the implementation and utilization of the DTP-based instructional materials, several limitations were noted. These limitations do not negate the materials' demonstrated impact; rather, they describe the empirical boundaries of the present iteration and constitute a foundation for continued, iterative refinement which is consistent with the Design Thinking principles upon which the materials are constructed.

Implementation Constraints. The four-week implementation period yielded statistically significant increases in both learning outcomes and student engagement; however, the brevity of this period imposed constraints on the depth to which students could develop proficiency across the trigonometry competency areas (Hennessey & Mueller, 2020). Although the experimental group achieved a posttest mean score of 36.61 out of 50 (73.22%), which is higher than their pretest mean of 12.89 (25.78%), this figure fell marginally below the 75% mastery threshold prescribed by the Department of Education (DepEd), indicating that the students' capacity to attain full mastery of the targeted trigonometry competencies can be limited by the implementation period.

Need for Teacher Scaffolding. A further limitation pertains to the degree to which the DTP-based instructional materials function as self-executing resources. Although the materials were designed and evaluated with the intention of independent operability, evidence gathered during implementation suggests that they are not entirely self-executing in practice. This observation is substantiated by the expert validation results. While the materials received an overall rating of 3.97, with a verbal interpretation of Very Satisfactory across all ten LRMDS criteria, the comparatively lower ratings assigned to the material's capacity to generate learner interest (3.90) and the adequacy of safety and cautionary information provided (3.80) merit particular attention. With respect to the latter rating, expert validators noted that the effective and safe use of the DTP materials is contingent upon active and informed teacher facilitation, particularly in activities involving practical measurements and cooperative problem-solving (Herianto et al., 2024).

Scope and Generalizability. The generalizability of the study's findings is further constrained by the specific boundaries within which the materials were developed, validated, and tested which are boundaries explicitly outlined in the Scope and Delimitation section of this research. The study was conducted at Paulba National High School, a rural public secondary institution situated in Ligao City, Albay. As the materials were developed and evaluated exclusively for Grade 9 Mathematics

(Math 9, Quarter 4 - Trigonometry), the findings cannot be assumed to transfer without modification to different grade levels, subject areas, school types, or regional contexts.

Resource Sensitivity. DTP instructional materials are print based. This was done to ensure that they could be accessed in low-resource, technology limited public schools in rural Bicol. While this was a strong design choice, it also represents an implicit limitation to the effectiveness of the DTP instructional materials in that their effectiveness rests on a set of "modest" but not universally present teacher classroom conditions present in all public secondary schools in the Philippines.

Conclusion and Recommendations

Conclusions and Implications

1. Design Thinking Process can be effectively operationalized as a framework for developing instructional materials in Grade 9 Trigonometry. The six DTP-based worksheets developed in this study demonstrate that abstract mathematical concepts can be meaningfully embedded within human-centered, iterative design challenges that are locally contextualized and curriculum-aligned. The Empathize–Define–Ideate–Prototype–Test structure provides a coherent pedagogical scaffold that transforms passive, procedural learning into active, reflective, and problem-solving-centered engagement.

2. The DTP-based instructional materials are highly valid and pedagogically sound for Grade 9 Trigonometry instruction. The 'Very Satisfactory' ratings from expert evaluators across content quality, instructional design, and technical characteristics confirm that the materials are developmentally appropriate, curriculum-aligned, and professionally produced, making them ready for large-scale classroom implementation.

3. Both instructional methods (traditional and DTP-based) are effective in improving student performance, but the integration of DTP-based instructional materials leads to a significantly higher level of academic achievement. The rejection of the null hypotheses for both groups confirms that learning occurred in both environments; however, the experimental group demonstrated a much more pronounced mastery of trigonometric concepts. This suggests that the structured, iterative nature of the Design Thinking Process provides a superior framework for addressing the conceptual and procedural difficulties typically associated with the subject. In addition, the DTP-based instructional materials foster a high level of multidimensional involvement in the learning process. The materials proved particularly successful in enhancing students' cognitive investment and self-efficacy, suggesting that the human-centered, iterative design of the lessons empowers students to take ownership of their learning and builds their confidence in tackling challenging trigonometry problems.

4. The evaluation of the DTP-based instructional materials' implementation exposes four defining boundaries, such as time constraints, dependence on skilled teacher facilitation, bounded contextual generalizability, and sensitivity to classroom resource conditions, that do not undermine the materials' proven validity and effectiveness, but instead sharpen the direction for their iterative refinement. This affirms that the Design Thinking Process demands not perfection at first execution, but the intellectual honesty to recognize, name, and act on the conditions that shape its fullest realization.

Recommendations

1. The Design Thinking Process (DTP) should be integrated into the development of lesson plans and instructional modules for other complex mathematics topics to replicate the high level of academic growth.

2. The DTP-based instructional materials should be formally adopted for classroom use and undergo a wider cycle of implementation to establish their long-term viability across different school environments.

3. The use of iterative instructional designs be expanded beyond a single unit of study to include all major competencies in the mathematics curriculum, ensuring that the enhanced performance levels are sustained throughout the entire academic year. In addition, future instructional designs should prioritize human-centered and iterative elements that focus on student self-efficacy, ensuring that the psychological and behavioral aspects of learning are addressed alongside academic content.

4. To fully realize the transformative potential of the DTP-based instructional materials, future implementations must be supported by an extended instructional timeline, a dedicated Teacher's Guide with structured professional development, multi-context validation studies, and a classroom readiness framework — collectively ensuring that the materials perform with fidelity, equity, and scalability across diverse educational settings.

Acknowledgement

The authors would like to thank the colleagues and institutions who provided guidance, feedback, and support throughout the conduct of this research and the preparation of this manuscript. Any remaining errors or omissions are the sole responsibility of the authors.

Funding

This research received no external funding from any public, commercial, or not-for-profit funding agency, and no organization provided financial support for the conduct of the study, authorship, or publication of this article.

Competing Interests Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study; all data used were obtained from previously published sources as cited in the reference list.

References

Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Brown, T. (2019). *Change by design: How design thinking transforms organizations and inspires innovation* (Revised ed.). Harper Business. https://books.google.com/books/about/Change_by_Design_Revised_and_Updated.html?id=JEdfDwAAQBAJ

EDCOM II. (2026, January 29). *Turning point: A decade of necessary reform (Final report)*. Second Congressional Commission on Education. https://edcom2.gov.ph

Hennessey, E., & Mueller, J. (2020). Teaching and learning design thinking (DT): How do educators see DT fitting into the classroom? *Canadian Journal of Education / Revue Canadienne de l'éducation, 43*(2), 498–521. https://doi.org/10.28991/cje.v43i2.4033

Herianto et al., (2023). Effect of science virtual laboratory combination with demonstration methods on lower-secondary school students' scientific literacy ability in a science course. *Education and Information Technologies, 28*(12), 16153–16175. https://doi.org/10.1007/s10639-023-11857-8

Hidayat et al., (2023). How can android-based trigonometry learning improve the math learning process? *Frontiers in Education, 7*, Article 1101161. https://doi.org/10.3389/feduc.2022.1101161

Li, T., & Zhan, Z. (2022). A systematic review on design thinking integrated learning in K-12 education. *Applied Sciences, 12*(16), Article 8077. https://doi.org/10.3390/app12168077

Maamin, M., Maat, S. M., & H. Iksan, Z. (2022). The influence of student engagement on mathematical achievement among secondary school students. *Mathematics, 10*(1), Article 41. https://doi.org/10.3390/math10010041

Mehddi, F., Kazi, A. S., & Butt, A. I. (2025). From theory to practice: How STEAM professional development shapes teacher beliefs and perceptions about design thinking activities. *SAGE Open, 15*(2). https://doi.org/10.1177/21582440251355779

OECD. (2021). *Adapting curriculum to bridge equity gaps: Towards an inclusive curriculum.* OECD Publishing. https://doi.org/10.1787/f76de618-en

Tytler et al., (2023). Exploring a framework for integrated STEM: Challenges and benefits for promoting engagement in learning mathematics. *Research in Integrated STEM Education, 1*(1), 1–30. https://doi.org/10.1163/27726673-00101002

Vianna, M., Vianna, Y., Adler, I. K., Lucena, B., & Russo, B. (2012). *Design thinking: Business innovation.* MJV Press. https://cdn2.hubspot.net/hubfs/1701231/Documents/Design_Thinking_The_Book/Design_Thinking_The_Book.pdf

Appendices

No appendices are attached to this study.