



## Development and Validation of Digitalized Instructional Material in Problem Solving Involving Probability in Las Nieves District Cluster III

Mariel G. Belonta<sup>1\*</sup>, Dr. Donald D. Orbillos<sup>2</sup>

<sup>1</sup>Saint Joseph Institute of Technology, Butuan City, Philippines

\*Corresponding author, mariel.belonta@deped.gov.ph

DOI: <https://doi.org/10.63680/ijstate062631.29>

### Abstract

This study developed and validated a digitized instructional material (DIM) on problem-solving involving Probability for Grade 10 learners in the Las Nieves District Cluster III, Agusan del Norte, Philippines. Guided by Mayer's Cognitive Theory of Multimedia Learning and the ADDIE Model (Analysis, Design, Development, Implementation, and Evaluation), the study employed a descriptive-developmental research design involving 106 Grade 10 learners and 10 Mathematics teachers for focus group discussions. Analysis of third-quarter examination results identified Probability as the least-mastered competency, obtaining a Mean Percentage Score (MPS) of 45%, interpreted as "Not Mastered," indicating a substantial competency gap. The developed DIM, created through PowerPoint with Visual Basic for Applications (VBA), incorporated animations, simulations, interactive quizzes, gamified activities, and self-assessment tools. Expert validation using the Learning Resources Management and Development System (LRMDS) evaluation tool confirmed the material's instructional validity and acceptability with respect to content, language, instructional design, multimedia functionality, and assessment quality. Effectiveness testing revealed a significant improvement in learners' academic performance, with mean scores increasing from 8.12 on the pretest to 22.41 on the posttest ( $p = 0.001$ ). Findings demonstrate that digital instructional materials are effective learner-centered interventions for addressing competency gaps and enhancing conceptual understanding and problem-solving skills in Mathematics 10 Probability.

**Keywords:** Digital Instructional Material, Probability, Mathematics 10, ADDIE Model, Multimedia Learning

### Introduction

The rapid pace of global change required schools and teachers to adopt innovative approaches that prepared learners for the demands of the 21st century. In the Philippines, Republic Act No. 10533, otherwise known as the Enhanced Basic Education Act of 2013, emphasized integrating technology into the K-12 curriculum through flexible, learner-centered, and responsive teaching approaches. Despite these mandates, many mathematics classrooms continued to rely heavily on traditional and static instructional materials. As a result, learners often struggled to understand abstract concepts, demonstrated low engagement, and had limited opportunities for interactive and visual learning experiences, particularly in Mathematics 10.

The persistent challenges in mathematics education were evident in both international and national assessments. According to the Program for International Student Assessment (PISA), Filipino learners continued to perform significantly below global standards in mathematics. The Philippines obtained an average score of 353 in Mathematics in 2018, far below the OECD average of 489 and ranking among the lowest-performing countries (World Bank, 2020). Similarly, in the 2022 PISA cycle, Filipino learners scored 355, which remained substantially lower than the OECD average of 490 (OECD, 2023).

These findings highlighted the ongoing difficulties faced by Filipino learners in mathematical literacy, critical thinking, and problem-solving (Philstar, 2023). Recent reports further underscored the severity of the country's numeracy crisis. The Second Congressional Commission on Education (EDCOM II) revealed that many Filipino learners were four to five years behind expected numeracy levels, with Grades 8 and 9 learners performing at approximately the Grade 4 level in mathematics (Rappler, 2025). Likewise, the Department of Education reported significant declines in mathematics proficiency across grade levels, with only a small proportion of senior high school graduates demonstrating functional numeracy skills (Philippine News Agency, 2026). Other national assessments showed minimal improvement in mathematics performance between 2019 and 2024 (Philstar, 2025), underscoring the urgent need for stronger instructional strategies, curriculum alignment, teacher capacity-building, and targeted intervention programs (Rappler, 2026).

These challenges were particularly evident in Las Nieves District Cluster III, Agusan del Norte Division, which included Durian National High School Main and Bokbokon Annex, Casiklan National High School, and Lawan-lawan National High School. Teachers handling Grade 10 Mathematics often encountered difficulties in addressing least-mastered competencies due to limited instructional resources. Existing textbooks and modules frequently failed to provide sufficient activities and learning experiences necessary for mastery. Moreover, the schools were situated in remote areas where access to technology remained limited, reducing learners' exposure to innovative digital learning resources. This situation highlighted the potential value of Digitalized Instructional Materials (DIMs), which could enhance conceptual understanding, learner motivation, and engagement through interactive and multimedia-based learning experiences.

The development of Digitalized Instructional Materials was supported by several Department of Education policies. DepEd Order No. 12, s. 2020 emphasized the use of the Most Essential Learning Competencies (MELCs) as a foundation for effective instruction. Likewise, DepEd Order No. 35, s. 1988 encouraged the development of instructional materials and teaching aids to improve the teaching-learning process. More recently, DepEd Order No. 24, s. 2023 highlighted the importance of developing alternative and contextualized learning resources to ensure accessible and effective instruction (Suaybaguio, 2025). Collectively, these policies reinforced the need for innovative instructional materials that addressed diverse learner needs and improved academic achievement.

Therefore, this study aimed to develop and validate Digitalized Supplementary Instructional Materials (SIMs) for Mathematics 10 in the Las Nieves District Cluster III. The materials were intended to address least-mastered competencies while providing innovative, technology-enhanced learning experiences that promoted conceptual understanding, problem-solving skills, learner engagement, and independent learning. Furthermore, the study sought to ensure that the developed materials were valid, reliable, and aligned with DepEd standards, thereby contributing to improved numeracy outcomes among secondary school learners.

## Related Studies

Serrano (2026) explored the teaching of matrix multiplication in secondary mathematics using GeoGebra-based instructional materials. The study performed digital studies of mathematical notions with students. Notably, digitalization in mathematics education also fosters collaborative and self-directed learning. Students were empowered to take active roles in their learning through access to interactive lessons, quizzes, and formative assessments (Weinhandl, 2025). Moreover, systematic reviews revealed that digital instructional materials positively influence learners' cognitive, affective, and psychomotor development, enhancing their overall readiness for higher-level mathematics and future career skills (Deslis, 2025).

Thus, a study revealed the importance of developing materials that address learners' differences. Digitized instructional materials supported differentiated instruction, nurtured students' multiple intelligences through content and skills, and enabled them to receive feedback tailored to their learning gaps

(Bantulo, 2025). This personalized approach has been associated with improved performance, motivation, and engagement in mathematics (Alghelib, 2025).

However, digital learning environments could offer personalized learning routes to meet the specific demands and learning styles of pupils (Joshi, 2025). Research has shown that early exposure to mathematical concepts predicts subsequent success, underscoring the importance of resources that promote exploration, problem-solving, and pattern recognition (Bantulo, 2025).

In this respect, society was still progressing digitally, and pupils were more likely to use interactive materials rather than traditional print resources. Hence, it was vital to foster learners' digital literacy to enable them to engage with these tools effectively (Wang et al., 2025). Interactive e-books and multimedia modules, contextualized and tailored, provide chances for learners to gain abilities relevant to the digital age (Cunha et al., 2025). These materials enabled customized learning, allowing students to advance at their own pace while offering immediate feedback.

Unfortunately, several recent studies highlighted the development and validation processes of digital instructional materials. Research has shown that structured instructional design frameworks, such as ADDIE and hybrid models, are effective for creating materials that meet educational standards and learners' needs (Udani, 2025). Validation through expert review and pilot testing ensured the reliability, accuracy, and appropriateness of content (Mamugay, 2025). These processes not only enhance the quality of instructional materials but also improve student learning outcomes.

Acantilado, meanwhile, developed interactive e-learning modules for Grade 5 science (2025). The project, which was based on the ADDIE instructional design paradigm, was reviewed by teachers, master teachers, and school administrators who are experts in the field. The materials were evaluated in terms of the learning environment, the teaching-learning process, and the evaluation procedures. Results showed that evaluators rated the resources highly overall and found that they were successful in helping to apply the program. The study's findings suggested that interactive e-learning materials encourage student engagement and provide meaningful learning experiences.

Studies further showed that the use of digital teaching tools in mathematics improves students' academic performance, engagement, and motivation. Digital tools such as interactive simulations, gamified modules, and virtual manipulatives have been shown to increase conceptual understanding and memory (Algheli, 2025).

One example was the Department of Education's Open Educational Resources (OER) program, which demonstrated how digital platforms can provide equitable access to high-quality learning materials, promoting curriculum implementation even in locations with inadequate connectivity (Deslis, 2025). These tools supported student-centered approaches and promoted continuity of learning. Additionally, Ibona-Mabini and Petancio (2025) investigated the effectiveness of game-based learning techniques in improving arithmetic achievement among 28 students in a one-group pretest-posttest action research design. The results showed that students' attitudes toward mathematics had changed and that their post-test scores had increased significantly. When participating in digital game-based learning activities, students reported increased motivation and engagement. The study found that the use of instructional materials and digital learning technologies improves students' mathematics learning outcomes.

Nevertheless, Macalikod and Simpall (2025) conducted a study on the creation and validation of Science Instructional Materials (SIMs) intended to address students' least-taught competencies in Grade 8. The study used a research and development methodology in which curriculum experts, science instructors, and master teachers verified SIMs developed from assessment data. High ratings for organization, presentation, and content quality were observed in the results. The results imply that learning gaps in science education can be filled using well-organized teaching resources. The authors concluded that proven educational resources greatly aid students' mastery of challenging ideas. Also, Fuentes (2025), to teach ideas and practices in Master of Public Administration programs, created and validated educational resources. Students assessed the modules' format, learning activities, and subject relevancy using a descriptive research approach. The modules' learning material was assessed as extremely satisfactory, according to the results, but the presentation and evaluation techniques needed improvement. The results highlighted how crucial well-organized teaching resources are for professional education. The study concluded that ongoing improvements to instructional materials guarantee improved learning outcomes in higher education programs.

On the other hand, Benedicto, Artajo, and Martir (2025) conducted a study on the development, acceptability, and validation of an Organization and Management learning module for senior high school students. The study design used was a descriptive research design and module development methodologies. The teachers and professionals rated the module's usability, format, and substance. The findings revealed that teachers and students regarded the instructional module as quite satisfying, notably in terms of curriculum relevance and exercise clarity. The researchers concluded that authorized instructional modules can improve students' understanding of management concepts and increase educational effectiveness. Ravalo and Flores (2024) studied the construction of digital supplemental materials to overcome arithmetic learning backlogs. Using the ADDIE instructional design technique, the researchers surveyed Grade 9 math teachers to pinpoint the least-mastered competencies. They developed additional digital resources that were validated by professional evaluators and piloted with 87 Grade 10 students. The results showed that the students' post-test scores were much higher than their pre-test scores, and the digital materials had good validity. The study concluded that well-designed digital supplemental instructional materials can boost curriculum completion and mathematics learning.

In the same way, Quintos (2024) studied the development and validation of instructional materials designed to teach university students Japanese (Nihongo). Using a quantitative descriptive research design, learning modules were developed based on learners' language proficiency levels and were verified by professionals. The findings revealed that instructional materials improved students' language and comprehension abilities, especially in grammar and communication. Validators gave the content excellent marks for both instructional value and clarity. The study concluded that well-crafted language-teaching resources help students learn foreign languages more successfully.

Conversely, Alcisto et al. (2024) created an electronic module to teach Earth's motions to sixth-grade science students. They assessed students' conceptual understanding before and after exposure to the e-module using a one-group pretest–posttest research design. Subject matter experts evaluated the teaching materials, which were created utilizing the 7E instructional approach. The results showed that students' interest in class and achievement levels had significantly improved. Interactive e-modules can effectively enhance science learning and target the least-mastered competencies, according to the study's findings. Likewise, Cuales and Palomares (2024) looked into the creation and verification of additional teaching resources on linear inequalities for eighth-grade pupils. The study employed a developmental research methodology, in which master teachers used evaluation rubrics to verify teaching materials developed based on least mastered competencies. The materials received very high scores for content accuracy, organization, and usefulness, based on data collected from 265 students. Results indicate that verified supplemental resources enhance students' comprehension of mathematical concepts and complement classroom instruction. The researchers concluded that creating instructional materials is crucial to closing math learning gaps.

To boost student engagement, Pagiling et al. (2024) investigated the development of mathematics teaching modules based on differentiated instruction. Twenty-two secondary students participated in the study, which used the ADDIE development paradigm. The produced module was highly valid, according to validity testing utilizing V-Aiken's technique, and teacher and student responses revealed strong practicality. The results showed improved cognitive, behavioral, and emotional engagement in studying mathematics. The study concluded that well-designed instructional modules can improve students' motivation and learning experience in mathematics.

Moreover, Gadingan (2024) evaluated students' opinions of module quality in terms of content, assessment, and presentation using a quantitative survey design. The results showed that students found the modules very acceptable and that greater acceptance was associated with better math performance. The study highlighted how well-made educational resources can promote self-directed learning and raise student achievement. The author concluded that instructional modules remain a useful addition to mathematics education. Pillas (2024) developed alternative teaching materials for Mathematics 10 to address the least-mastered skills among secondary pupils. The researcher evaluated the effectiveness of the materials produced using a one-group pretest–posttest design among secondary school pupils. The results demonstrated the effectiveness of the educational materials, as the students' post-test scores improved significantly. Teachers also rated the resources high for usage and relevance. The study found that good teaching tools can help pupils'

understanding of mathematical concepts.

In addition, Angraini et al. (2024) studied the use of augmented reality as a digital learning aid to improve mathematical computational thinking by using augmented reality apps in junior high school math courses as part of the study's experimental research approach. The findings indicated that students who used digital technology demonstrated higher levels of computational thinking and problem-solving ability than those who employed traditional methods. The results show how digital teaching resources can increase the interactive character of mathematics instruction. The study has found that technological teaching resources increase students' understanding and involvement.

Thus, Lim (2024) studied an interactive learning module aligned with the K-12 curriculum. The study was developed and validated through expert evaluation and experimental testing with eighth-grade students. Results showed that students who received the interactive module performed better academically than those who received regular instruction. The module's instructional design and usability were also scored well. The findings of the study suggest that interactive digital modules are good supplementary teaching materials.

Ramos and Adventist (2024) studied the mathematical skills of seventh-grade students to identify the least-taught skills. The researchers employed a quantitative descriptive method and diagnostic tests. Results indicated that several competencies required instructional support, particularly in mathematics and number skills. The researchers concluded by developing specific teaching resources to address the learning gaps. The research findings demonstrate the effectiveness of competency-based teaching tools in improving students' learning outcomes. However, Kandukoori et al. (2024) examined the efficacy of digital learning resources compared with conventional methods of teaching mathematics. Students were split into two groups using an experimental design, with one group using digital platforms and the other using conventional worksheets. The results demonstrated that pupils who used digital tools outperformed those in the traditional group in terms of improving their arithmetic skills. The study concluded that students' mathematics learning outcomes can be improved through the use of digital instructional tools.

Therefore, a study emphasized the need to develop materials that respond to learner diversity. Digital instructional tools support differentiated instruction, so students with varying abilities can access content, practice skills, and receive feedback tailored to their learning needs (Bantulo, 2025). This personalized approach has been linked to better results, motivation, and engagement in mathematics (Alghfelib, 2025). However, digital learning environments offer personalized learning paths that cater to students' specific needs and learning styles (Joshi, 2025). Research shows that early engagement with mathematical concepts predicts later achievement, stressing the importance of materials that promote exploration, problem-solving, and pattern recognition (Bantulo, 2025).

In this regard, society is still moving forward with digitalization, and students prefer more interactive materials than traditional print materials. Hence, developing learners' digital literacy is vital to engage effectively with these tools (Wang et al., 2025). Interactive e-books and multimedia modules, contextualized and personalized, provide opportunities for learners to develop competencies relevant to the digital age (Cunha et al., 2025). These resources enable differentiated learning, allowing students to learn at their own pace and receive instant feedback. Additionally, Kumar and Sharma (2024) examined how students' interest in social science education was affected by digital teaching resources. The study employed a mixed-methods research approach that included academic assessments, surveys, and classroom observations. The results demonstrated that the use of digital resources enhanced students' engagement and understanding of social science concepts. The resources were also useful to teachers while teaching difficult subjects. The study concluded that digital instructional tools enhance interactive learning environments.

Lim (2024) also developed and validated an interactive Earth Science learning module for Grade 8 that aligns with the K-12 curriculum. One group of students used the generated module, while another group received traditional training, as part of the study's research and development design, which included experimental testing. Expert validators assessed the content, design, and usability of the material. Results indicated that students who used the interactive module showed greater involvement in class and scored higher on science exams. According to the study's findings, interactive modules are useful supplementary teaching resources that enhance students' conceptual understanding and engagement. Also, Santos (2023) investigated the creation of multimedia teaching resources for secondary mathematics education. Multimedia modules were tested with students and validated by subject matter experts using a developmental research

design. The integration of multimedia resources into courses was found to boost student comprehension and engagement. Additionally, instructors stated that using digital resources helped them deliver lessons more successfully. Multimedia-based teaching resources are helpful when teaching mathematics, according to the study's findings.

Unfortunately, Dickey and Bejarano (2023) created educational materials by utilizing generative artificial intelligence. The study investigated how AI technologies can assist with content generation and curriculum design using a framework development process. The results indicated that, while maintaining quality and instructional relevance, AI-assisted instructional design shortens the time required to create instructional materials. The framework integrates technological, pedagogical, and content knowledge principles. The study concluded that there is great promise in increasing the effectiveness of educational material creation through AI-supported instructional development. Subsequently, Garcia and Torres (2023) investigated the creation of multimedia teaching resources for teaching history. Multimedia resources were developed and tested with secondary school students using a developmental research design. The findings showed that students who used multimedia resources showed greater levels of engagement and historical comprehension. Teachers said that interactive and visual components made difficult historical events easier to understand. Multimedia teaching resources enhance learning outcomes in humanities education, according to the study's findings.

Yan et al. (2023) also reviewed the application of large language models in education and their role in creating instructional content. The study analyzed more than 100 research articles to determine how AI technologies support teaching tasks such as feedback generation and content development. The results showed that AI technology can help teachers create educational materials and enhance learning support systems. However, the study also brought attention to implementation-related ethical and practical issues. The authors concluded that when applied sensibly and under human supervision, AI technologies can improve the creation of educational materials. Subsequently, Ahmed and Lee (2023) analyzed digital learning modules developed for secondary mathematics education. The study utilized an experimental research design to assess the effectiveness of the modules among secondary school students. Results showed that students who used the digital modules performed better on tests and solved problems more effectively. The study emphasized the importance of using digital technology in math lessons. The study found that digital modules improve how well students learn and what they learn.

Moreover, Tan and Ong (2023) created an online course for secondary school math instruction. The module was developed using instructional design principles and validated through student testing and expert evaluation. High validity ratings and increased student achievement following module use were found in the results. Additionally, students reported feeling more motivated and interested in learning mathematics. According to the study's findings, e-learning modules are useful resources for improving math instruction. Additionally, Lopez (2023) investigated the usefulness of additional digital teaching resources in secondary mathematics education. The researcher compared students' academic performance before and after the use of the materials in a quasi-experimental design. Students' math scores significantly improved after using the digital resources, according to the results. Additionally, students showed increased confidence in their ability to solve mathematical puzzles. The study concluded that digital supplemental materials can effectively support learning mathematics.

To address the least mastered competencies, Domingo (2023) explored the development and assessment of an Earth and Life Science learning module for Grade 11 students. The research and development design used in this study was adapted from the ADDIE model and consisted of the preparation, development, and validation phases. During instruction, students used the material, and five science professionals evaluated the module's content accuracy, organization, and instructional quality. The results showed that the module had high validation scores and was useful to students' learning. The study found that competency-driven modules designed utilizing structured design frameworks could improve students' understanding of scientific concepts and lead to effective teaching. In this context, Tan and Ong (2023) studied the development of a business education e-learning module. The module's effectiveness was validated by the researchers using expert validation and instructional design principles. Students who used the lesson exhibited increased excitement for their learning and improved understanding of business concepts. Instructors commented that the curriculum encouraged self-directed learning. The study's findings indicate that e-learning modules offer

flexible learning opportunities in modern education.

Zhao and Chen (2023) improved science teaching in secondary schools. A mixed-methods approach was used to collect teacher feedback and student performance data. The study found that students who used the digital platform were more engaged and performed better than their counterparts who used traditional approaches. Teachers said the program enabled engaging learning opportunities. The study suggests that digital platforms can be beneficial teaching tools to further science learning objectives. Thus, Rahman (2022) investigated the creation of technology-based teaching resources for mathematics in secondary schools. Expert validation and field testing were part of the study's research and development methodology. The results showed that the resources created successfully increased students' comprehension and engagement in math classes. Additionally, students expressed favorable opinions of digital learning materials. The study concluded that technology-based teaching resources are useful tools for improving mathematics instruction.

Garcia (2022) investigated the extent to which additional teaching resources enhanced secondary students' mathematics performance. The researcher compared students who used supplemental materials with those who received traditional instruction using a quasi-experimental design. The findings showed that students with access to additional materials performed better on achievement tests. The results highlight how crucial it is to offer more teaching materials in math classrooms. The study concluded that additional resources support students' comprehension of mathematical ideas. However, Chen (2022) looked into the creation and assessment of technology-based teaching resources for math classes. The materials were created, verified by professionals, and tested with students using a developmental research methodology. The utilization of technology-based materials was found to enhance learning outcomes and increase student engagement. The study emphasized the importance of incorporating digital tools into math instruction. The study concluded that validated digital instructional resources improve both teaching and learning processes.

The recent global health crisis has transformed educational practices, particularly highlighting the need for flexible and technology-assisted teaching (Gabriel et al., 2022). Moreover, interactive E-books, through contextualization and personalization, provide opportunities to access learning and to form and develop competencies for current learners (Lam et al., 2022). Furthermore, Hamora et al. (2022) examined students' evaluations of faculty-developed instructional modules employed during modular learning in higher education. A total of 644 college students participated in the study, which employed a descriptive-correlational research methodology. They evaluated the instructional quality, intelligibility, and relevance of the modules. The findings showed that students thought the modules were beneficial for supporting independent learning and gave them high ratings. Several modifications were proposed to improve the presentation and evaluation components. The study concluded that continuous evaluation and adjustment of educational modules are necessary to maintain instructional quality and effectiveness.

Hamamsy et al. (2022) developed the Computational Thinking Test (cCTt), sanctioned by El-, for application with upper primary school students. More than 1,500 students participated in the evaluation, which utilized psychometric validation methods such as confirmatory factor analysis and classical test theory. The results demonstrated the instrument's significant validity and reliability in evaluating computational thinking abilities. The researchers concluded that verified assessment tools are essential for measuring educational outcomes and guiding curriculum development in digital education. Consequently, Rahman and Islam (2022) examined the development of technology-driven educational materials for language acquisition. The researchers developed digital modules using a research and development methodology and subsequently validated them through expert evaluation and classroom implementation. Findings demonstrated enhanced student enthusiasm and language proficiency following the utilization of the materials. Additionally, students held favorable views of technology-integrated education. The study concluded that digital teaching resources enhance the effectiveness and engagement of language training.

Furthermore, Cruz's (2022) learning materials are meant to re-teach the least-learned concepts and skills. These materials are given to students to help them master competencies they could not develop in a regular classroom setting. The new pedagogical approaches can be challenging to implement. Many teachers are not experts in learning strategies and have not immersed themselves in the extensive literature on teaching and learning; teachers are experts in their disciplines, and many teach using traditional methods that reflect how students learn. Students need to learn and master the competencies in the early grades, particularly in Math, for one skill may be a prerequisite to another. Thus, Math teachers should be equipped with more than

just teaching strategies and techniques. However, they should also be equipped with appropriate instructional materials, such as Digitalized Instructional Materials, as highlighted in this study.

In summary, the literature review highlighted the growing significance of digital instructional materials in mathematics education, particularly in enhancing learner engagement, achievement, and readiness for higher-level learning. The research emphasized the need for systematic development, validation, and teacher preparation to maximize the effectiveness of these materials. These insights form the foundation of the present study, which aimed to develop and validate digitized instructional materials for Mathematics 10 learners in the Las Nieves District Cluster III.

## **Theoretical / Conceptual Framework**

This study was anchored on Mayer's Cognitive Theory of Multimedia Learning (CTML), which posits that learners acquire, process, and retain information more effectively when instructional materials are designed to align with the cognitive processes involved in learning (Mayer, 2001, 2005). According to Mayer, humans process information through two separate channels – visual and auditory – with a limited capacity for each, and learning occurs by actively selecting, organizing, and integrating information from these channels. The application of CTML in digital instructional design has been supported by numerous studies demonstrating improvements in learner engagement and academic achievement. Ravalo and Flores (2024) found that multimedia-based instruction enhanced students' conceptual understanding through carefully designed visual and auditory elements. Similarly, Lim (2024) reported that instructional materials developed using multimedia learning principles significantly improved mathematics learning outcomes. Niño and Lomibao (2026) further revealed that multimedia-enhanced instruction strengthened learners' retention and problem-solving abilities. Likewise, Alcisto et al. (2024) emphasized that instructional resources designed in accordance with CTML principles promoted deeper understanding and more meaningful learning experiences.

The Mayer theory was used in this study on the development and validation of digitized instructional material in Mathematics 10 as a framework for creating multimedia content that promotes a better understanding of mathematical ideas. The instructional material reduces cognitive overload and enhances students' ability to process complex ideas by following the principles of multimedia learning, such as coherence (removing unnecessary material), modality (presenting words as audio rather than text with visuals), contiguity (aligning visuals with corresponding verbal explanations), and signaling (highlighting essential information) (Ravalo & Flores, 2024). Studies have shown that multimedia resources developed on these principles contribute to understanding of mathematics (Lim, 2024) and to memory and problem-solving skills (Niño & Lomibao, 2026).

CTML also supports the premise that learners' engagement, comprehension, and retention can be improved through digital instructional resources based on sound multimedia design principles. As Mayer (2001) and Alcisto et al. (2024) stress, learning is not only the result of being given knowledge through technology but also of structuring content to optimize the learner's cognitive resources. The use of CTML in designing digital course materials ensures a technologically advanced and cognitively enhanced learning process. This is especially true when helping students solve probability problems, where diagrams, animations, and narrated explanations can scaffold their understanding.

To operationalize the principles of CTML, this study adopted the ADDIE Model (Analysis, Design, Development, Implementation, and Evaluation) as its instructional design framework. The ADDIE Model provided a systematic and iterative process that translated multimedia learning principles into a functional, learner-centered, and validated instructional resource. The integration of CTML and ADDIE ensured that the instructional material was not only technologically enhanced but also cognitively sound and pedagogically appropriate.

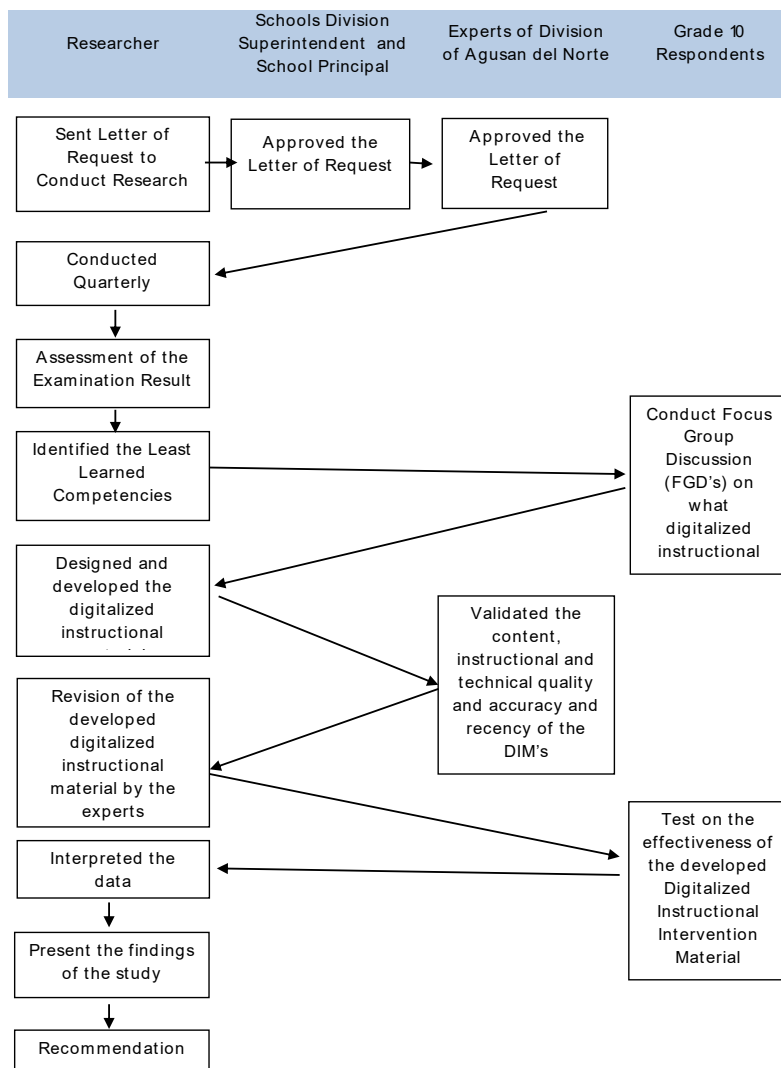
During the Analysis Phase, the researcher identified the learners' needs, examined the least-mastered competencies based on assessment results, reviewed curriculum requirements, and determined existing instructional gaps. The findings from this phase served as the basis for planning the content and instructional strategies of the digitalized material. During the Design Phase, the principles of CTML guided the preparation of storyboards, lesson sequencing, user interface layouts, assessment activities, and multimedia integration plans. Particular attention was given to organizing content to facilitate cognitive processing and promote

meaningful learning experiences.

During the Development Phase, the actual digital instructional material was produced. Interactive multimedia elements, including animations, simulations, audio support, visual representations, and formative assessments, were incorporated based on the identified learner needs and the principles of multimedia learning. The developed material underwent expert validation to ensure content accuracy, instructional quality, technical functionality, and visual appropriateness. During the Implementation Phase, the developed instructional material was administered to the target learners for pilot testing and actual utilization. This phase provided opportunities to determine the usability, effectiveness, and acceptability of the material in improving learners' understanding of probability concepts. During the Evaluation Phase, the quality and effectiveness of the instructional material were assessed through expert validation and learner evaluation. Feedback gathered during this stage was utilized to refine and improve the material, ensuring its relevance, effectiveness, and alignment with curriculum standards.

The study's conceptual framework illustrated the integration of CTML and the ADDIE Model into the development process. Inputs such as learner needs, least-mastered competencies, curriculum standards, multimedia learning principles, and expert recommendations informed the development of the instructional material. These inputs underwent the sequential phases of Analysis, Design, Development, Implementation, and Evaluation, resulting in a validated Digitalized Instructional Material in Mathematics 10. The outputs included expert validation results, learner acceptance ratings, instructional effectiveness data, and recommendations for the continuous improvement of the material.

Figure 1. Figure 1. Swim Lane Diagram of the Study



## Objectives of the Study

This study sought to: (1) determine the performance of Grade 10 learners in Mathematics 10 based on the third-quarter examination results as basis for the development of the digitalized instructional material; (2) determine the instructional design features and multimedia elements to be incorporated in the digitalized instructional material based on the results of the Focus Group Discussion (FGD); (3) develop the digitalized instructional material for Mathematics 10 following the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) Model; (4) determine the level of validity of the developed digitalized instructional material as evaluated by Mathematics experts using the Learning Resources Management and Development System (LRMDS) evaluation tool in terms of language mechanics and readability, content and instructional design, functionality and multimedia integration, and assessment and closure; (5) determine the improvements that may be proposed to enhance the digitalized instructional material based on expert and learner evaluations; (6) determine whether there is a significant difference between the pretest and posttest scores of Grade 10 learners after the implementation of the digitalized instructional material; and (7) propose recommendations based on the findings of the study for the improvement, utilization, and future development of digitalized instructional materials in Mathematics 10.

## Methodology

The study employed a descriptive-developmental research design anchored in the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) Model to develop and validate a digitized instructional material (DIM) in Mathematics 10, focusing on problem-solving involving Probability. The study was conducted in selected secondary schools in Las Nieves District Cluster III, Agusan del Norte, involving 106 Grade 10 learners selected through total enumeration and 10 Mathematics teachers chosen through purposive sampling for the Focus Group Discussion (FGD). Data were gathered using third-quarter examination results to identify the least-mastered competency; a semi-structured FGD guide to determine instructional design features and multimedia elements; an expert validation checklist adapted from the Learning Resources Management and Development System (LRMDS) evaluation tool; and a pretest-posttest instrument to assess instructional effectiveness. The digitized instructional material was developed in PowerPoint using Visual Basic for Applications (VBA) and incorporated animations, simulations, interactive quizzes, gamified activities, and self-assessment tools. Quantitative data were analyzed using Mean Percentage Score (MPS), mean, and paired *t*-test. In contrast, qualitative data were analyzed through thematic analysis to identify themes that informed the development and refinement of the instructional material.

## Results and Discussion

**Problem 1. What are the learning needs and competency gaps of Grade 10 learners in Mathematics 10, as reflected in their performance on the third-quarter examination, that will serve as the basis for developing the digitized instructional material?**

Table 1 presents the least-learned competencies identified among Grade 10 learners in Mathematics 10, based on their performance in the third-quarter examination.

Table 1. *Identified Least-Learned Competencies*

Least-Learned Competencies	No of items	MPS	Remarks
1. Illustrates the permutation of objects.	4	61%	Nearly Mastered
2. Solves problems involving permutations.	4	61%	Nearly Mastered
3. Illustrates the combination of objects.	5	59%	Nearly Mastered
4. Differentiates permutation from combination of $n$ objects taken $r$ at a time	2	62%	Nearly Mastered
5. Solves problems involving permutations and combinations.	5	62%	Nearly Mastered

6. Illustrates events and the union and intersection of events.	4	62%	Nearly Mastered
7. Illustrates the probability of a union of two events.	4	62%	Nearly Mastered
8. Finds the probability of the union.	5	60%	Nearly Mastered
9. Illustrates mutually exclusive events.	3	61%	Nearly Mastered
10. Solves problems involving probability.	4	45%	<b>Not Mastered</b>

The data in the table show that most of the competencies in permutations, combinations, and probability are interpreted as “Nearly Mastered” with a Mean Percentage Score (MPS) of 59% to 62%. However, the competency “solves problems involving probability” received the lowest MPS of 45%, with the interpretation “Not Mastered.” This suggests that learners encountered considerable difficulty applying probability concepts in problem-solving situations. This was the most important competency gap and the primary rationale for developing the digitized instructional material.

The results suggest that the learners could partially understand basic concepts such as illustrating permutations, combinations, and events but had difficulty when required to use higher-order analytical and problem-solving skills. This low mastery level may be because solving probability problems requires learners to analyze the situation, interpret the conditions, and apply mathematical reasoning accurately. Batanero and Álvarez-Arroyo (2023) highlighted that students often have misconceptions about probability due to difficulties with understanding sample spaces, interpreting events, and applying probabilistic reasoning in contextualized situations. Susanto et al. (2024) also found that students with weak conceptual understanding struggle with solving probability problems, especially when translating word problems into mathematical expressions. Low mastery of probability problem-solving underscores the need for digitized instructional materials that provide interactive, contextualized, and step-by-step learning experiences. Intervention studies have demonstrated that technology-enhanced and contextualized instructional materials improve learners’ engagement, conceptual understanding, and mathematical performance, particularly in least-mastered competencies (Combo et al., 2025).

Furthermore, intervention-based mathematics studies consistently emphasize that instructional materials in specific areas greatly improve student performance in the least-mastered competencies. The research by Combo, Olino, and Rivas (2025) found that employing contextualized reinforcement and intervention programs in Mathematics effectively enhanced learners' proficiency through guided activities, interactive tasks, and differentiated instruction. The researchers found that intervention programs are most effective when they address specific learner difficulties and provide engaging learning experiences to meet students’ needs. Moreover, intervention strategies such as visual representations, guided problem-solving, and technology-based instruction were found to be effective in improving mathematical understanding and student engagement (Dimou, 2021).

In relation to the present study, the identified competency gap in probability problem-solving strongly supports the development of digitized instructional materials focused on interactive, learner-centered activities. Digitized strategic intervention materials, including visual simulations, step-by-step examples, immediate feedback mechanisms, and contextualized activities, may enhance learners’ comprehension and recall of probability concepts. Probability is an abstract, analytical concept; therefore, incorporating multimedia elements and interactive problem-solving challenges may help learners build stronger mathematical reasoning skills and improve their academic performance (Suaybaguio, 2025).

**Problem 2. What instructional design features and multimedia elements should be incorporated into the digitized instructional material based on the results of the Focus Group Discussion?**

Table 2 presents the teachers’ responses to the focus group discussion on the instructional design aspects needed to develop digitized instructional materials in Probability. The responses showed that teachers strongly emphasized the need for a structured, systematic design for learning, especially with explicit learning objectives and a step-by-step progression to help students understand probability concepts in an organized, guided, and developmentally appropriate way.

**Table 2. Emerging Themes on the Teachers’ Responses on the Instructional Design Features for the Development of the Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
• Clear Learning Objectives	1	<i>The material should include clearly stated learning objectives, and lessons should be arranged from simple to complex to guide students systematically in understanding probability concepts. Interactive practice exercises with instant feedback should be included to help students identify errors and improve their understanding in real time. Then the material should incorporate real-world scenarios. Activities should have different levels of difficulty to cater to all learners. Students should be able to check their own progress through self-assessment quizzes.</i>
• Clear Learning Objectives	2	<i>I think interactive simulations would really help students see probability. If we tie lessons to real-life examples, students will connect better. The material should adjust to each student’s level so no one feels left behind—clear objectives at the start of the lesson to keep students focused. Word problems should be realistic and relatable.</i>
• Clear Learning Objectives	3	<i>For me, same as teacher number 1. Objectives should be placed at the start of the material. Students need step-by-step guides so they do not get lost in solving.</i>
• Clear Learning Objectives	6	<i>When creating digital instructional material on probability, I would first ensure that each lesson begins with clear learning objectives so students know exactly what they are expected to achieve. The content should be organized from simple concepts to more complex applications, allowing learners to build their understanding step by step. Guided practice activities are essential, and these should provide immediate feedback so students can quickly identify and correct mistakes. To make the subject more meaningful, I would incorporate real-world scenarios so students can see how probability applies outside the classroom. Lastly, self-assessment tools such as quizzes or progress trackers would allow students to monitor their own growth and take ownership of their learning.</i>
• Clear Learning Objectives	7	<i>For instructional design, I think it is important that lessons begin with a clear outline of what students are expected to learn. Using examples tied to everyday situations, like using things available in the environment. Moreover, reflection questions at the end of lessons encourage students to connect what they have learned to real-world problem solving.</i>
• Clear Learning Objectives	8	<i>When objectives are laid out upfront, learners know exactly what to focus on. Then, practice tasks that provide immediate explanations when mistakes occur are essential, as they help learners correct misunderstandings right away.</i>
• Clear Learning Objectives	9	<i>First, the objectives must be visible to the students before the lesson starts. Then, there should be questions to assess whether students really understand the lesson, and interactive simulations that students can manipulate. Differentiated questions should be included.</i>

Explicit learning objectives are the common sub-theme, as revealed by the responses of participants 1, 2, 3, 6, 7, 8 and 9. This means that teachers see clear objectives as an important feature of good digital instructional resources. Setting objectives at the beginning of the class increases students' awareness of what they are supposed to learn, directs their attention to learning, controls learning, and allows monitoring of progress. Khaled and Alghfeli (2025) further support this conclusion since they found that organized digital lectures with clear success criteria and self-assessment strategies improved students’ math performance and motivation. Progressive learning growth was a sub-theme that was stressed repeatedly (P1, P3, P6). The teachers stressed that teaching probability should progress from simple to complex ideas so that students can build understanding gradually and not be overwhelmed. That means digitized instructional materials must provide more than content; they must also shape learning experiences through scaffolded exercises, guided practice, and progressive mastery. Similarly, UNESCO (2023) found that digital technology can facilitate

learning by delivering immediate feedback and enabling learners to adjust the pace and sequence of learning to their needs.

The findings suggest that teachers like digitalized instructional tools that are intentional, systematic, and learner-focused. The continuous pursuit of goals and progress suggests that appropriate digital resources in Probability should provide guidance and structure while systematically moving from basic ideas to complex applications. This is consistent with the current literature, which identifies digital learning as more effective when it includes specific objectives, organized content, feedback, and opportunities for learners to self-assess their progress (Haleem et al., 2022; Khaled & Alghfeli, 2025).

Table 3 presents teachers' viewpoints on the instructional design aspects of creating digital instructional materials in Probability, with a focus on interactive and engaging learning experiences.

**Table 3. Teachers' Responses on the Instructional Design Features for the Development of the Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
• Immediate Feedback Mechanisms	1	<i>The material should include clearly stated learning objectives and lessons arranged from simple to complex to guide students systematically in understanding probability concepts. Interactive practice exercises with instant feedback should be included to help students identify errors and improve their understanding in real time. Then the material should incorporate real-world scenarios. Activities should have different levels of difficulty to cater to all learners. Students should be able to check their own progress through self-assessment quizzes.</i>
• Immediate Feedback Mechanisms	2	<i>I think interactive simulations would really help students see probability. If we tie lessons to real-life examples, students will connect better. The material should adjust to each student's level so no one feels left behind—clear objectives at the start of the lesson help keep students focused. Word problems should be realistic and relatable.</i>
• Immediate Feedback Mechanisms	4	<i>For me, same as Teacher 1. Objectives should be placed at the start of the material. Students need step-by-step guides so they do not get lost in solving.</i>
• Immediate Feedback Mechanisms	6	<i>The content should be organized from simple concepts to more complex applications, allowing learners to build their understanding step by step. Guided practice activities are essential, and these should provide immediate feedback so students can quickly identify and correct mistakes. To make the subject more meaningful, I would incorporate real-world scenarios so students can see how probability applies outside the classroom. Lastly, self-assessment tools such as quizzes or progress trackers would allow students to monitor their own growth and take ownership of their learning.</i>
• Immediate Feedback Mechanisms	8	<i>When objectives are laid out upfront, learners know exactly what to focus on. Then practice tasks that provide immediate explanations when mistakes are made are essential, since they help learners correct misunderstandings right away.</i>
• Immediate Feedback Mechanisms	10	<i>One of the most effective ways to help students grasp probability is to give them opportunities to practice through interactive exercises that provide instant feedback. When learners can immediately see where they went wrong and how to fix it, their understanding deepens. I would also design activities at varying levels of difficulty so that beginners can build confidence while more advanced students stay challenged.</i>

As shown in the table, the Immediate Feedback Mechanisms is the common sub-theme that was mentioned by participants 1, 2, 4, 6, 8, and 10. This means educators appreciate digital resources that enable students to identify their mistakes quickly, receive explanations, and correct misconceptions. Immediate feedback is particularly helpful in learning probability, since students sometimes have difficulty with abstract concepts and procedural errors as they adjust their thinking in real time. According to Söderström et al. (2024),

feedback is particularly valuable in the teaching of mathematics when it is timely, specific, and closely related to the students' approaches to problem solving.

A notable sub-theme is Interactive Exercises and Simulations as indicated by the responses of Participants 2, 4, 6, 9 and 10. Simulations, educators say, help kids better understand probability, allow them to manipulate difficulties in the learning process, and create engagement with subjects rather than passive reading. This means that digitized educational material should include activities such as virtual experiments, probability games, manipulable models, and scenario-based exercises. Recent studies demonstrate that digital tools in mathematics can enhance visualization, exploration, and conceptual understanding when designed for active learner involvement rather than mere information transmission (Darmanova et al., 2025; Dan et al., 2024).

The sub-theme Guided Practice Activities, while less often mentioned, is still important in linking feedback and interaction to structured learning support. Participant 6 said 'guided practice should provide trainees with an opportunity to correct errors and gradually increase their knowledge'. This aligns with Dai et al. (2023), who found that learning aids in digital game-based mathematics situations facilitate problem-solving and enhance conceptual understanding.

Table 4. Teacher's feedback on instructional design aspects for developing digitized instructional materials in Probability, emphasizing contextualized, real-world learning applications.

**Table 4. Teachers' Responses on the Instructional Design Features for the Development of the Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
<ul style="list-style-type: none"> <li>Real-World Scenarios and Relatable Examples</li> </ul>	1	<i>The material should include clearly stated learning objectives and lessons arranged from simple to complex to guide students systematically in understanding probability concepts. Interactive practice exercises with instant feedback should be included to help students identify errors and improve their understanding in real time. Then the material should incorporate real-world scenarios. Activities should have different levels of difficulty to cater to all learners. Students should be able to check their own progress through self-assessment quizzes.</i>
<ul style="list-style-type: none"> <li>Real-World Scenarios and Relatable Examples</li> </ul>	2	<i>I think interactive simulations would really help students see probability. If we tie lessons to real-life examples, students will connect better. The material should adjust to each student's level so no one feels left behind—clear objectives at the start of the lesson help keep students focused. Word problems should be realistic and relatable.</i>
<ul style="list-style-type: none"> <li>Real-World Scenarios and Relatable Examples</li> </ul>	6	<i>When creating digital instructional material on probability, I would first ensure that each lesson begins with clear learning objectives so students know exactly what they are expected to achieve. The content should be organized from simple concepts to more complex applications, allowing learners to build their understanding step by step. Guided practice activities are essential, and these should provide immediate feedback so students can quickly identify and correct mistakes. To make the subject more meaningful, I would incorporate real-world scenarios so students can see how probability applies outside the classroom. Lastly, self-assessment tools such as quizzes or progress trackers would allow students to monitor their own growth and take ownership of their learning.</i>
<ul style="list-style-type: none"> <li>Real-World Scenarios and Relatable Examples</li> </ul>	7	<i>Using examples tied to everyday situations, like using things available in the environment. Moreover, reflection questions at the end of lessons encourage students to connect what they have learned to real-world problem solving.</i>

The data on the table shows that the predominant sub-theme is real-world circumstances and realistic instances, as indicated by the responses of Participants 1, 2, 6, and 7. This suggests that educators firmly advocate for the instruction of Probability using relatable contexts, including daily decision-making, games of

chance, weather forecasting, classroom occurrences, local environmental instances, and recognizable community experiences. Given that Probability is often abstract, contextualized examples help students recognize the practical significance of mathematical concepts beyond the classroom. Saga (2026) supports this, as their study on contextualized probability classes using agricultural principles revealed that real-life situations enhanced students' involvement, the relevance of learning, and their comprehension of probability concepts.

Notably, the ancillary sub-theme of reflection and authentic issue solving emerged in Participant 7's response. While it seldom occurs, it holds instructional significance, as it demonstrates that educators seek not only student responses to probability questions but also contemplation of the application of these principles in real-world decision-making. This aligns with recent studies highlighting that contextualized mathematics training enhances problem-solving by enabling learners to link abstract mathematical concepts to real-life contexts (Anugraheni et al., 2025; Mahmuti, 2025).

Table 5 presents the teachers' responses on the instructional design features for the development of digitized instructional material in Probability under the theme of differentiated and inclusive instruction.

**Table 5. Teachers' Responses on the Instructional Design Features for the Development of the Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
• Varied Difficulty Levels	1	<i>The material should include clearly stated learning objectives and lessons arranged from simple to complex to guide students systematically in understanding probability concepts. Interactive practice exercises with instant feedback should be included to help students identify errors and improve their understanding in real time. Then the material should incorporate real-world scenarios. Activities should have different levels of difficulty to cater to all learners. Students should be able to check their own progress through self-assessment quizzes.</i>
• Varied Difficulty Levels	4	<i>For me, same as teacher number 1: Objectives should be placed at the start of the material. Students need step-by-step guides so they do not get lost in solving.</i>
• Varied Difficulty Levels	5	<i>To support students in understanding and solving probability problems, digital instructional materials should emphasize active engagement and structured progression. Activities should be designed at varying levels of difficulty to accommodate diverse learners, ensuring that beginners build confidence while advanced students remain challenged.</i>
• Varied Difficulty Levels	9	<i>First, the objectives must be visible to the students before the lesson starts. Then, there should be questions to assess whether students truly understand the lesson, as well as interactive simulations that students can manipulate. Differentiated questions should be included.</i>
• Varied Difficulty Levels	10	<i>One of the most effective ways to help students grasp probability is to give them opportunities to practice through interactive exercises that provide instant feedback. When learners can immediately see where they went wrong and how to fix it, their understanding deepens. I would also design activities at varying levels of difficulty so that beginners can build confidence while more advanced students stay challenged.</i>

The table shows that the most frequent sub-theme is Varied Difficulty Levels, which was mentioned by participants 1, 4, 5, 9, and 10. Educators stressed the need for a variety of probability tasks at varying levels so that students who are struggling can build confidence gradually and proficient students can be challenged. This finding suggests that instructors are cognizant of the variability among learners and the need for flexible instructional techniques in mathematics education. The need for differentiation in education arises because it helps teachers address differences in students' preparation, learning rates, and problem-solving abilities. Vacalares et al. (2024) found in a study in the Philippines that diverse instructional strategies significantly improved students' performance, engagement, and understanding of mathematics by designing activities that

meet learners' varying needs.

A recurring sub-theme is Adaptive Learning Support, as indicated by the responses of Participants 2 and 5. Teachers denote the importance of tailoring digital instructional tools to students' learning levels so that no child is left behind. This underscores the significance of learner-centric, personalized digital environments in Probability learning. A recent study has demonstrated that adaptive digital learning systems can offer personalized education by providing targeted feedback, allowing for variable pacing, and delivering tailored learning experiences. Baldinger et al. (2026) found that digital adaptive learning tools in mathematics improve engagement and conceptual understanding by providing instruction matched to students' current proficiency levels.

As Participant 9 viewed, the sub-theme Differentiated Questions signifies the need for inclusive mathematics teaching. Differentiated questioning allows students of all abilities to participate in learning activities in a meaningful way, promoting higher-order thinking and problem-solving skills. Sabitillah et al. (2025) emphasized the necessity of personalized instruction in mathematics classrooms to accommodate diverse learner characteristics, particularly to promote inclusive participation and equal learning opportunities.

Table 6 presents teachers' responses regarding the instructional design characteristics for developing digital instructional materials in Probability under Learner Autonomy and Assessment.

**Table 6. Teachers' Responses on the Instructional Design Features for the Development of the Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
• Self-Assessment and Progress Monitoring	1	<i>The material should include clearly stated learning objectives and lessons arranged from simple to complex to guide students systematically in understanding probability concepts. Interactive practice exercises with instant feedback should be included to help students identify errors and improve their understanding in real time. Then the material should incorporate real-world scenarios. Activities should have different levels of difficulty to cater to all learners. Students should be able to check their own progress through self-assessment quizzes.</i>
• Self-Assessment and Progress Monitoring	6	<i>When creating digital instructional material on probability, I would first ensure that each lesson begins with clear learning objectives so students know exactly what they are expected to achieve. The content should be organized from simple concepts to more complex applications, allowing learners to build their understanding step by step. Guided practice activities are essential, and these should provide immediate feedback so students can quickly identify and correct mistakes. To make the subject more meaningful, I would incorporate real-world scenarios so students can see how probability applies outside the classroom. Lastly, self-assessment tools such as quizzes or progress trackers would allow students to monitor their own growth and take ownership of their learning.</i>

The primary sub-theme, as illustrated in the table, is Self-Assessment and Progress Monitoring, as evidenced by the replies of Participant 1 and Participant 6. Both instructors emphasized the importance of self-assessment quizzes and progress trackers, recommending that digital educational resources enable students to evaluate their comprehension during their studies. This is essential in Probability because students need regular opportunities to identify misconceptions, monitor their progress, and enhance their problem-solving skills. A study by Khaled and Alghfeli (2025) revealed that structured online classrooms with self-assessment methodologies enhanced students' mathematics achievement, motivation, and self-regulation of learning.

The sub-theme assessment for Understanding, articulated in Participant 9's response, underscores the importance of formative evaluation in digital learning. She emphasized the importance of inquiry to determine if the students had comprehended the lesson. This indicates that evaluation serves not merely for grading but also for education, identifying deficiencies and aiding students in their improvement. According

to UNESCO (2023), digital technologies facilitate formative evaluation by providing learners with immediate feedback and the ability to adjust their learning pace and trajectory.

Reflective Learning Practices are not widespread, but they are very important because reflection allows students to connect assessment results to their own learning decisions. Students who set goals, assess their understanding, and reflect on their progress improve their self-regulated learning in online math instruction. Letchumanan et al. (2024) underlined the importance of self-regulated learning in online mathematics contexts, as it promotes learner autonomy, self-monitoring, and responsibility for their learning.

The data show that the teachers' preferences are for digital educational tools in Probability that offer more than material delivery. The material should include self-assessment quizzes, instruments for monitoring progress, reflective questions, and formative evaluation exercises to make the learners more autonomous, aware of their learning gaps, and proactive in taking responsibility for improving their understanding of mathematics.

**Table 7. Teachers' Responses on Multimedia Elements for the Development of Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
• Interactive Simulations	1	<i>Interactive simulations such as virtual dice rolling to demonstrate probability experiments in real time. Interactive quizzes with instant feedback, allowing students to practice and see corrections immediately. Gamified activities, such as probability-based mini-games or challenges, to increase motivation.</i>
• Interactive Simulations	3	<i>To make learning about probability more engaging, the material could include virtual experiments, such as rolling dice, which would be exciting for students. Also, interactive simulations that let students manipulate probability experiments. Moreover, gamified challenges, games where students have fun at the same time they are learning too.</i>
• Interactive Simulations	8	<i>To make probability more engaging, interactive tools that let students experiment, such as virtual dice rolls, are highly effective. Interactive quizzes that provide instant corrections give students the chance to practice actively and learn from their mistakes. Adding gamified challenges, such as mini-games based on probability scenarios, can boost motivation and make learning feel more like play than work.</i>
• Interactive Simulations	9	<i>To make probability more engaging and easier to understand, I would integrate interactive simulations that let students experiment with dice rolls; moreover, I would use other games to capture their attention in the classroom.</i>
• Interactive Simulations	10	<i>On the multimedia side, I would make sure students can experiment with probability in a hands-on way. Simulations that let them roll virtual dice, flip coins, or draw cards bring abstract concepts to life. To keep motivation high, I would also include gamified activities, such as mini-games.</i>

The responses of Participants 1, 3, 8, 9, and 10 demonstrate that Interactive Simulations is the predominant sub-theme, as indicated by the data in the table. Virtual dice rolling, coin turning, card drawing, and probability simulations were consistently emphasized by educators as effective methods for making abstract concepts comprehensible and tangible. This suggests that teachers recognize the importance of transitioning Probability from a purely symbolic lecture to an exploratory learning experience, which allows students to observe outcomes, compare results, and understand chance through repeated trials. Instruction in probability is improved by tasks that encourage students to reason through experiments, simulations, and data-driven experiences, rather than relying merely on formulas, as emphasized by Batanero and Chernoff (2024).

Educators underscored the necessity for students to be able to execute numerous trials, visualize potential outcomes, and conduct digital experiments. This suggests that interactive learning environments must be included in digitized teaching materials to enable learners to assess predictions, analyze trends, and connect theoretical probability to experimental probability. In a similar vein, Xu (2025) found that a game-based adaptive probability learning tool that employs simulated dice activities improved learner engagement

and comprehension by adjusting task complexity in response to student performance.

Additionally, teachers prefer digital instructional resources in Probability that are immersive, visually appealing, and learner-centered. The frequent reference to simulations and virtual experiments suggests that students may better understand probability when they can modify events, evaluate results, and learn through iterative digital trials. This discovery is consistent with recent research suggesting that students' motivation, engagement, and conceptual comprehension can be improved through digital game- and simulation-based mathematics learning when they are actively involved in the learning process (Dan et al., 2024; Debrenti, 2024).

Table 8 presents the teachers' responses on the multimedia elements for the development of digitized instructional material in Probability under Gamified and Motivational Learning Experiences.

**Table 8. Teachers' Responses on Multimedia Elements for the Development of Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
• Gamified Activities and Mini-Games	1	<i>Interactive simulations such as virtual dice rolling to demonstrate probability experiments in real time. Interactive quizzes with instant feedback, allowing students to practice and immediately see corrections. Gamified activities such as probability-based mini-games or challenges to increase motivation.</i>
• Game-Based Learning and Motivation	2	<i>Games that let students apply probability in fun challenges. Practice problems with animated solutions and interactive quizzes with instant feedback to allow students to practice</i>
• Gamified Activities and Mini-Games	3	<i>To make learning about probability more engaging, the material could include virtual experiments, like rolling dice, which would be exciting for students. Also, interactive simulations that let students manipulate probability experiments. Moreover, gamified challenges, games where students have fun at the same time they are learning too.</i>
• Game-Based Learning and Motivation	4	<i>For multimedia elements, integrating probability into games increases intrinsic motivation, and Interactive quizzes with rewards or progress tracking keep students engaged and encourage them to master specific checkpoints.</i>
• Gamified Activities and Mini-Games	5	<i>To make learning probability more engaging, interactive, and easier to understand, multimedia elements can play a huge role. Include interactive tools that let students run thousands of trials to visualize outcomes. Gamified challenges in which learners guess outcomes before the probability is explained.</i>
• Game-Based Learning and Motivation	6	<i>I think Interactive virtual games; students really love fun while learning, and it would make probability more engaging. Moreover, sound effects should be present for both correct and incorrect answers, as they can add fun and keep students motivated.</i>
• Game-Based Learning and Motivation	7	<i>When it comes to multimedia elements, interactive tools are a game-changer. Imagine students rolling dice to see probability; that kind of hands-on experience makes abstract concepts tangible. It is really more engaging and exciting if games are included to challenge students and add a fun, competitive edge to practice.</i>
• Gamified Activities and Mini-Games	8	<i>To make probability more engaging, interactive tools that let students experiment, such as virtual dice rolls, are highly effective. Interactive quizzes that provide instant corrections give students the chance to practice actively and learn from their mistakes. Adding gamified challenges, such as mini-games based on probability scenarios, can boost motivation and make learning feel more like play than work.</i>
• Game-Based Learning and Motivation	9	<i>To make probability more engaging and easier to understand, I would integrate interactive simulations that let students experiment with dice rolls; moreover, I would use other games to capture their attention in the classroom.</i>
• Gamified Activities	10	<i>On the multimedia side, I would make sure students can experiment with probability in a hands-on way. Simulations that let them roll virtual dice, flip coins, or draw cards</i>

and Mini-  
Games

*bring abstract concepts to life. To keep motivation high, I would also include gamified activities, such as mini-games.*

The table demonstrates that the most dominant sub-theme is Gamified Activities and Mini-Games, as shown by the replies of Participants 1, 3, 5, 8, and 10. Educators found that mini-games and challenges focused on probability boost learning and fun while helping students apply probability concepts to meaningful problems. This implies that gamification might change the way probability is taught, from a passive calculation to an active, engaging, and exploratory learning experience. Dan et al. (2024) found that digital game-based learning in mathematics increases learners’ engagement and provides interactive opportunities to understand mathematical concepts in gaming contexts.

The second most frequent sub-theme is Game-Based Learning and Motivation, which is reported by Participants 2, 4, 6, 7, and 9. Teachers reported that games help motivate pupils, increase intrinsic motivation, and make probability assignments more fun. This is consistent with Jaramillo-Mediavilla et al. (2024), who found through a systematic review that gamification in educational environments had a beneficial effect on motivation and academic achievement. According to Debrenti (2024), game-based learning could improve mathematics understanding since the games are designed to promote reasoning and higher-order thinking skills.

The rare but important sub-theme is Audio Effects and Enjoyment, as described in Participant 6’s response. Auditory signals for correct and incorrect responses can boost engagement by providing immediate sensory input and making digital learning more enjoyable. This sub-theme (while only stated once) reinforces the overall tendency for instructors to want multimedia materials to be engaging, adaptive, and enjoyable for pupils.

The results showed that including gamified activities, mini-games, prizes, progress checkpoints, and interactive hurdles in the digital instructional materials for Probability would be helpful. Such characteristics may even enhance motivation and enable learners to view probability as an interesting, dynamic process rather than a purely abstract mathematical topic.

Table 9 presents the teachers’ responses on the multimedia elements for the development of digitized instructional material in Probability under the theme Immediate Feedback and Active Practice.

**Table 9. Teachers’ Responses on Multimedia Elements for the Development of Digitized Instructional Material in Probability**

Sub-themes	P	Verbatim Responses
• Interactive Quizzes with Instant Feedback	1	<i>Interactive simulations such as virtual dice rolling to demonstrate probability experiments in real time. Interactive quizzes with instant feedback, allowing students to practice and immediately see corrections—gamified activities such as probability-based mini-games or challenges to increase motivation.</i>
• Interactive Quizzes with Instant Feedback	2	<i>Games that let students apply probability in fun challenges. Practice problems with animated solutions and interactive quizzes with instant feedback to allow students to practice</i>
• Interactive Quizzes with Instant Feedback	8	<i>To make probability more engaging, interactive tools that let students experiment, such as virtual dice rolls, are highly effective. Interactive quizzes that provide instant corrections give students the chance to practice actively and learn from their mistakes. Adding gamified challenges, such as mini-games based on probability scenarios, can boost motivation and make learning feel more like play than work.</i>

From the data in the table, the top sub-theme is Interactive Quizzes with Instant Feedback, as seen by the responses of Participants 1, 2, and 8. Teachers emphasized that students should be corrected for their mistakes and given explanations as soon as possible after tests or exercises. This suggests that feedback is an important teaching tool, as it allows learners to detect errors, adjust strategies, and improve conceptual

understanding as the learning process unfolds. In their comprehensive evaluation of feedback in mathematics education, Söderström and Palm (2024) found that timely and accurate feedback has tremendous benefits for mathematics learning and student achievement.

Teachers have noted that recurrent practice activities, dynamic solutions, and checkpoint-oriented learning assignments help learners gradually acquire the principles of probability. The results of this study show that learners learn better through active learning in problem solving and the practice of mathematical concepts. Hershkovitz et al. (2024) conducted a study on learning analytics in mathematics education. They found that instant feedback on digital mathematics tasks enables active learner interaction and improves engagement in mathematics learning environments.

The sub-theme Corrective and Immediate Responses was articulated by Participants 6 and 8 and highlights the need for responsive multimedia elements, including immediate corrections and audio feedback. Teachers have found that feedback giving can enhance the learning process and allow students to learn from their mistakes. A study conducted by Avenir (2025) shows that technology-based feedback tools considerably improved the learning experience of mathematics by providing quick educational support, especially for the pupils who are struggling.

The results suggest that teachers prefer digital instructional materials in Probability that facilitate active learner involvement via continuous practice, interactive assessments, and immediate corrective feedback. The sustained emphasis on instant feedback and practice-based assignments suggests that multimedia-supported formative assessment could improve conceptual understanding, student engagement, and motivation in mathematics education. Emergent themes on the multimedia elements suggested by teachers for the construction of digitized instructional material in Probability.

### **Problem 3. How may the digitalized instructional material for Mathematics 10 be developed following the ADDIE Model?**

The development of the digitalized instructional material for Mathematics 10 followed the ADDIE Model, which includes Analysis, Design, Development, Implementation, and Evaluation stages. The initiative began with thorough planning and the identification of the least-mastered skills in Mathematics 10 through a Probability test. This indicates a detailed analysis of students' test results and their classroom performance. Identifying the least-mastered skills among the students will be the guiding principle in the analysis phase.

During the Analysis Phase, an assessment was conducted to identify the least-mastered competency among students in Mathematics 10 Probability. In connection with the identification of the least-mastered skills, a Focus Group Discussion (FGD) was organized with teacher-participants from the three identified schools in the Las Nieves District to gather empirical perspectives on how current trends in digital instructional materials should be designed in light of technological advancements. The responses emphasized the need for clear learning objectives, structured course progression, interactive simulations, gamified learning experiences, timely feedback mechanisms, contextualized examples, differentiated activities, and learner-centered assessment tools. This phase corresponds with the ADDIE framework, which emphasizes learner analysis and instructional planning as essential elements of effective instructional design (Ding & Toran, 2025).

In the Design Phase, the instructional material will commence based on feedback from the focus group discussion. The digitized instructional material was carefully developed based on the key themes identified in the Focus Group Discussion (FGD). The material is designed as game-based instructional content with interactive simulations, mini-games, and self-assessment quizzes to improve their performance and enhance their engagement in class. This will create an avenue for self-paced, teacher-guided learning, which illustrates how multimedia learning theory enhances student learning. Teachers identified the need for contextualized examples and alternative learning activities to promote inclusion and student involvement. This pedagogical strategy is in line with recent research showing that simulation- and game-based teaching aids enhance students' engagement, motivation, and conceptual understanding in mathematics education (Dan et al., 2024; Jaramillo-Mediavilla et al., 2024).

In the Development Phase, the digitized instructional materials for Mathematics 10 are aligned with the results of the least-learned competencies and compacted around the key themes identified in the focus

group discussion. The DIM consists of a Microsoft PowerPoint presentation combined with Visual Basic for Applications (VBA) to enhance the technical quality and appeal to learners. This includes animations, interactive quizzes, simulations, gamified activities, audio effects, and a progress tracker to address corrective feedback to the learner. Using PowerPoint aligns with the Department of Education's mandate, as stipulated in the LRMS tool assessment form, which identifies PowerPoint as a user-friendly application for digital instructional materials. Thus, the material is validated by the mathematics expert to ensure the consistency, relevance, and accuracy of the material's content, instructional, technical, and other findings.

Moreover, activities of varying complexity were incorporated to cater to learners with diverse learning abilities and needs. Laksana (2024) asserts that incorporating digital gamification and interactive multimedia components into mathematics education markedly enhances students' problem-solving abilities and engagement.

During the Implementation Phase, the digitized instructional material serves as the foundation for assessing how effectively it supports students in their least-mastered skills. The teacher sends a letter to the Public Schools District Supervisor requesting permission to implement the DIMs. The DIMs will then be implemented among 3 secondary schools in the Las Nieves District. The implementation will commence with a pretest and last 1 month to ensure mastery and provide students with one-on-one experience using the developed digital instructional materials. After a month of implementation, the post-test is administered to assess students' mastery of the DIMS. The incorporation of interactive multimedia technologies enabled students to investigate probability topics individually while receiving immediate feedback on their performance. UNESCO (2023) highlighted that digital learning environments are more efficacious when students engage in interactive, learner-centered activities facilitated by technology.

Ultimately, during the Evaluation Phase, the researcher evaluated the results of the pretest and posttest among students based on their scores after administering the digitized instructional material. The assessment evaluated whether the material sufficiently covered the least-mastered competency in Probability and whether the multimedia features contributed to learner engagement, comprehension, and mathematical performance. The evaluation results were used to revise and improve the instructional content to meet learners' needs and curriculum standards. Research on the development of instruction based on the ADDIE model highlights the importance of evaluation in determining instructional effectiveness and continuously improving digital learning materials (Sidik, 2023).

The learning objectives of the digitized instructional material were in accordance with the least learned abilities in Mathematics 10, notably Probability. These aims were to improve learners' conceptual comprehension, critical thinking, and problem-solving skills through interactive, learner-oriented activities. Students were able to explain probability principles, identify sample spaces and favorable outcomes, use probability formulas, and solve real-life probability scenarios using contextualized examples and interactive simulations. Additionally, the goals supported learner autonomy by including gamified quizzes and self-assessment activities that enabled students to track and assess their own progress.

The stated learning objectives were very clear and helped to structure and provide purpose to the learning experience. Clear objectives in digital mathematics instruction raise learner engagement and academic achievement by steering students toward expected outcomes, as suggested by Khaled and Alghfeli (2025). Similarly, UNESCO (2023) noted that digital teaching resources are more effective when learning objectives are made explicit and supported by interactive learning activities. Thus, the instructional basis of the digitized Probability content was the learning objectives.

The digitized instructional material is built using Microsoft PowerPoint as an offline interactive learning platform for Mathematics 10, specifically on the topic of Probability. Materials included well-structured lessons, virtual simulations (dice rolling, coin tossing, etc.), animated demonstrations, gamified activities, interactive quizzes with instant feedback, and differentiated exercises ranging from basic to intermediate levels. It had a coherent instructional flow of objectives, guided activities, analysis, abstraction, and application stages, enabling systematic and meaningful learning.

Visual Basic for Applications (VBA) was used to power the interactive elements of the material. This enabled automatic navigation, clickable buttons, interactive assessments, score tracking, simulations, and immediate feedback, all within the PowerPoint presentation.

The use of Microsoft PowerPoint with VBA also increased accessibility, since students could access the

content even without internet connectivity, making learning more flexible and easier. The use of multimedia components, such as animations, hyperlinks, transitions, photos, and sound effects, increased the lessons' interest and visual appeal (UNESCO, 2023). Likewise, Almelhes (2022) stated that multimedia presentation tools enhance learner motivation and conceptual understanding through interactive learning experiences.

The preparatory activity in the digitalized instructional material is designed as a 10-item game-based activity in Probability. It presents real-life probability questions with multiple-choice options, lifeline features, visual graphics, and interactive buttons. Students must answer each item correctly before they can proceed to the next question, making the activity mastery-based and reinforcing accurate understanding before progression. This structure promotes active practice, immediate correction, and learner accountability. Since the activity is developed in Microsoft PowerPoint and uses VBA-coded interactive elements, it supports offline access while still providing a game-like digital experience.

Recent literature supports this design, as digital game-based learning in mathematics increases learners' engagement, motivation, and participation when activities are aligned with learning objectives (Dan et al., 2024). Gamification also improves motivation and academic performance by using challenges, rewards, and progress-based tasks (Jaramillo-Mediavilla et al., 2024). Likewise, UNESCO (2023) emphasizes that digital tools support learning when they provide practice, feedback, and accessibility.

The activity segment of the digitalized educational material employs interactive probability simulations to familiarize learners with experimental probability via hands-on digital inquiry. Students conduct virtual coin tosses and dice rolls, monitoring the frequency of outcomes, experimental probabilities, and variations in results across numerous trials. The activity incorporates reflective guiding questions that allow learners to explore patterns, compare theoretical and experimental probabilities, and develop their understanding through inquiry-based learning. The simulations utilize VBA-coded interactive components in Microsoft PowerPoint, enabling learners to engage with the exercises offline while obtaining real-time updates and feedback.

This activity fosters experiential, active learning as students participate in probability experiments rather than relying exclusively on abstract calculations. Batanero and Chernoff (2024) assert that probability ideas gain significance when learners engage with simulations and conduct repeated experimental trials. Campos et al. (2024) assert that simulation-based mathematics education improves conceptual comprehension by enabling students to perceive mathematical results and discern patterns through active engagement.

In the analysis phase, the digitized instructional material uses animated explanations, worked examples, and interactive checks to guide learners in understanding the concept of probability. This includes the probability formula, key concepts such as sample space and favorable outcomes, and a real-world example of how to find the probability of rolling an even number on a die. Color-coded outcomes, progressive visual reveals, guiding questions, and answer boxes help the learner analyze the process before working independently. These features promote conceptual clarity, as students can see the outcomes, classifications, and probability computations. The interactive check also contributes to formative assessment by enabling learners to test the concept immediately after the explanation.

This design aligns with recent research indicating that the effectiveness of digital mathematics materials is enhanced when they incorporate visual representations, guided practice, and interactive feedback. UNESCO (2023) argues that technology-supported learning is useful when it improves access, interaction, and learner participation. Söderström and Palm (2024) also argue that feedback in mathematics enhances learners' problem-solving ability and conceptual understanding.

The abstraction phase of the digital instructional material is designed to help learners generalize and apply probability concepts through structured procedures and differentiated practice activities. The material introduces a 5-step method to solving probability problems. The steps are to identify the experiment, determine the sample space, identify favorable outcomes, apply the probability formula, and simplify the answer. Further differentiated practice activities (basic, intermediate, and challenging) are also provided to deepen understanding. These features allow learners to learn at their level of understanding and to strengthen mastery through guided and independent practice. The activities are interactive, built on VBA-coded elements in Microsoft PowerPoint, and can be used offline, with automated navigation and learner interaction.

The abstraction phase encourages conceptual retention and higher-order thinking as learners

progress from guided explanation to the independent application of concepts. Ding and Toran (2025) note that digital learning environments benefit from structured, sequential instructional procedures that improve learners' understanding and skill development. Similarly, UNESCO (2023) stresses that differentiated and interactive digital activities facilitate learner engagement, inclusiveness, and self-paced learning.

During the application phase, the digitized instructional material aims to enhance learners' mastery of probability concepts through interactive, game-based learning activities. Students practice the concepts and procedures learned in the previous lessons by playing application games such as "Choose a Turkey" and "20 Coin and Slots." These games incorporate probability scenarios, decision-making problems, scorekeeping, difficulty levels, and interactive navigation features, all built using VBA-coded elements in Microsoft PowerPoint. Activities encourage learners to apply probability formulas, interpret results, and solve real-world problems in a fun and engaging environment. Adding ratings, game levels, and interactive buttons also improves learner motivation and engagement.

In the application phase, students are encouraged to learn through experience and focus on the learner. They actively show their understanding through gameplay and problem-solving tasks. Jaramillo-Mediavilla et al. (2024) highlight that gamified learning environments, when integrated with meaningful instructional objectives, can boost learner motivation, engagement, and academic achievement. Also, Dan et al. (2024) highlight that interactive, fun activities in digital game-based mathematics learning contribute to conceptual understanding and active engagement.

**Problem 4. What is the validity of the developed digital instructional material, as evaluated by mathematics experts using the LRMDS evaluation tool, in terms of language mechanics and readability; content and instructional design; layout and visual design; functionality and multimedia integration; and assessment and closure?**

Table 10 presents the summary of the level of validity of the developed DIMs in Mathematics 10

**Table 10. The level of validity of the DIM's**

Category	Remarks
1. Language Mechanical and Readability	Passed
2. Content and Instructional Design	Passed
3. Layout and Visual Design	Passed
4. Functionality and Multimedia Integration	Passed
5. Assessment and Closure	Passed
<b>Overall</b>	<b>Passed</b>

The results demonstrated that the digitized teaching material was valid, acceptable, and appropriate for classroom use. The passing score for language mechanics and readability indicates that the item employed clear, accurate, and learner-appropriate language that was easy for students to understand. Further assessment of the content and instructional design indicated that the lessons were aligned with the intended learning competencies, systematically structured, and instructionally sound. Similarly, the favorable assessment of layout and visual design indicated that the material was visually organized, understandable, and helpful for learners' understanding and engagement.

The results indicated that the content successfully incorporated interactive and multimedia features, which boosted learner engagement and accessibility. The passing mark in assessment and closure showed that the content included formative assessments, post-tests, and synthesis activities that helped deepen students' understanding of the material. The findings support the study by Lego (2025), which confirmed that mathematics educational materials should reflect the quality of the content, language, organization, readability, and evaluation components. Aguelo (2024) similarly concluded that contextualized mathematics learning resources should undergo both curricular and statistical validation to ensure their appropriateness for instruction. Similarly, Galangco et al. (2024) emphasized the significance of expert validation in assessing the quality of learning packages, especially with competencies, activities, assessments, and lesson arrangement.

The digitized instructional material was validated and rated as pedagogically adequate, technically functional, visually acceptable, and aligned with the learning goals of the Mathematics 10 learners.

**Problem 5. What improvements may be proposed to enhance the digitized instructional material based on expert and learner evaluations?**

Based on evaluations by experts and learners, recommendations were provided to improve further the quality, functionality, and instructional efficacy of the digitized instructional material for Mathematics 10. The recommendations were to increase multimedia interactivity, enhance visual presentation, improve the sequence of instructional activities, and increase students' involvement through more contextualized and varied learning assignments. Validators recommended adding more practice and feedback opportunities to improve learner understanding, improving the consistency of animations and transitions, offering clearer directions for interactive activities, and refining visual layouts for better readability. Other recommendations included enhancing gamified exercises, providing contextualized examples, and incorporating higher-order thinking challenges to develop students' analytical and problem-solving skills further.

The experts also stressed the necessity of having well-defined learning objectives, a well-structured course progression, and the appropriate integration of multimedia elements to ensure alignment with learning competencies and learners' requirements. Students' feedback highlighted that easy navigation, engaging simulations, and fast corrective feedback were important for keeping them motivated and actively involved in the lessons.

All comments, ideas, and recommendations from the validators and learners were incorporated into the revised version of the digitized instructional material, as shown in the improved content submitted via the Google Drive link. The revamp involved major changes to the presentation of content, multimedia elements, interaction, assessment components, and instructional delivery, resulting in a more learner-centered, engaging, accessible, and instructionally effective approach for Mathematics 10 students. Below are the link and QR code for the material.



<https://tinyurl.com/3n6dkz3v>

**Problem 6. Is there a significant difference in scores before and after the implementation of digital instructional materials?**

Table 11 presents the t-test results for the pretest and posttest of students using the digitized instructional material in Mathematics 10.

Table 11. *Paired t-test results on the difference between the pre-test and post-test scores of the learners*

Test Setting	Mean	Standard Deviation	P-value	Remarks
Pre-test	8.12	2.88	0.001	Significant
Post-test	22.41	2.68		

The findings showed that the digitized instructional material had a considerable effect on Grade 10 students' performance in Probability. The mean score increased from 8.12 in the pre-test to 22.41 in the post-test. This reflects a significant increase in the learners' understanding after exposure to the intervention.

Students demonstrated a limited understanding of the target skill prior to using the digital educational resource, but their performance improved substantially afterward. In addition, the post-test standard deviation decreased, indicating that students' results were more consistent after implementation and suggesting that the material proved useful for both low- and high-performing learners.

The p-value of 0.001, which was statistically significant, further affirmed that the improvement in students' scores was not by chance. This means that the interactive, gamified, feedback-oriented, and competency-based components of the digitized teaching material contributed greatly to boosting learners' knowledge of Probability concepts. This study aligns with Bantulo (2025), who demonstrated that digital instructional materials substantially improved Mathematics learning among Filipino students through a pre-test-post-test methodology. Repolito (2025) similarly reported that the application of designed mathematics learning materials enhanced learners' post-test performance. Furthermore, Reyes and Belleza (2025) found that interactive digital resources significantly improved the Mathematics performance of Grade 9 students in Albay. These studies corroborate the current result that digital and interactive teaching resources help bridge learning gaps and enhance mathematics achievement among Filipino students. The findings demonstrate that the digital instructional material is an effective intervention for enhancing Grade 10 students' performance in Probability.

### **Problem 7. What recommendations may be proposed, based on the study's findings, for the improvement, utilization, and future development of digitized instructional materials in Mathematics 10?**

The digitized instructional material in Mathematics 10 must be improved and made competency-based, especially in Probability problem-solving, which was observed to be the least mastered competency with a Mean Percentage Score (MPS) of 45%, interpreted as "Not Mastered". The material should still focus on step-by-step demonstrations, guided practice activities, contextualized problems, visual simulations, and immediate feedback mechanisms to help develop students' analytical thinking and mathematical problem-solving skills, thereby further enhancing learners' understanding.

There are also several components of the material that need ongoing improvement, including the consistency of animations, the readability of slides, navigation features, interactivity, clarity of instructions, practice exercises, feedback systems, gamified activities, contextualized examples, and higher-order thinking tasks. Experts and learners said they needed clearer activity directions, better visual organization, stronger multimedia integration, and more engaging, learner-centered experiences. These enhancements will be crucial for improving the effectiveness and accessibility of the teaching material for pupils.

Mathematics 10 teachers are urged to use the digitized teaching materials as supplementary and remedial tools, especially when diagnostic and quarterly assessment results indicate low student performance in Probability and related skills. Classroom discussions, intervention sessions, enrichment activities, self-paced learning, and formative evaluations can use the information. In terms of pedagogical soundness, technical functionality, visual organization, and alignment with curricular standards, the content was deemed genuine. The material was deemed appropriate for classroom use. School heads and the Mathematics coordinators should also be supported in applying the material through access to devices, internet connectivity or offline digital copies, teacher orientations, and monitoring methods. Since the study was conducted in schools where students had limited access to technology, institutional support remains important to ensure that digital instructional materials serve as tools for inclusive and equitable mathematics learning rather than additional barriers to education.

Further work on the content should focus on extending its coverage to other, less-mastered competencies in Mathematics 10 beyond Probability. To further enhance the learning experience, future iterations could also include adaptive learning pathways, student progress dashboards, localized examples, game-based evaluations, offline accessibility, and learner analytics. Future studies can also examine the content's usefulness using larger samples, experimental study designs, longer implementation periods, and additional grade levels to determine its broader applicability and long-term durability. Furthermore, the study suggests that digitalized instructional materials in Mathematics 10 should not be merely electronic copies of printed modules, but rather interactive, contextualized, differentiated, assessment-supported, and learner-

centered materials that target identified competency gaps and foster deeper mathematical understanding among learners.

## Conclusions

Based on the findings given, the following are drawn:

1. The low proficiency of Grade 10 learners in answering probability problems demonstrates that many students still have problems with higher-order mathematical reasoning and problem-solving skills, which require focused and competency-based digital instructional interventions.
2. Effective digital instructional materials in Probability should have well-structured lessons, integrated multimedia features, contextualized learning activities, differentiated instruction, and learner-centered assessment strategies to meet different learning needs and improve students' engagement.
3. The ADDIE Model has proven to be an effective framework in generating digital instructional materials, as it provided a systematic and learner-centered method in ensuring the right planning, interactive multimedia integration, and alignment with the identified least mastered competencies.
4. The generated digital instructional material was valid, instructionally sound, visually arranged, technically functioning, and conforming to the curricular criteria and so appropriate for use in Mathematics 10 education.
5. The usability, interactivity, instructional clarity, accessibility, and general learner engagement of the digital educational material were greatly enhanced by the inclusion of input from both experts and learners.
6. The use of the digital teaching material has led to a considerable improvement in the performance of the Grade 10 learners in Probability. This is evident in the significant increase in post-test scores following the intervention.
7. The results also reaffirmed that digital instructional materials in Mathematics 10 can be utilized as effective learner-centered intervention tools that can bridge competency gaps through interactive, contextualized, and technology-enhanced learning experiences, hence improving students' engagement, conceptual understanding, and problem-solving skills in Probability.

## Recommendations

Based on the conclusions drawn, the following recommendations are offered for consideration.

**Department of Education (DepEd).** They may enhance the use of digital instructional materials in Mathematics, supporting the development, validation, and implementation of competency-based and interactive learning resources aligned with the Most Essential Learning Competencies (MELCs).

**Schools Division Superintendent.** They may initiate division-wide programs, provide technical assistance, and conduct monitoring activities to support the use of validated digital teaching materials to address the least mastered competencies in Mathematics.

**Education Program Supervisors.** They may provide ongoing instructional supervision, mentorship, and capacity-building activities to help instructors develop and implement technology-enhanced, interactive mathematics educational resources.

**School Principal.** They may use technical resources, instructional monitoring, and professional development opportunities that support innovative teaching methods in Mathematics to reinforce the integration of digital instructional materials into classroom instruction.

**Math Teachers.** Learner-centered, interactive, and gamified digital educational resources can be used

regularly by mathematics teachers to improve learners' engagement, conceptual understanding, and problem-solving skills in Probability and other mathematical competencies.

**Students.** They can employ interactive exercises, simulations, self-assessment tools, and technology-supported learning experiences to engage with digital instructional materials actively, further enhancing their mathematical understanding and academic performance.

**Educational Policy Makers.** They may develop policies and funding programs that promote the accessibility, sustainability, and greater use of technology-enhanced teaching resources in Mathematics education.

**Stakeholders.** They may engage with schools to provide technological assistance, digital learning resources, and learning facilities that can enhance the implementation of innovative and interactive mathematics instruction.

**Future Researchers.** They may study the long-term effectiveness of digital instructional resources across a variety of mathematics skills, grade levels, and educational settings, using larger samples and more rigorous experimental research designs.

### Declaration of Conflicting Interest

The authors declare no potential conflicts of interest regarding the research, authorship, or publication of this article.

### Funding

The author received no financial support for the research, authorship, and publication of this article.

### References

- Acantilado, M. J. (2025). Development and validation of interactive e-learning materials for Grade 5 science. *Science and Technology Education Journal*, 6(2), 45–56.
- Aguelo, J. (2024). Development and validation of contextualized learning material in mathematics (Bikol Central) for kindergarten. *International Journal of Research Studies in Education*, 13(17), 41–53. <https://doi.org/10.5861/ijrse.2024.24749>
- Ahmed, R., & Lee, S. (2024). Effectiveness of digital instructional modules in engineering education. *International Journal of Engineering Education*, 40(2), 350–362.
- Albento, E. A. (2023). Development and validation of remediated learning material in Mathematics 6. *International Journal of Research Studies in Education*, 12(7). <https://consortiacademia.org/10-5861-ijrse-2023-53/>
- Alcisto, J. C., Ramos, L. P., & De Vera, M. A. (2024). Development and validation of an e-module for teaching Earth's motion in Grade 6. *International Journal of Research and Innovation in Social Science*, 8(5), 1550–1560. <https://rsisinternational.org/journals/ijriss/articles/development-and-validation-of-e-module-in-teaching-earths-motion-for-grade-6/>

- Almelhes, S. A. (2022). The effects of interactive multimedia learning tools on students' achievement and motivation. *International Journal of Emerging Technologies in Learning*, 17(2), 4–18. <https://online-journals.org/index.php/ijet/article/view/27101>
- Anugraheni, I., et al. (2025). The impact of realistic problem-based learning on students' mathematical problem-solving ability. *Cogent Education*. <https://doi.org/10.1080/2331186X.2025.2523078>
- Avenir, C. (2025). *Timely feedback through technology-based assessment*. Retrieved from <https://ejournals.ph/article.php?id=31985>
- Baldinger, S., & colleagues. (2026). *Digital adaptive learning in secondary mathematics: A systematic study of adaptive mathematics learning environments*. *Journal of Computer Assisted Learning*. <https://onlinelibrary.wiley.com/doi/full/10.1002/jcal.70178>
- Bantulo, J. (2025). Effectiveness of supplementary materials utilizing digitized instructional materials in enhancing Mathematics learning. *Psychology and Education: A Multidisciplinary Journal*. <https://ejournals.ph/article.php?id=31846>
- Batanero, C., & Álvarez-Arroyo, R. (2023). *Teaching and learning of probability*. *ZDM–Mathematics Education*. <https://doi.org/10.1007/s11858-023-01511-5>
- Benedicto, J. P., Artajo, M. R., & Martir, E. L. (2025). Development, validation, and acceptability of an instructional module in Organization and Management. *International Journal of Science and Management Studies*, 8(4), 107–115. <https://ijmsjournal.org/ijms-v8i4p107.html>
- Borja, M. M., & Palomares, N. R. (2024). Development, validation, and testing of video-assisted instruction in Mathematics 8. Zenodo. <https://zenodo.org/records/14201852>
- Campos, N., Corlu, C. G., Nogal, M., Juan, A. A., & Caliz, C. (2024). Simulation-based mathematical learning for higher education students from heterogeneous backgrounds. *Journal of Simulation*. <https://doi.org/10.1080/17477778.2024.2314716>
- Chen, Y. (2022). Technology-based instructional materials in mathematics education. *International Journal of Educational Technology*, 19(2), 45–56.
- Combo, J. E. A., Olino, M. V. D., & Rivas, A. M. G. (2025). *A contextualized reinforcement and intervention program in mathematics for selected senior high school students*. *International Journal of Multidisciplinary: Applied Business and Education Research*, 6(2), 736–752. <https://doi.org/10.11594/ijmaber.06.02.23>
- Dan, N. N., Hoi, T. T., & Liem, N. V. (2024). Digital game-based learning in mathematics education at primary school level: A systematic literature review. *EURASIA Journal of Mathematics, Science and Technology Education*, 20(3), em2411. <https://www.ejmste.com/article/digital-game-based-learning-in-mathematics-education-at-primary-school-level-a-systematic-literature-14377>
- Debrenti, E. (2024). Game-based learning experiences in primary mathematics education. *Frontiers in Education*, 9, 1331312. <https://www.frontiersin.org/journals/education/articles/10.3389/educ.2024.1331312/full>
- Department of Education. (1988). DepEd Order No. 35, s. 1988: Teaching aids, equipment, and textbooks. DepEd Philippines.
- Department of Education. (2020). DepEd Order No. 12, s. 2020: Adoption of the Most Essential Learning Competencies (MELCs). DepEd Philippines.
- Department of Education. (2023). DepEd Order No. 24, s. 2023: Development of alternative learning tools and resources. DepEd Philippines.
- Dickey, M. D., & Bejarano, A. (2023). Generative AI for instructional design: The GAIDE framework. *Educational Technology Research and Development*, 71(5), 2431–2448.
- Dimou, E. (2021). Systematic review of the effectiveness of intervention strategies for teaching mathematics to secondary school students. *Open Access Library Journal*, 8(5), 1–27. <https://doi.org/10.4236/oalib.1107392>

- Ding, Y., & Toran, H. (2025). Application of the ADDIE model as an instructional design framework in teaching and rehabilitation: A review. *International Journal of Learning, Teaching and Educational Research*, 24(1), 87–115. <https://ijlter.org/index.php/ijlter/article/view/12239>
- Dizon, R. C. (2026). Development and validation of collaborative learning modules in Chemistry 9. *World Education Connect Multidisciplinary E-Publication*, 6(1), 33–45. <https://www.pinagpalapublishing.com/publications/world-education-connect-multidisciplinary-e-publication/wec-2026-issues/wec-vol-vi-issue-i-january-2026/development-and-validation-of-collaborative-learning-modules-in-chemistry-9>
- Domingo, A. P. (2023). Development and validation of a module in Earth and Life Science for Grade 11 students. *International Journal of Research and Innovation in Social Science*, 7(9), 1012–1019. <https://rsisinternational.org/journals/ijriss/articles/development-and-validation-of-a-module-in-earth-and-life-science-for-grade-11-students/>
- El-Hamamsy, L., Schneckenberg, L., Borgeaud, S., & Zufferey, J. (2022). Validation of the computational thinking test for upper primary education. *Computers & Education*, 190, 104607.
- Fuentes, R. L. (2025). Development and validation of instructional materials for teaching theories and practices in the Master of Public Administration program. *International Journal of Educational Studies*, 12(1), 88–97. <https://theaspd.com/index.php/ijes/article/view/8145>
- Galangco, J. S., et al. (2024). Development and validation of learning package in mathematics. *Diversitas Journal*, 9(4). [https://diversitasjournal.com.br/diversitas\\_journal/article/download/3201/2754](https://diversitasjournal.com.br/diversitas_journal/article/download/3201/2754)
- García, L. (2022). Supplementary instructional materials and mathematics achievement of secondary students. *Journal of Educational Research and Practice*, 12(3), 89–102.
- García, M. T., & Torres, A. D. (2023). Development of multimedia instructional materials for history education. *Journal of Social Studies Education Research*, 14(2), 210–225.
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education. *Sustainable Operations and Computers*, 3, 275–285.
- Hamora, J. C., Dela Cruz, R. T., & Villanueva, M. A. (2022). Students' evaluation of faculty-made instructional modules during modular learning. *Journal of Education, Management and Development Studies*, 2(3), 1–10. <https://journals.cspc.edu.ph/index.php/jemds/article/view/109>
- Hershkovitz, A., et al. (2024). Learning analytics in mathematics education: The case of immediate feedback in digital classification tasks. *ZDM—Mathematics Education*. <https://link.springer.com/article/10.1007/s11858-024-01551-5>
- Hidayat, R., et al. (2024). Online game-based learning in mathematics education among Generation Z: A systematic review. *International Electronic Journal of Mathematics Education*, 19(1), em0763. <https://www.iejme.com/article/online-game-based-learning-in-mathematics-education-among-generation-z-a-systematic-review-14024>
- Jaramillo-Mediavilla, L., Basantes-Andrade, A., Cabezas-González, M., & Naranjo-Toro, M. (2024). Impact of gamification on motivation and academic performance: A systematic review. *Education Sciences*, 14(6), 639. <https://www.mdpi.com/2227-7102/14/6/639>
- Khaled, F. J., & Alghfeli, A. S. (2025). The impact of structured digital lessons and self-assessment strategies on mathematics achievement and motivation among school students in the UAE. *International Electronic Journal of Elementary Education*, 17(3), 445–465. <https://files.eric.ed.gov/fulltext/EJ1476556.pdf>
- Kumar, R., & Sharma, S. (2024). Digital instructional materials and student engagement in social science education. *International Journal of Educational Technology in Higher Education*, 21(1), 1–14.
- Lego, D. (2025). Contextualized learning module on least mastered competencies of Grade 9 mathematics learners. *Psychology and Education: A Multidisciplinary Journal*, 37(10). <https://ejournals.ph/article.php?id=30275>

- Letchumanan, M., & Yew, W. T. (2024). Self-regulated learning in mathematics online learning environments: A systematic review. *International Journal of Academic Research in Progressive Education and Development*, 13(4). <https://files.eric.ed.gov/fulltext/EJ1445644.pdf>
- Lim, R. P. S. (2024). Development and validation of an interactive learning module in Grade 8 Earth science. *European Journal of Theoretical and Applied Sciences*, 2(5), 238–246.
- Lopez, J. (2023). Supplementary digital instructional materials and mathematics learning outcomes. *Journal of Educational Multimedia and Hypermedia*, 32(2), 155–170.
- Macalikod, J. R., & Simpall, R. P. (2025). Development and validation of science instructional materials that address least-learned competencies. *Journal of Science and Humanities Education*, 4(1), 15–27.
- Madrilejos, K. A. (2024). Validation of a mathematics teaching assessment scale for K–12 basic education: A confirmatory factor analysis approach. *Journal of Interdisciplinary Perspectives*, 2(6), 6–20. <https://doi.org/10.69569/jip.2024.0081>
- Mahmuti, A. (2025). The impact of contextual teaching and learning on improving student achievement in economic mathematics. *International Electronic Journal of Mathematics Education*. <https://www.iejme.com/download/the-impact-of-contextual-teaching-and-learning-on-improving-student-achievement-in-economic-16233.pdf>
- Munap, M. S. (2025). The use of formative assessment to enhance students' learning experiences: The case of Maimbung District, Division of Sulu. *Journal of Education and Academic Settings*, 2(1). [https://www.researchgate.net/publication/389928646\\_The\\_Use\\_Of\\_Formative\\_Assessment\\_In\\_Enhancing\\_Student\\_Learning\\_Experiences\\_The\\_Case\\_Of\\_Maimbung\\_District\\_Division\\_Of\\_Sulu](https://www.researchgate.net/publication/389928646_The_Use_Of_Formative_Assessment_In_Enhancing_Student_Learning_Experiences_The_Case_Of_Maimbung_District_Division_Of_Sulu)
- Niño, E. J. A., & Lomibao, L. S. (2026). A systematic review of the development and validation of instructional materials used in Philippine mathematics classrooms. *Journal of Innovations in Teaching and Learning*, 6(1), 1–12.
- OECD. (2023). PISA 2022 results (Volume I and II): Country notes – Philippines. Organization for Economic Co-operation and Development. <https://www.oecd.org/pisa>
- Paguirigan, E. M., & Paguirigan, M. J. R. (2024). Development of a mathematics module using the 5E learning model. *International Journal of Learning, Teaching and Educational Research*, 23(11), 125–142. <https://www.ijlter.org/index.php/ijlter/article/view/11602>
- Paynandos, J. R. R. (2025). Validation of the developed innovative supplemental materials (ISMs) on the least-learned competencies in Grade 8 physics. *International Journal of Multidisciplinary: Applied Business and Education Research*, 6(3). <https://ejournals.ph/article.php?id=26240>
- Philippine News Agency. (2026, March 3). Senate reviews DepEd plan to shift to 3-term school year. <https://www.pna.gov.ph>
- Philstar. (2023, December 6). Philippines still lags behind world in math, reading and science — PISA 2022. Philstar.com. <https://www.philstar.com>
- Philstar. (2025, December 17). New study finds no real progress in Philippines' literacy and numeracy crisis. Philstar.com. <https://www.philstar.com>
- Pilar, S. M. (2025). Development, validation, and summative evaluation of code-mixed localized instructional materials in Mathematics I. *Asian Journal of Education and Social Studies*, 51(6), 1209–1220. <https://doi.org/10.9734/ajess/2025/v51i62068>
- Quintos, C. M. (2024). Development and validation of instructional materials in Nihongo language education. *Asian Journal of Arts, Humanities and Social Studies*, 7(3), 44–53. <https://e-pallipublishers.com/index.php/ajahs/article/view/3440>
- Rahman, M. (2022). Development of technology-based mathematics instructional materials for secondary education. *International Journal of Education and Development Using Information and Communication Technology*, 18(3), 94–108.

- Rahman, M., & Islam, A. (2022). Development of technology-based instructional materials for language learning. *International Journal of Education and Development Using ICT*, 18(3), 94–108.
- Ramos, R. I. A., & Adventist, C. R. (2024). Assessment of students' mathematical learning competencies: Basis for instructional material development. *International Journal of Educational Studies*, 6(2), 45–58.
- Rappler. (2025, January 27). Filipino students 4 to 5 years behind expected standards. Rappler.com. <https://www.rappler.com>
- Rappler. (2026, January 26). 88% of students entering Grade 7 struggling in reading and numeracy. Rappler.com. <https://www.rappler.com>
- Ravalo, P. V., & Flores, J. S. (2024). Developed digital supplementary material: Learning backlog intervention in Grade 9 mathematics lessons. *Jurnal Inovasi Pendidikan*, 3(4). <https://doi.org/10.60132/jip.v3i4.534>
- Repolito, M. R. M. (2025). Enhancing the performance of Grade 3 learners in Mathematics through teacher-made, contextualized learning activity sheets. *Psychology and Education: A Multidisciplinary Journal*. <https://ejournals.ph/article.php?id=31409>
- Reyes, J. D., & Belleza, S. S. (2025). The effects of interactive digital materials on Grade 9 students' performance in Mathematics. *International Journal of Science and Research Archive*, 15(3), 1031–1043. <https://doi.org/10.30574/ijssra.2025.15.3.1926>
- Ronquillo, E. B. (2025). Development and validation of worksheets to address the least learned competencies in Mathematics 4. *Pantao: The International Journal of the Humanities and Social Sciences*, 4(2). <https://doi.org/10.69651/PIJHSS040291>
- Sabitillah, L., et al. (2025). Teachers' strategies in implementing differentiated instruction in mathematics learning. *European Journal of Education and Teaching*. <https://ejset.saintispub.com/ejset/article/view/1316>
- Saga, A. (2026). Contextualizing mathematics through agriculture: Examining the effects on students' probability proficiency. *Journal of Education and Learning*. <https://files.eric.ed.gov/fulltext/EJ1495360.pdf>
- Santos, M. L. (2023). Multimedia instructional materials for improving mathematics learning. *Journal of Educational Media Research*, 15(1), 35–49.
- Serrano, F. D. L. C. (2026). GeoGebra-mediated instructional design for matrix multiplication. arXiv. <https://arxiv.org/abs/2602.02747>
- Söderström, S., & Palm, T. (2024). Feedback in mathematics education research: A systematic literature review. *Research in Mathematics Education*. <https://www.tandfonline.com/doi/full/10.1080/14794802.2024.2401488>
- Suaybagoio, G. (2025). *Development of Digitalized Strategic Intervention Material in Science 8 in Cabadbaran City National High School*. DOI: <https://doi.org/10.55248/gengpi.6.0525.1707>
- Susanto, E., et al. (2024). *Enhancing students' numeracy skills in solving probability problems through realistic mathematics education*. [https://www.researchgate.net/publication/381431073\\_Enhancing\\_Students%27\\_Numeracy\\_Skills\\_in\\_Solving\\_Probability\\_Problems\\_through\\_Realistic\\_Mathematics\\_Education](https://www.researchgate.net/publication/381431073_Enhancing_Students%27_Numeracy_Skills_in_Solving_Probability_Problems_through_Realistic_Mathematics_Education)
- Tan, C., & Ong, P. (2023). Development of e-learning modules for business education. *Computers and Education Open*, 4, 100123.
- Turro, I. R. K., & Giducos, R. M. (2024). Development and validation of manipulatives in teaching Mathematics 6. *Randwick International of Education and Linguistics Science Journal*, 6(2). <https://doi.org/10.47175/rielsj.v6i2.1163>
- UNESCO. (2023). *Global Education Monitoring Report 2023: Technology in Education: A Tool on Whose Terms?* UNESCO. <https://gem-report-2023.unesco.org/technology-in-education/>

Vacalares, A. B., Elbanbuena, C. O., & Comon, J. D. (2024). Differentiated instructional practices and academic performance in mathematics. *European Modern Studies Journal*, 8(4). [https://www.researchgate.net/publication/384852397\\_Differentiated\\_Instructional\\_Practices\\_and\\_Academic\\_Performance\\_in\\_Mathematics](https://www.researchgate.net/publication/384852397_Differentiated_Instructional_Practices_and_Academic_Performance_in_Mathematics)

Villanueva, M. G. (2025). Real-world context in mathematics teaching: Teachers' perspectives and instructional practices. *International Journal of Innovative Science and Research Technology*. <https://www.ijisrt.com/assets/upload/files/IJISRT25MAR1723.pdf>

Wahyuni, R., & colleagues. (2026). Adaptive learning in digital technology-based mathematics education through systematic literature review. *International Conference on Education, Language, and Humanities*. <https://callforpaper.unw.ac.id/index.php/ICOELH/article/download/1632/1018/8516>

Wangge, M. C. T. (2024). Developing and validating contextual learning instructional materials for two-variable linear equation systems in senior high school mathematics. *Journal of Transdisciplinary Studies in Education*, 1(1). <https://doi.org/10.64268/jtse.v1i1.13>

World Bank. (2020). PISA 2018 country report: Philippines. World Bank Group. <https://documents.worldbank.org>

Xu, X. (2025). Game-based adaptive learning in probability education. *International Journal of Information and Education Technology*, 15(1), 109–115. <https://www.ijiet.org/vol15/IJiet-V15N1-2212.pdf>

Yan, L., Wang, Y., & Zhao, J. (2023). Applications of large language models in education: A systematic review. *Educational Technology & Society*, 26(4), 123–137.

Zhao, X., & Chen, Y. (2023). Digital learning platforms for improving science instruction. *Journal of Educational Computing Research*, 61(5), 1024–1043.

Zulyadaini, Z. (2022). Instructional development of mathematics learning materials in higher education. *International Journal of Instructional Media and Technology*, 14(2), 60–72.

## Acknowledgment

The researcher is grateful, above all, to God for all the blessings given to her, for without Him, this study would not have been possible.

**Dr. Levita B. Grana**, Chair of the panel and Assistant Dean of the Graduate School. Your dedicated mentorship and guidance in defending my manuscript.

**Dr. Rodelio B. Pasion and Dr. Benjie P. Jacob**, members of the panel, for contributing their research expertise.

**Dr. Donald D. Orbillos**, adviser, for his support, guidance, expertise in learning resource management, and valuable comments and suggestions that contributed to the success of this study.

**Jeanie L. Mativo, CESO V**, Schools Division Superintendent, for allowing the researcher to conduct the study in the Division of Agusan del Norte.

**Dr. Carlos G. Samontina**, Public School District Supervisor, for allowing the researcher to conduct the study in Las Nieves District Cluster III.

**Lilibeth S. Apat**, EPS in Mathematics; Michael L. Tadulan, language expert; Neil J. Arado, LRMS representative, for checking and validating the researcher's digitized instructional material.

**Janelle J. Gaviola**, Durian National High School and Durian National High School - Bokbokon Annex Principal, **Ma. Lourdes L. Luna**, Casiklan National High School Principal, and **Christian Lozano, Lawan-Lawan National High School School Head**, for allowing the researcher to conduct the study in their respective schools.

**Grade 10 students of Las Nieves District Cluster III**, the study's respondents, for their support and cooperation in

providing the researcher with all the necessary outputs.

**Mathematics 10 teachers of Las Nieves District Cluster III**, for their valuable participation in Focus Group Discussion.

**Malou P. Casane**, the researcher's friend, for her constant affirmation, "you can do it," and supportive words of encouragement.

To her children **Althea Chloe and Ace Jharred**, for being an inspiration throughout the study.

**Joel B. Balagot**, husband, for being her number one supporter and always being there from the beginning of the study. The presence, financial support, and motivation mean a lot to her throughout the journey.

**Roquesa and Raymundo Belonta**, researchers' parents, for the endless love and support.