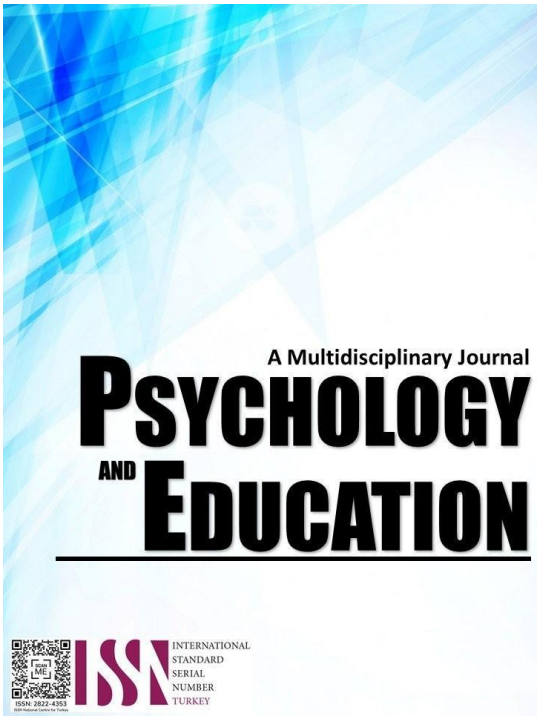
BRINGING MATH TO LIFE: ENHANCING PROBLEM SOLVING SKILLS IN PROBABILITY OF RANDOM VARIABLES THROUGH DIGITIZED COMICS



PSYCHOLOGY AND EDUCATION: A MULTIDISCIPLINARY JOURNAL

Volume: 41
Issue 10
Pages: 1207-1228
Document ID: 2025PEMJ4036
DOI: 10.70838/pemj.411010
Manuscript Accepted: 06-04-2025

Psych Educ, 2025, **41**(10): 1207-1228, Document ID:2025PEMJ4036, doi:10.70838/pemj.411010, ISSN 2822-4353

Research Article

Bringing Math to Life: Enhancing Problem Solving Skills in Probability of Random Variables through Digitized Comics

Rima R. Bestil,* Ronaldo A. Punla
For affiliations and correspondence, see the last page.

Abstract

Abstract concepts in mathematics, such as probability, often present significant challenges for students, impacting their comprehension and problem-solving abilities. This study investigated the effectiveness of digitized comics as strategic intervention materials (SIMs) to improve students' skills in solving probability-based word problems. The research aimed to make learning accessible, reduce math anxiety, and enhance student motivation by integrating complex mathematical concepts into visually engaging, story-driven comic formats. The study employed a mixed-methods design, collecting both quantitative and qualitative data to examine the impact of comic-based SIMs on student learning outcomes. Quantitative data, gathered from pre-test and post-test scores of control and experimental groups, showed a statistically significant improvement in performance for students utilizing the comics. The experimental group achieved a post-test mean score of 20.07 (Very Satisfactory) compared to the control group's 11.67 (Fairly Satisfactory). Furthermore, the experimental group's mean gain score (14.93) was notably higher than the control group's (6.33), with a statistically significant difference ($t=7.82$, $p<0.001$), confirming the SIM's effectiveness in enhancing problem-solving abilities. Qualitative data indicated that students experienced reduced math anxiety and increased interest through comics-based learning, which also facilitated the recall and application of problem-solving strategies. However, challenges in mathematical reasoning persisted, and student feedback highlighted areas for improvement, including the incorporation of more color, summaries, diverse problem types, and additional practice problems. The study concluded that digitized comics are an effective tool for enhancing both cognitive and affective aspects of learning probability. The findings underscored the effectiveness of SIMs that combine visual and narrative elements, validating comics as a powerful tool for supporting learning in mathematics. Integrating comic-based SIMs into the mathematics curriculum presents a promising strategy for improving student engagement and comprehension in challenging subjects like the probability of random variables.

Keywords: *digitized comics, Strategic Intervention Material (SIM), word problems, mathematical skills, student engagement*

Introduction

In the world of education, mathematics stands as a foundational pillar, shaping students' analytical and critical thinking skills. However, teaching mathematical word problems has often posed challenges, as students may struggle to grasp abstract concepts and connect them with practical applications. Traditional methods, while effective to some extent, may not fully capture students' attention or make the subject matter relevant to their lives. This is where the study steps in as a groundbreaking initiative to transform the learning experience.

They are aligned with the goals and mission of the National Council of Teachers of Mathematics (NCTM). In November 16, 2023, the organization announced the creation of a joint conference focusing on literacy and mathematics, Ken Krehbiel (2023), NCTM Executive Director said that the organizations are excited about working together with NCTE to support elementary teachers who have the added responsibility of teaching multiple subjects in students' early years. The conference addressed the foundational topics of math, reading, and writing and helped to provide teachers with tools to inspire young learners.

Initially, according to a study by Khoshaim, (2020), Math instructors are ready to provide their students with word problem activities. However, teachers typically avoid using such word problems in the classroom since students believe them to be extremely difficult. The findings showed that students' poor mathematical skills and unfavorable attitudes about the subject made solving such problems more challenging. If left untreated, these issues cause further tension and anxiety in the classroom and eventually lead to a fear phobia of global issues. The results also showed that for teachers to invest the necessary time and effort into its implementation, they must comprehend the significance of such duties.

Recent research highlights the effectiveness of strategic intervention materials (SIM) and comics in enhancing mathematics learning. SIM has shown positive impacts on mastering the least-learned competencies in secondary education (Arpilleda, 2021). For students with learning disabilities, explicit instruction models like graphic organizers and schema-based instruction have proven beneficial (Dimou, 2021). Similarly, for primary students with intellectual disabilities, systematic and explicit instruction with feedback and manipulatives is effective (Schnepel & Aunio, 2021). These interventions should be well-structured, high-intensity learning sequences adapted to students' achievement levels.

Additionally, comics are gaining attention as an instructional tool in primary mathematics education. The TSCT (Theme, Storyline, Character, Text) framework has been proposed for designing comic-based mathematics lessons, potentially increasing student interest

and motivation (Chu & Toh, 2020). These findings suggest diverse approaches to improve mathematics instruction across different student populations.

Moreover, according to curriculum specialist Tracy Edmunds, studies show that reading comics with both text and pictures improves learning acquisition. The four Cs of math education—critical thinking, creativity, cooperation, and communication—are highlighted by Edutopia- an educational website, as being particularly important in comics. Comics encourage critical thinking in students through the simultaneous analysis of several elements, including layout, symbolism, and linguistic components. Internet tools like Pixton or Storyboard demonstrate to students how effectively visuals can communicate concepts (Seelow, 2020).

Sinco (2020) emphasizes that Strategic Intervention Materials (SIMs) play a critical role in addressing specific learning gaps in mathematics by offering targeted, structured support that traditional teaching methods may not provide. By integrating digitized comics in the SIMs, the study aims to revolutionize the way mathematical word problems are presented, providing an innovative and dynamic platform that captivates students' imagination and creativity. By leveraging the power of visual storytelling, interactive graphics, and relatable narratives, digitized comics offer a unique opportunity to bring complex mathematical scenarios to life. This approach immerses students in scenarios that resonate with their lives, allowing them to visualize and connect with the problems at hand.

As the digital age continues to shape educational landscapes, harnessing multimedia tools has become increasingly essential in engaging tech-savvy students. Digitized comics open a world of possibilities, enabling educators to create interactive, visually appealing, and captivating learning materials that cater to diverse learning styles. Students are invited to explore mathematical concepts in a dynamic and immersive manner, making learning both enjoyable and meaningful.

In the recent school year 2022-2023 in Baruya High School, the results of the Regional Mid-year Assessment (RMYA), the Mean Percentage Score (MPS) for Statistics and Probability show that the Most Essential Learning Competency (MELC) with the lowest rank is Solving Word Problems in computing probabilities to a given random variable. Digital comics with interactive elements are one form of educational content that has the potential to make significant contributions to education. Teachers can take advantage of the potential of contemporary technology to design interactive, immersive learning experiences by converting traditional comics to digital formats.

Additionally, the research aligned with constructivist learning principles by exploring how engaging and relevant experiences, facilitated by digitized comics, can enhance students' learning outcomes. Moreover, the study responds to the need for innovative teaching tools that cater to the preferences of 21st-century learners, aiming to increase student motivation and engagement in mathematics through interactive and visually appealing narratives. These efforts are intended to bridge existing gaps and offer new insights into the potential benefits of incorporating multimedia tools in mathematics education.

Beyond fostering a deeper understanding of mathematical concepts, the study also sought to empower Grade 11 students in Statistics and Probability as confident problem solvers. By presenting word problems in a context that they can relate to, students can develop a stronger connection with the subject matter by using the strategic material incorporated with comics, leading to increased motivation and active engagement in their learning journey.

Research Questions

This study aimed to determine the effectiveness of digitized comics and the challenges and difficulties of the Grade 11 learners in Word Problems involving Probabilities of Random Variables during the School Year 2023-2024. Specifically, this study sought to answer the following questions:

1. How may the mathematical word problem skills of control and experimental groups be described during the Pre-test?
2. How may the mathematical word problem skills of control and experimental groups be described during the Post-test?
3. Is there any significant difference in the performance of the groups in solving mathematical word problems based on pretest?
4. Is there any significant difference in the performance of the groups in solving mathematical word problems based on the post-test?
5. Is there any significant difference in the overall performance of the groups in solving mathematical word problems based on the mean gain?
6. What inputs may be derived from the shared experiences of the learners on the challenges and difficulties in solving word problems in probability of random variables through the use of the digitized comics?
7. Based on the study's findings, what enhanced strategic intervention material may be proposed?

Literature Review

The present study is anchored on Jerome Bruner's (1996) Constructivist Theory, Benjamin Bloom's (1968) Mastery of Learning Theory, and Gordon Pask's (1975) Conversational Theory.

Bruner's Constructivist Theory states that learners form new concepts and ideas using their current or past experiences and knowledge and that learning is continuous and involves active engagement among learners. The learner chooses and processes information, makes

educational guesses, and constructs conclusions using the structure of cognition.

Bruner's Constructivist Theory applies to this research since teachers construct and make comics to address their students' least-developed competencies. The resources were properly prepared according to the students' comprehension level and what the theory mentions. Additionally, students are free to create their own concepts and methods for addressing the problems presented in the comics. If kids study independently rather than through traditional instruction, their learning had greater significance. (Prakash, 2023).

Additionally, a clear method for providing instructions to close learners' learning gaps was described in Benjamin Bloom's Mastery of Learning Theory. Bloom highlights how important it is for teachers to provide students with various learning opportunities to raise their attainment levels. Teachers arrange ideas, concepts, and the abilities they wish to impart to their pupils through mastery learning. Planning goes first so that the teaching and learning process run smoothly. After providing initial instruction, teachers administer formative assessment. The purpose of these formative assessments is to provide initial feedback and information regarding the progress of the learners. Teachers pair precise "corrective" activities for use in correcting the learners' difficulties using the result gathered from the formative assessment (Akpan, 2020).

Teachers may provide sources of information on a specific topic, such as giving specific page numbers in the workbook and textbook where that concept is discussed. They may also identify alternative learning resources including different textbooks, other learning printed materials, instructional videos, or computerized instructional materials. The Mastery of Learning administers a formative assessment so that teachers can identify the students' difficulties. After identifying the needs of the students, teachers have provided interventions to close the gaps. The intervention that the researcher proposed is a SIM highlighting the enhancement of digitized comics that are designed based on the least mastered skills of the students.

Pask's Conversational Theory was established within the paradigm of cybernetics and attempts to address learning in both machines and biological things. The primary tenet of the theory was that students learn best when they are allowed to engage in meaningful discourse about the material. Students develop their thoughts in this way by drawing on their prior knowledge of the subject. Pask stated that to help the students, the material should be illustrated using entailment structures that demonstrate the concepts that need to be learned. The crucial method in Conversation Theory as emphasized by Pask is "teach-back" wherein a student shares their knowledge with others about what they have learned (Werner, 2019).

Through this Theory, students were able to engage in conversation with the material—which is determined to be crucial for their learning, making this hypothesis applicable to the current study. Comics as Strategic Intervention Material: This resource gives students a step-by-step way to support their learning needs and even allows them to evaluate what they have learned because it offers a correction key. To facilitate more relevant learning, the SIM may also be administered to the students in groups or pairs.

In conclusion, constructivist theory discussed how students create new concepts based on prior knowledge. It mostly focuses on how pupils come to understand concepts on their own. On the other hand, mastery of learning theory places more of an emphasis on bridging the gaps between students by addressing their formative assessment learning challenges. Finally, the Conversational Theory emphasized the value of having meaningful conversations about the topic matter to acquire meaningful information. Since comics as SIM enable students to build ideas independently through independent material learning, all the theories are pertinent to the ongoing research. Because SIM is only focused on the learner and the subject matter, there are fewer pressures. SIM also correct immediately the responses of the students leading to a mastery of learning.

Comics

A study done Manalo (2024) explored the potential of comics as an assessment tool for mathematical knowledge, specifically examining the perspectives of pre-service mathematics teachers. Using a qualitative approach with semi-structured interviews, the study investigated these teachers' perceptions of comics as a method for evaluating their mathematical abilities and the broader implications for mathematics education.

The thematic analysis revealed that pre-service teachers perceived comics as effective for demonstrating conceptual understanding, applying mathematical knowledge, fostering creativity and critical thinking, and promoting reflective learning. Furthermore, the study emphasized comics' value in cultivating 21st-century skills and their potential as a genuine formative, self, and peer evaluation method in mathematics. These findings on the evaluative capacity of comics directly support the rationale the current study, suggesting that if comics can effectively assess mathematical understanding, they also hold significant promise as strategic intervention materials to improve learning and address knowledge gaps in mathematics.

The effectiveness of using educational comics and cartoons to teach social studies to 6th graders was investigated by (Sentürk & Simsek, 2021). Employed a mixed-methods embedded design, researchers used a quasi-experimental approach with pre- and post-tests across two experimental groups (comics and cartoons) and a control group (total of 266 students). Quantitative data, analyzed using ANOVA, showed both comics and cartoons significantly improved academic achievement compared to traditional instruction, with comics demonstrating the strongest impact. Qualitative data from student experiences, analyzed through content analysis of phenomenological interviews, revealed that students viewed both visual aids as effective learning tools in various ways. The findings suggest that incorporating educational comics and cartoons can be a valuable strategy for enhancing social studies learning.

Akcanca (2020) highlights a common hurdle in science education: the abstractness of concepts that often hinders student comprehension and effective teaching. To address this challenge, he proposed educational comics as a practical and accessible solution. These visual resources capitalize on the inherent appeal and affordability of comics, aiming to enhance student engagement in science. A key point emphasized by Akcanca is the necessity for careful design when creating educational comics. The importance of balancing entertainment within the comic format with rigorous adherence to scientific accuracy and curriculum goals were stressed. Ultimately, the author anticipates that utilizing comics in science classrooms lead to a more approachable and understandable learning experience, fostering improved student perception and grasp of often difficult scientific concepts.

Educational comics, as highlighted by Pixton Comics, offer a highly engaging and enjoyable medium that effectively captures student attention, cultivating a more positive attitude towards learning. The inherent visual communication within comics significantly enhances comprehension, acting as a powerful tool for diverse learners, including English Language Learners and visual learners, by transcending language barriers and presenting information in an easily digestible visual format. Beyond engagement and accessibility, comics serve as versatile educational resources that bolster essential literacy skills such as reading, writing, and critical thinking. Their ability to simplify complex subjects makes them particularly effective for tackling challenging topics in education.

Furthermore, the use of comics in education fosters student creativity and facilitates differentiated instruction, enabling educators to cater to varied learning styles and empower students to express their understanding in unique and personalized ways. These multifaceted advantages of educational comics, particularly their capacity for visual communication and engagement, strongly suggest their potential as effective strategic intervention materials for learning abstract concepts like probabilities in a digitized format, which is the focus of the current study.

The Graphic Medicine International Collective showcases the potent ability of comics to effectively communicate intricate narratives, particularly within the realm of health and medicine. This organization champions comics as a valuable educational tool, demonstrating their success in patient education and medical training by conveying complex medical information in an accessible format. Furthermore, Graphic Medicine underscores the medium's capacity to cultivate empathy and deeper understanding around sensitive health-related issues, offering a unique avenue for exploring human experiences with illness and healthcare.

Crucially, the visual storytelling inherent in comics is shown to bridge communication gaps between healthcare professionals and patients, ultimately enhancing health literacy and promoting patient engagement. This demonstrated effectiveness of comics in conveying complex and often sensitive information in the medical field lends significant weight to the current study's investigation into digitized comics as strategic intervention materials for learning probabilities. If comics can clarify intricate medical narratives and improve understanding in healthcare contexts, their visual and narrative strengths suggest a strong potential for making abstract mathematical concepts like probabilities more comprehensible and engaging for students.

Comic-Con International Education strongly advocates for comics in education, recognizing their wide-ranging benefits for students. They assert that comics enhance fundamental skills like literacy, artistic expression, and the ability to understand narratives. Moreover, Comic-Con emphasizes the development of crucial visual literacy and critical thinking abilities fostered by engaging with comics, essential skills in today's world. To support practical classroom integration, Comic-Con Education provides resources and workshops for teachers across various subjects, highlighting the versatility of comics. This endorsement of comics as a powerful educational tool, especially for enhancing literacy and critical thinking, directly supports the current study's exploration of digitized comics as strategic intervention materials for making abstract concepts like probabilities more accessible and engaging to learners.

Oxford Owl (n.d.) underscores the significant educational value of comics and graphic novels, particularly for boosting literacy by offering an accessible entry point to reading and enriching vocabulary through visuals. Comics uniquely develop visual literacy, a crucial skill for today's world, by training students to integrate information from both images and text, thus enhancing comprehension. Their engaging and enjoyable format fosters a positive learning attitude, making complex subjects more approachable for students. Therefore, digitized comics hold strong potential as strategic intervention materials to make abstract probability concepts more accessible and engaging for learners.

A journal on geography comics showed pre-service teachers benefited in two ways: deeper content learning and exposure to a novel teaching method. Creating comics fostered rich discussions and reflection on thinking processes often missed in word-based learning environments. The researchers' concluded comics are valuable, yet underused, for teaching spatial thinking. Combining images and text sparks creativity, allowing a more complete grasp of spatial ideas than words alone. This method also helps teachers better assess student understanding, going beyond traditional verbal assessments, which strengthens the rationale for using digitized comics as strategic interventions for learning probabilities in the current study (Reumont & Budke, 2021).

Validated character-based comics for Grade IV thematic learning were rated "Very good" by experts, proving their classroom readiness. These comics effectively increased student discipline and responsibility, evidenced by questionnaires and observations over time, showcasing comics as valuable educational technology. The engaging design of comics, combining visuals and text, boosted student motivation and provided novel learning stimuli. This success in character education suggests that similarly well-designed digitized comics hold strong potential as strategic interventions for enhancing engagement and understanding in probability learning (Rina, 2020).

Statistics and Probability

Statistics and probability serve as foundational pillars for understanding and interpreting the vast amounts of data generated across a multitude of disciplines.

An Introduction to Statistical Learning (ISL) by James et al. (2023) highlights the importance of statistics and probability, ISL provides a rigorous statistical foundation for understanding the underlying principles of simulations, which, when visualized through comics, can make complex probabilistic models more accessible to a wider audience. By emphasizing practical applications and model evaluation, ISL parallels the goal of SIM with comics, which aims to translate abstract statistical concepts into engaging, visual narratives for improved comprehension and knowledge retention. The book's focus on predictive accuracy and data-driven insights aligns with the potential of SIM with comics to create dynamic, story-driven simulations that illustrate the real-world impact of statistical phenomena.

Sheldon Ross's (2020) "A First Course in Probability" is known for its mathematical rigor, requiring a strong foundation in calculus. This highlights the importance of a solid mathematical understanding for grasping probability theory. It provides a deep dive into the theoretical underpinnings of probability, establishing a strong analytical framework. While Ross's book develops intuition through examples, comics can further enhance this by creating relatable scenarios and characters. By presenting probability problems in a story-driven format, SIM with comics can make learning more engaging and memorable.

GeeksforGeeks (2025) showcases the importance of probability and statistics through its comprehensive coverage of fundamental concepts and their practical applications, particularly in computer science and data science. The site emphasizes problem-solving with numerous examples and code, making these fields accessible to a wider audience. By demonstrating the relevance of these disciplines to real-world challenges, GeeksforGeeks reinforces their crucial role in analytical thinking and decision-making.

BYJU's (2025), a prominent educational technology company highlights that the foundational principles of statistics and probability are vital for data analysis across domains, highlighting the essential distinction between descriptive and inferential methods for data interpretation and prediction, which directly supports the current study's use of SIM with comics to simplify the complex concepts of probability of random variables for students. Furthermore, the necessity of probability theory for risk assessment and informed decision-making was emphasized, thus justifying the study's innovative approach in making these abstract concepts more accessible through visual and engaging comic-based scenarios.

Word Problems

Caudill, (2021) highlighted the importance of "Teaching Math Word Problems with Pictures" notably, it presented strong supports to the use of visual representation as a means to make abstract mathematical concepts more accessible, which is precisely the goal of the SIM with comics approach. The emphasis on drawing as a step in the problem-solving process aligns with the comic-based format of the SIM, which encourages students to visualize and interpret word problems through visual narratives. It also suggested the use of real-life scenarios and visual prompts to reinforces the study's aim to connect mathematical concepts to students' everyday experiences. Aligned with the current study, it provides a strong theoretical foundation for the use of SIM with comics as an effective pedagogical tool for enhancing students' comprehension and problem-solving skills in mathematics.

"Third Space Learning's" strategies revealed a strong alignment with the pedagogical principles underpinning the use of SIM with comics in teaching math word problems. It emphasized the crucial need for students to grasp the underlying meaning of word problems, moving beyond mere numerical manipulation, a concept effectively realized through the visual storytelling of comics. It emphasized a step-by-step problem-solving that is directly connected to SIM with comics, where each comic panel can visually represent a distinct stage of the solution process. Additionally, the encouragement of visual models, such as drawings and diagrams, finds a direct parallel in the comic format, which uses panels to illustrate the problem's narrative. The importance of connecting word problems to real-world scenarios, as highlighted by Third Space Learning, is readily achieved through the relatable characters and situations depicted in SIM with comics. Ultimately, the convergence of these strategies underscores the efficacy of SIM with comics as a method that prioritizes visual understanding, structured problem-solving, and the establishment of meaningful connections to students' lives.

Math Project Empowering Minds (2025) emphasized the critical role of word problems in developing mathematical understanding. It was highlighted that word problems facilitated the application of mathematical concepts to real-world scenarios, thereby enhancing students' problem-solving abilities. It presents the importance of breaking down complex word problems into manageable steps, which was deemed essential for fostering a systematic approach to problem-solving in its essay "Word Problems in Math" Ultimately, it was concluded that engaging with word problems contributed significantly to the development of critical thinking and analytical skills, which were considered fundamental for success in Mathematics.

Word problems were recognized as a significant challenge for mathematics learners, resulting in extensive research over the past 50 years. Specifically, the study highlighted the importance of comprehension, problem-solving strategies, and cognitive resources in effectively addressing word problems. Furthermore, it was found that the use of graphical representations and the connection between traditional word problems and real-world mathematical modeling were critical areas of investigation. Ultimately, it was concluded that the learning environment, including textbooks, software, and teacher instruction, significantly influenced the development of word

problem-solving competence (Verschaffel, 2020) .

Strategic Intervention Material (SIM)

Tsuma (2020) investigated the significant impact of language competency on mathematics instruction within South Africa's Intermediate Phase, specifically focusing on challenges arising from multilingual educational settings. The research highlighted the gap between artificial classroom word problems and authentic mathematical modeling, underscoring the necessity for contextualized learning experiences. Furthermore, it was concluded that the findings regarding language and contextualization directly supported the current study's use of SIM with digitized comics, as the visual narratives and contextualized scenarios within the comics aimed to bridge language barriers and enhance the understanding of probability word problems.

The book Mathematica: A Secret World of Intuition and Curiosity by Bessis (2024) explored a tool for fostering intuition and curiosity in mathematical exploration. It was highlighted that the software's capabilities allowed for visual and interactive engagement with complex mathematical concepts. Ultimately, it emphasized on visual and intuitive learning, as demonstrated through Mathematica, provided a theoretical foundation for the current study's use of SIM with comics, as both methodologies aim to demystify complex mathematical ideas through visual and engaging approaches, specifically in the context of solving probability word problems involving random variables.

Scott, (2021) work presented a general theory of learning Math Word Problems centered on objects and their relations, emphasizing the construction of knowledge through interaction with the environment. Furthermore, the book explored how learners develop understanding by forming and manipulating mental representations of objects and their connections. this theory of object-relations directly supported the current study's SIM with comics, as the comics act as "objects" that facilitate learning by visually representing and relating the components of probability word problems, thereby aiding in the construction of mental models for random variables and their associated probabilities.

Digitized Comics

Fawaz et. al (2020) edited volume, "Keywords for Comics Studies," provided a comprehensive exploration of key terms and concepts critical to understanding the field of comics studies. The book facilitated a nuanced understanding of comics as a multifaceted medium, encompassing diverse genres, styles, and theoretical approaches. It was concluded that this study's in-depth analysis of comics studies terminology provided a valuable foundation for the current study's SIM with comics. By establishing a clear understanding of the fundamental elements of comics, such as paneling, narrative sequencing, and visual rhetoric, this research informs the effective design and implementation of SIM with comics. This ensures that the comics are not merely decorative, but rather, strategically constructed to enhance students' comprehension and problem-solving skills in probability of random variables through a well-informed application of comics conventions. The study of the key words of comic studies helps the current study to utilize the comic medium in a way that is most effective.

Brunet & Davis (2022) emphasized in their book, "Comic Book Women: Characters, Creators, and Culture in the Golden Age," that focused on the historical role of women within the early comic book industry, examining both the female characters depicted and the women who contributed to their creation. Furthermore, the study explored how these women navigated and influenced the cultural landscape of the Golden Age of comics, contributing to the medium's development and evolution. Ultimately, 326historical exploration of women's agency and influence within the comics industry provided a broader cultural context for the current study's SIM with comics. While not directly linked to mathematical pedagogy, this study underscores the versatility and cultural significance of comics as a medium. By demonstrating how comics have historically served as a platform for diverse voices and perspectives, it indirectly strengthens the argument for their potential as an engaging and accessible educational tool. This research helps to understand that comics have been a medium where diverse voices have been heard, and that they are a medium that has been used to tell many kinds of stories. This reinforces that comics are a valid medium for telling the story of mathematical word problems.

Catan (2020) reviewed of Elder's "Hemingway in Comics" highlighted the diverse ways in which the iconic author has been portrayed and adapted within the comic book medium, ranging from faithful representations to satirical interpretations. Furthermore, the review emphasized the shared economy of words between Hemingway's writing style and the visual storytelling of comics, suggesting a natural affinity between the two. Furthermore, while this study focused on the adaptation of a literary figure into comics, it provided an interesting parallel to the current study's SIM with comics. Both study involves translating complex material (Hemingway's persona and writing style, and mathematical concepts, respectively) into the visual language of comics. The review underscores the versatility of comics as a medium capable of interpreting and conveying diverse subjects, thus indirectly supporting its use in mathematics education to make abstract concepts more accessible and engaging.

Adams, Zuccaro, & McCardle (2020), "FACT or FICTION: Developing Graphic Novels for Science," explained the use of graphic novels to teach scientific concepts and literacy skills. The book highlighted how pre-service science education teachers created graphic novelettes to facilitate the learning of scientific concepts and promote literacy skills. This review directly supports the current study's SIM with comics. It demonstrates the effectiveness of graphic novels in conveying complex information and enhancing comprehension in science, which aligns with the goal of SIM with comics to make probability word problems more accessible and engaging. The creation of graphic novelettes by science teachers, further shows that the graphic novel format can be used to effectively teach subject

matter, and that this format can be created by educators.

Soper (2022) reviewed two comic books on the work of R. Crumb, exploring his contributions to the comics medium and analyzing his unique artistic style and autobiographical approach. Furthermore, the review highlighted Crumb's influence on the development of alternative and autobiographical comics. This review focuses on the artistic and cultural significance of a particular comic book creator, it offers valuable insights into the expressive potential of the medium itself. By showcasing the diverse ways in which comics can be used to convey personal narratives and artistic visions, the review indirectly supports the current study's SIM with comics. It reinforces the idea that comics are a versatile and powerful medium, capable of engaging audiences and conveying complex information in a visually compelling manner. Villaran et. al. (2023) demonstrates how well Strategic Intervention Materials assist in improving science students' academic achievement while highlighting the necessity of tailored instructional tools to meet individual learning challenges. Comparably, the goal of the current study is to develop a strategic intervention that makes use of comics, which can be a dynamic SIM. Students can be visually and contextually engaged by comics, which helps them relate to and comprehend difficult ideas like probability. The study's encouraging results imply that using comics could improve students' mathematical understanding and performance in a similar way.

Furthermore, according to Marribay on SIMs' effects on English language competency, learning outcomes can be considerably improved by using well-structured materials. This emphasizes how crucial it is to create intervention resources that address specific needs, in this example, understanding probability word problems. Just as successful SIMs in Marribay's study aided learning, use of comics can give abstract ideas more tangible form. Comics can assist students understand the underlying mathematical principles by making studying more interesting and providing context and linguistic reinforcement for word problems (Marribay, 2022).

Methodology

Research Design

This study integrates Mixed-method approach composed of Quasi-experimental Design and Descriptive Qualitative Design and has proven effective in studies involving Strategic Intervention Material (SIM) in mathematics education. The research employed a Quasi-Experimental Design, starting with quantitative data collection followed by descriptive qualitative interviews to gain deeper insight into the effects. This mixed-methods approach underscores the importance of combining various methodological perspectives to improve learning outcomes in Mathematics (Consortia Academia). Pretest Posttest Control Group Design under Experimental Design were included in this design for each of the two groups, to account for testing effects and confounding variables. When assessing the efficacy of strategic intervention materials, this approach can be very useful in the field of education. Researchers can evaluate these materials' effect on learning outcomes while taking testing effects and biases into consideration by utilizing the Mixed-Method Design. Dependent variables often consist of scores representing measures of learners, while the independent variables are hypothesized to affect those scores.

There are also other types of dependent variables, such as scores on questionnaires and/or tests of individual differences such as working memory, motivation, beliefs, attitudes, or anxiety. Dependent variables are often continuous or interval because such mathematical properties are necessary to conduct many statistical analyses that allow interpretation of the effects of the independent variables. In other words, it is expected that a change or effect occurred on the dependent variable caused by the independent variable. In this study, the independent variable which is the SIM was expected to affect the dependent variable which was the performance of the Grade 11 in solving worded problems related to random variables in probability.

Respondents

The target population for this study consisted of all Grade 11 students enrolled in Baruya High School during the School Year 2023-2024.

A teacher-made pretest based from the RMYA was given to all grade eleven students in Baruya High School to determine their mathematical skills in solving probability problems. Based on the pretest among the grade eleven students. In the result of the pretest, 2 out of 4 sections were classified as nearly solvers and non-solvers. These sections were the respondents of the study. One section treated as the control group while the other section took as the experimental group of the study.

For the quantitative phase, a total of 30 students participated. These students were divided into two groups: 11-A students in the control group and 11-B students in the experimental group.

For the qualitative phase, eight students were purposively selected from the experimental group to participate in in-depth interviews. Purposive sampling was employed to ensure diverse perspectives were captured, including students with varying levels of engagement and performance with the digitized comics, as identified from the quantitative phase results

This study used purposive sampling in determining the respondents of the research. Lavrakas (2008) defines a purposive sample also known as an expert or judgmental sample as a type of nonprobability sample. The purpose of this sampling technique is to form a sample which is assumed to logically come from the target population. These samples are said to be a good representation of the population. This method is selected and applied once you have a piece of expert knowledge about the desired population, and by that,

you can choose samples in a nonrandom manner that can stand as an accurate representation of the whole subject under study.

Table l presents the sample of the study. These respondents come from two different sections in which they were all classified as solvers, nearly solvers and non-mathematical problem solvers. The basis of the classification is the result of the pretest. These groups of students were divided into 2 groups namely, experimental group and control group.

Table 1. *Sample of the Study*

Class Section	*Total Number of Students*	*Experimental Group*	*Control Group*	*Total Participants*
11-A	15	0	15	15
11-B	15	15	0	15
Total	30	15	15	30

Instrument

This study integrated the tools used in the Guidelines on the Conduct of the Regional Mid-Year Assessment (RMYA), Kindergarten, learning areas from grades 1-10, and core learning areas in Senior High School. The RMYA aimed to determine the percentage of learners who achieved the minimum level of proficiency in the core subjects of senior high school and to determine the most and least learned competencies to develop a school intervention for the identified gaps in the core learning areas. The results and analysis of the RMYA were the basis for the content of the strategic intervention material to supplement the lesson to address the least competencies (Regional Memo No. 099, s. 2023).

This research outlined the process of creating strategic material incorporated with digitized comics, encompassing a comprehensive approach that combined creativity, technological innovation, and strategic planning. Initially, the researcher identified the purpose and target audience, determining that the material was to supplement the lowest competency in the rank among the most essential learning competencies of Statistics and Probability based on the RMYA results. With clearly defined objectives, the study was able to guide the content and design effectively. The researcher then analyzed the importance of understanding the target audience, which was grade 11 students, emphasizing the necessity of tailoring the content to meet their preferences and needs. The content creation phase involved developing engaging and relevant stories aligned with the material's objective. The researcher focused on creating relatable and memorable characters that could drive the narrative and resonate with the audience. Additionally, script writing was crucial, ensuring that dialogues and captions were clear, concise, and complementary to the visuals, thereby enhancing the storytelling.

The SIM was composed of five parts; the Guide Card introduces the topic, objectives, and instructions, setting the stage for the lesson, this also serves as the motivation to capture students' interest with engaging questions and an introduction to the comic's characters and storyline. The Activity Card presents core activities through comic strips, embedding interactive tasks and providing immediate feedback within the narrative. The Assessment Card evaluates students' comprehension through formative along with self-assessment opportunities. The Enrichment Card offers advanced activities and extended storylines to deepen understanding and encourage critical thinking. The Answer Card provides the students and teachers with the solution and answer. The Reference Card presents additional resources, a glossary of key terms, and citations for further learning.

The study also highlighted the significance of visual design, including the selection of an appropriate art style that fits the theme and audience. The Master Teacher with the help of the Curriculum Development Committee of the school checked the pedagogy of the material to bring the story and characters to life, with quality illustrations significantly impacting the engagement level. Attention was given to color schemes and page layouts, as these elements influenced readability and overall aesthetic appeal.

In terms of digitization and interactivity, the researcher decided on suitable digital formats such as PDF accessible in scanned QR code. The researcher utilized various technologies and tools, including comic creation software like Canva and Comic Life or Pixton. For interactivity, tools such as QR.io, and other free code generator websites were employed, these platforms for distribution were chosen to easily access the comic intervention material.

The SIM was evaluated with the Senior High School Department to measure the impact, and performance metrics such as user completion rates, and feedback ratings were established. Regular analysis of the impact of SIM on the grade 11 students was conducted to determine if the desired outcomes were being achieved, with adjustments made based on these insights.

Finally, the research addressed legal and ethical considerations, ensuring that all content was properly licensed and original works were protected by copyright. Accessibility features were incorporated to ensure the material was accessible to all users. Cultural sensitivities were also considered, ensuring the content was respectful and appropriate for diverse audiences. Through this detailed and methodical approach, the material was successfully created as impactful and engaging digitized comics that effectively served their intended purpose and resonated with the target audience.

Procedure

Data gathering and collecting relevant information were divided into three major phases: pre-experiment, actual experiment, and post-experimental phase.

In the pre-experimental phase, the RMYA results were analyzed to determine the respondents' least mastered skills and for the SIM

content creation phase. The SIM was validated by the master teacher and pilot testing was conducted. All grade eleven students were gathered. A Pre-test was administered before the intervention to classify the students as non-solvers and nearly solvers. The students were divided into two groups: the control and experimental groups.

During the actual experiment, the two groups were given differentiated instruction; learning activity sheets were given to the control group while SIM was given to the experimental group. The SIM was given to the experimental group during their math class. Questions for instructions and clarifications among the students were entertained. Collaboration between and among students was also allowed. For the evaluation to assess the effectiveness of the SIM, both groups were given a post-test, and the results were compared and tested.

After the conduct of the experiment, the post-experimental phase included interviews with eight students about their challenges and difficulties encountered in learning statistics and probability and their experiences using the SIM.

Data Analysis

The data obtained from the questionnaire before and after the experiment were encoded and statistically processed using Microsoft Excel 2021 and MAXQDA 2018. The mean percentage score was used to describe the mathematical performance of the grade eleven students at Baruya High School in the school year 2023-2024.

For the Quantitative part, Mean and Standard Deviation were used to describe the performance of the respondents in the probability problems for both pretest and posttest. T-test for independent samples was used to determine if there was a significant difference in the performance of the control and experimental groups for both pre-test and post-test. T-test of paired samples to determine if there is a significant difference in the pre-test and post-test for both the control and experimental groups.

For the Qualitative part, in analyzing the effectiveness of SIM incorporated with digitized comics, collected data underwent Braun and Clarke (2020) Thematic Analysis with the help of MAXQDA. Initially, thorough familiarization with the data, including interview transcripts, observational notes, and student feedback, is conducted. Subsequently, initial codes relevant to the research question are generated. Following this, broader patterns or themes are identified by grouping related codes. A critical review of these themes is then performed to ensure accuracy and coherence. Once refined, the themes are clearly defined and named. Finally, the findings, supported by evidence from the data, are presented in a comprehensive report, with the implications of the findings discussed.

Ethical Consideration

The "Health Science Journal" by Fouka & Mantzorou (2020) explains the significance of ethics in research. They draw attention to the four main ethical dilemmas that carrying out research. Protecting the respondent's or patient's right to self-determination can be accomplished through informed consent. Through autonomy, it seeks to incorporate the rights of an autonomous individual. Additionally, it seeks to protect the respondent's character and preserve their freedom of choice and judgment; (2) beneficence, which is defined as "be of benefit, do no harm". (3) Respect for anonymity and secrecy indicates respect for adherence and dignity. A good researcher should evaluate all possible results of the research, including the possibility of revealing sensitive information. Respect for privacy: in a study, a researcher should not respond to or make decisions on behalf of the respondents or any other person regarding their responses regarding the study. Participant-respondents should be informed of their rights, and the researcher must take all necessary steps to ensure the safety of the patients. Before gathering responses, individuals or respondents must be informed about the study's objectives, materials, tools, and methodology.

To overcome these ethical issues in research, the researcher asked the permission of the school principal to conduct the study among the grade eleven students and collaborated with the teachers and advisers.

Results and Discussion

This study is composed of 7 (seven) parts comprehensive presentations of findings.

Part I. SHS Students' Mathematical Word Problem Performance in terms of Pre-Test.

Table 2 describes the SHS Students' mathematical word problem performance in terms of the pre-test.

It can be gleaned from Table 1 that before the conduct of the experiment, the result of the analysis using the pretest of the participants indicates that the Control group (Mean=5.33, SD=2.29) did not meet the expectation. Similarly, the experiment group (Mean=5.13, SD=2.13) did not also meet the expectations.

The data suggested that the Control and Experimental groups did not meet expectations in the pre-test, with mean scores of 5.33 and 5.13, respectively. This indicates a baseline level of difficulty in solving mathematical word problems among students before the intervention. The similarity in the performance of both groups supports the idea that they were on relatively equal footing at the start of the study.

Bernido (2023) emphasized the importance of similarity in the performance of control and experimental group in the Pre-test. It is highlighted that pre-test results are crucial for establishing a baseline understanding of students' initial skills before the intervention, without a pre-test, it was difficult to determine whether the intervention was effective.

Similarly, the study of Bacatan (2022) emphasized the importance of baseline characteristics in comprehension in solving math problems. These studies are consistent with the findings of the study that highlight pre-test results as a critical factor in exploring the effectiveness of interventions.

As emphasized by Bernido (2023) and supported by Bacatan (2022), pre-test results are essential for establishing this baseline understanding of students' initial skills. The importance of pre-tests is that it allows the researcher to measure the effectiveness of the intervention. Without this baseline, it was challenging to determine whether any observed changes in students' abilities were due to the intervention or pre-existing differences.

By establishing that both groups had similar initial skills in solving word problems, this attributes the significant improvement observed in the experimental group to the use of digitized comics.

Table 2. *Students' Mathematical Word Problem Performance Based on Pre-test*

Group	*Mean*	*SD*	*Descriptive Interpretation*
Control	5.33	2.29	Did Not Meet Expectations
Experimental	5.13	2.13	Did Not Meet Expectations

Legend: 1.00-6.00 Did Not Meet Expectations; 7.00-12.00 Fairly Satisfactory; 13.00-18.00 Satisfactory; 19.00-24.00 Very Satisfactory; 25.00-30.00 Outstanding

Part II. SHS Students' Mathematical Word Problem Performance in terms of *Post-Test*

Table 3 describes the SHS Students' mathematical word problem performance in terms of the post-test.

Table 3. *Students' Mathematical Word Problem Performance Based on Post-test*

Group	Mean	SD	Descriptive Interpretation
Control	11.67	1.83	Fairly Satisfactory
Experimental	20.07	3.73	Very Satisfactory

Legend: 1.00-6.00 Did Not Meet Expectations; 7.00-12.00 Fairly Satisfactory; 13.00-18.00 Satisfactory; 19.00-24.00 Very Satisfactory; 25.00-30.00 Outstanding

Data revealed that after the conduct of the experiment, the result of the analysis using the posttest of the participants indicates that the performance of the Control group (Mean=11.67, SD=1.83) is considered fairly satisfactory. On the other hand, the experiment group (Mean=20.07, SD=3.73) is very satisfactory.

After the intervention, there is a clear improvement in the performance of both groups, particularly the Experimental group. The Experimental group, with a mean score of 20.07, moved into the "Very Satisfactory" category, suggesting that the digitized comics had a positive effect on their mathematical problem-solving skills. In contrast, the Control group improved but only reached the "Fairly Satisfactory" category, indicating a less significant impact on the use of learning activity sheets.

Pornobi (2024) explored the strategic instructional materials designed to provide focused practice and support in the identified areas of reading and writing. These materials might include exercises, graphic organizers, and explicit instruction.

Pornobi's study and the current study, use SIM as an intervention strategy to address learning gaps in reading and writing, post-test results showed improved reading comprehension, writing quality, or specific literacy skills. The current study highlights the improvement in post-test scores as evidence of the effectiveness of SIM with comics. The higher post-test scores in the experimental group indicate that the intervention was successful in enhancing mathematical problem-solving skills. Although, the Pornobi's study focuses on reading and writing gaps, while the current study targets gaps in solving word problems involving random variables.

This confirms the study of Anabo (2024) who explored the use of SIM for quadratic equations, while the current study focused on SIM with comics in solving word problems in probability of random variables. The higher post-test scores are evident in the experimental group indicated that SIM is effective for learning quadratic equations.

A noticeable improvement in the performance of both groups following the intervention was observed; however, the experimental group demonstrated a more substantial gain.

Part III. Significant Difference Between the Pre-Test Scores of the Control and Experimental Groups.

Table 4 presents the significant difference between the pre-test scores of the control and experimental groups.

Table 4. *Comparison in the Level of Performance of the Groups in terms of Pre-test*

Group	*Mean*	*SD*	*t*	*Sig.*	*Decision on Ho*	*Interpretation*
Control	5.33	2.29	0.25	0.81	Failed to Reject	Not Significant
Experimental	5.13	2.13				

at .05 level of significant

The result of the analysis using the t-test indicated that there is not enough evidence to claim a significant difference in the level of performance between the Control group (Mean=5.33, SD=2.29) and Experimental group (Mean=5.13, SD=2.13), as provided by the t-value of 0.25, significant at 0.81, which is statistically greater than the alpha of .05, thus, failing to reject the null hypothesis.

The t-test results showed no significant difference between the Control and Experimental groups in the pre-test, reinforcing the conclusion that both groups had similar mathematical skills before the intervention. This finding is crucial as it validates the experimental design, ensuring that any post-test differences can be attributed to the intervention.

The importance of comparable pre-intervention performance between control and experimental groups is emphasized in prior research. Specifically, Bernido (2023) highlighted that pre-test results are critical for establishing a baseline understanding of students' initial skill levels. It is indicated that the effectiveness of an intervention cannot be accurately determined without this baseline measure. Similarly, Bacatan (2022) underscored the significance of baseline characteristics in comprehension within mathematical problem-solving.

It is apparent that establishing the equivalence of control and experimental groups at the outset of a study is crucial for valid research design. The necessity of pre-tests in providing this baseline is underscored by the difficulty in ascertaining intervention effectiveness in their absence.

Part IV. Significant Difference Between the Post-Test Scores of the Control and Experimental Groups.

Table 5 presents the significant difference between the post-test scores of the control and experimental groups.

Table 5. *Comparison in the Level of Performance of the Groups in terms of Post-test*

Group	*Mean*	*SD*	*t*	*Sig.*	*Decision on Ho*	*Interpretation*
Control	11.67	1.84	7.82	<.001	Reject	Significant
Experimental	20.07	3.73				

at .05 level of significant

Table 5 showed that there exists enough evidence to claim a significant difference in the level of performance between the Control group (Mean=11.67, SD=1.84) and Experimental group (Mean=20.07, SD=3.73), as provided by the t-value of 7.82, significant at <.001, which is statistically lesser than the alpha of .05, thus, rejecting the null hypothesis.

The significant difference in post-test scores between the groups, as indicated by a t-value of 7.82, suggests that the intervention was effective. The Experimental group's superior performance indicates that the digitized comics were a successful tool in enhancing mathematical problem-solving skills compared to the Learning activity sheets used in the Control group.

Sterner (2020) showed that explicit instruction using mathematical representations enhances students' understanding and problem-solving abilities, a principle that supports the current study's approach. Furthermore, the study leverages the capacity of comics to effectively communicate complex concepts visually, as illustrated by Tuset and Casale (2020) in the field of architecture. Ultimately, the use of SIM with comics in the current study is important because it provides a method for visually representing and explaining abstract concepts in probability of random variables, with the aim of improving students' comprehension and problem-solving skills.

Part V. Significant Difference in the Overall Performance of the Control and Experimental Groups in terms of Mean Gain.

Table 6 presents the significant difference in the overall performance of the control and experimental groups in terms of mean gain.

Table 6. *Comparison in the Overall Performance of the Groups based on Mean Gain*

Group	*Mean*	*SD*	*t*	*Sig.*	*Decision on Ho*	*Interpretation*
Control	6.33	1.05	15.31	<.001	Reject	Significant
Experimental	14.93	1.91				

at .05 level of significant

Table 6 shows that there exists enough evidence to claim a significant difference in the overall performance between the Control group (Mean=6.33, SD=1.05) and Experimental group (Mean=14.93, SD=1.91), as provided by the t-value of 15.31, significant at <.001, which is statistically lesser than the alpha of .05, thus, rejecting the null hypothesis.

The analysis reveals a significant difference in the mean gain scores between the groups, with the Experimental group showing a much larger improvement. This further reinforces the effectiveness of the digitized comics, indicating not only a higher post-test performance but also a greater overall improvement from the pre-test.

Wilner (2022) explored the use of comics to represent and interpret case histories, demonstrating how the visual and narrative elements of comics can provide unique perspectives on complex subjects. This is similar to the current study's SIM with comics, as both leverage the power of comics to translate complex information into an accessible and engaging format. Barbieri (2020) examined the effectiveness of a number line combined with cognitive learning strategies as a strategic intervention material for improving fraction understanding. Both this study and the current study's SIM with comics aim to enhance mathematical understanding through visual and cognitive support, with SIM with comics using visuals to represent probability concepts.

The current study aligns with previous research by demonstrating that visual tools and structured materials can effectively improve students' mathematical understanding and performance.

Part VI. Textual Presentations of the Shared Experiences of the Participants

This part presents the shared experiences of the learners on the challenges and difficulties in solving mathematical word problems, coded, analyzed and interpreted.

The result of the thematic analysis of the qualitative data from the transcript of interviews with the selected students of Grade 11 in Baruya High School Division of Pampanga had varied experiences in the exposure of SIM integrated with comics.

The analysis resulted in the emergence of four main themes which are: Learners' Attitudes toward math word problems, Learners' Mathematical Reasoning, Structured Learning Developed by the SIM, and the Suggested development of the SIM.

Table 7. *Textual Presentations of the Shared Experiences of the Participants*

Themes	*Sub-Themes*
Theme 1: Learners' Attitudes Toward Math Word Problems	Heightened Interest, Prolonged Engagement, Motivation, Enthusiastically Engaged
Theme 2: Learner's Mathematical Reasoning	Multiple Probability Event, Divisibility, Conversion of Fractions, Decimals and Percentage
Theme 3: Structured Learning Developed by the SIM	Recalling and Applying Strategies Are Effective, Visual Explanations Are Easier to Understand,
Theme 4: Suggested Development of the SIM Integrated with Comics	Make The Comics More Colorful, Include a Summary of Key Points, Include Diverse Problem, Additional Practice Problems

Theme 1: Learners' Attitudes Toward Math Word Problems

Learners' attitudes toward Math word problems play a significant role in their performance and understanding of mathematical concepts. This study highlights that students who experience high levels of math anxiety struggle more with word problems due to the combination of reading comprehension and mathematical reasoning.

Heightened Interest

The participants of the study highlighted that the SIM with comics is a great way to loosen up the tension with math word problems. Studies have shown that presenting math problems in comic form can significantly boost student interest. The study's findings, indicating reduced tension and enhanced interest through the implementation of SIM with comics, reinforce and validate the efficacy of visual representation in mathematics education, as emphasized by Caudill (2021).

Heightened Interest	*The use of comics significantly increased my interest in the subject; they made the concepts easier to understand and more enjoyable. (Participant 3)* *The comics made learning more fun and kept me interested throughout the lessons. (Participant 5)* *The integration of comics into the lessons kept me interested and helped me maintain focus better than learning activity sheets. (Participant 8)*

The combination of visual storytelling and humor makes learning more engaging. Comics' narrative structure keeps students entertained and interested in finding solutions to the problems embedded in the storyline.

The result of qualitative analysis resulted in three (3) emerging sub-themes namely "Prolonged Engagement", "Motivation", and "Enthusiastically Engage".

Prolonged Engagement

According to the response of the participants of the study, one of the sub-themes under "Learners' Attitudes toward Math word problems" that was revealed in the resulting study is "Prolonged Engagement", suggesting that students stay with the material compared to other learning activity sheets.

Prolonged Engagement	*I found the material much more engaging with the comics; they added an element of fun that traditional methods lacked. (Participant 2)* *I stayed engaged with the material much longer because of the entertaining comic elements. (Participant 3)*

The study's finding of "Prolonged Engagement" is observed to align with Scott's (2021) theory of object-relations, wherein comics function as visual "objects" facilitating sustained interaction.

It is inferred that the extended engagement supports the facilitation of environmental interaction and mental representation construction, suggesting that comics create a stimulating learning environment conducive to deeper cognitive processing. The study concluded that students were more likely to engage deeply with the material because they associated comics with fun and creativity rather than routine academic tasks.

Motivation

Comics foster intrinsic motivation by making learning math more enjoyable and creative. When math problems are presented in a story-driven, visual format, students feel a greater sense of curiosity and are more eager to engage. The study conducted by Manalo (2024) indicated that pre-service mathematics teachers perceived comics as effective in fostering creativity and promoting reflective learning. These findings align with the proposition that comics can enhance intrinsic motivation in mathematics education. Specifically, comics make learning more enjoyable and creative is supported by the pre-service teachers' perception of comics as a tool that fosters creativity.

Motivation	*I felt more motivated to study because the comics made the lessons less dull and more interactive. (Participant 7)* *The integration of comics into the lessons kept me interested and helped me maintain focus better than learning activity sheets. (Participant 8)*

Enthusiastically Engaged

Comics provide a visual medium that presents mathematical concepts in an engaging, story-driven format. This interactive nature encourages students to participate actively, as they follow characters through problem-solving scenarios.

The study's description of comics as an engaging, story-driven format reinforces the multifaceted nature of comics as detailed by Fawaz et al. (2020), demonstrating the practical application of comics studies terminology, such as narrative sequencing, discussed within that framework. This alignment is crucial in the context of the current study, which utilizes SIM with comics to teach probability of random variables. By understanding the core elements of comics, as outlined by Fawaz et al. (2020), the current study strategically constructs its materials to move beyond mere decorative visuals, ensuring that narrative sequencing and visual rhetoric are effectively utilized to enhance student comprehension.

Enthusiastically Engaged	*The visual and humorous approach of the comics made me more enthusiastic about learning statistics and probability. (Participant 6)*

The consistent thread running through these studies reveals that integrating comics into mathematics education effectively enhances student engagement and learning. The implementation of SIM with comics demonstrably reduces tension and boosts interest in math word problems, thereby validating the efficacy of visual representation, as articulated by Caudill (2021). Furthermore, the observed "Prolonged Engagement" aligns with Scott's (2021) object-relations theory, suggesting that comics cultivate a stimulating learning environment conducive to deeper cognitive processing, and crucially, that students perceive comics as enjoyable, rather than a routine academic task. Additionally, comics foster intrinsic motivation, making math learning more enjoyable and creative, a perception corroborated by pre-service teachers who view comics as a tool for creativity and reflective learning (Manalo, 2024).

Finally, the engaging, story-driven format of comics encourages active student participation, thereby reinforcing the multifaceted nature of comics as a pedagogical tool, as detailed by Fawaz et al. (2020), and emphasizing the strategic utilization of narrative sequencing and visual rhetoric for enhanced comprehension. These findings collectively underscore that comics not only mitigate math anxiety and augment engagement but also promote deeper cognitive processing and intrinsic motivation, thus validating their effectiveness as a valuable and multifaceted educational tool within mathematics.

Therefore, utilizing SIM integrated with comics can serve as a valuable tool to enhance students' attitudes toward mathematics by increasing students' attitudes toward mathematics, their mathematical performance can be enhanced.

Theme 2: Learner's Mathematical Reasoning

Research has also focused on how mathematical reasoning enhances problem-solving skills. It is inferred that students enter the learning environment with varying levels of visual literacy. Prior exposure to and comprehension of visual narratives, as found in comics and cartoons, would likely influence their ability to effectively utilize SIM with comics. Sentürk & Simsek (2021) demonstrated the overall effectiveness, but individual student differences should be considered. The study also highlights that reasoning involves flexibility, allowing learners to approach problems from different angles and use a variety of strategies.

Multiple Probability Event	*I truly struggled with the questions involving multiple probability events because they were more complex. I think, Question No. 6. (Participant 1)* *The question no. 6. What is the probability that the coins will land on both heads? Was very challenging for me. (Participant 5)* *Yes. I think the question no. 6 was hard for me. (Participant 4)* *The question no. 6. Was very hard for me. What is the probability that the coins will land on both heads? (Participant 3)*

Multiple Probability Event

Solving multiple probability events often involves combining probabilities through addition or multiplication rules, which can lead to

cognitive overload, especially when multiple steps are involved.

It was observed that the students in terms of problem-solving were having a hard time translating a word problem into mathematical formula and solution. The abstract nature of multiple probability events, mirroring challenges in education, can be effectively addressed using educational comics, as posited by Akcanca (2020). However, students' prior knowledge significantly influences their interpretation of these visual aids; those with limited exposure to probability concepts may struggle with the visual representations presented. Meticulous design is paramount to bridge knowledge gaps and rectify misconceptions, ensuring that the engaging nature of comics is balanced with mathematical rigor. Ultimately, when appropriately crafted, comics possess the potential to enhance students' comprehension of complex probability concepts by rendering them more accessible and engaging.

Divisibility

Students often struggle with understanding divisibility rules because it requires students to combine two distinct mathematical concepts: divisibility and probability. There is a struggle with the integration of these ideas, as they must not only understand number theory (in terms of divisibility) but also apply probabilistic thinking to these scenarios.

This section presents the results of the study on the experiences of family caregivers who have a family member with Alzheimer's disease. It addressed the experiences of family caregivers in terms of Roles and Responses; Challenges encountered; and the coping strategies employed. The succeeding sections are organized in view of the identified cases of the study.

Divisibility	*The question no. 4 since I do not know what divisibility means. (Participant 6)* *I think the question no. 4 since I do not know the meaning of divisibility. (Participant 8)*

The accessibility of complex mathematical concepts, such as probability involving divisibility rules, can be significantly enhanced through the use of graphic novels, as demonstrated by Adams, Zuccaro, and McCardle (2020). However, students' prior understanding of divisibility rules directly influences their comprehension of these visual representations within probability contexts, necessitating properly designed to ensure accurate and clear conveyance of information. Furthermore, the variance in student visualization and literacy skills will impact their learning from the SIM with comics.

Conversion of Fractions, Decimals and Percentage

Even when students understand the conceptual equivalence of fractions, decimals, and percentages, they often struggle with the procedures involved in converting between them.

Conversion of Fractions, Decimals and Percentage	*The questions that were hard to convert between fractions, decimals, and percentages were tough for me because I did not have my calculator with me. (Participant 2)* *The conversion was hard for me because I do not own my calculator, I'm having a hard time doing manual calculations. (Participant 7)*

The versatility of comics, as evidenced by Soper (2022)'s exploration of R. Crumb's work, can be effectively applied to visually represent the complex procedures of fraction, decimal, and percentage conversions, thereby addressing students' procedural struggles. By leveraging the power of comics to convey complex information, these conversion processes can be simplified and clarified, making them more accessible to students. However, the external factors such as students without a calculator and having a problem with manual calculations affected students in certain way. Furthermore, the engaging nature of comics, as highlighted by Soper (2022), has the potential to motivate students to actively engage with and comprehend these mathematical conversions. Procedural struggles with fractions, decimals, and percentages can be addressed through the visual representation offered by comics.

Learner's Mathematical Reasoning explored the cognitive processes employed by students when engaging with mathematical problems, particularly within the context of SIM with comics. It has been observed that student mathematical reasoning involves flexibility, facilitating diverse problem-solving strategies, yet is also influenced by varying levels of prior visual literacy (Sentürk & Simsek, 2021). Specifically, students encountered difficulties with multiple probability events, indicating cognitive overload associated with complex, multi-step problems. This challenge is further exacerbated by the abstract nature of these events, which necessitates meticulous comic design to bridge knowledge gaps and enhance accessibility (Akcanca, 2020).

Similarly, the comprehension of probability involving divisibility rules was hindered by students' lack of foundational knowledge, highlighting the need for accurate and clear visual representations, alongside consideration of students' visualization and literacy skills (Adams, Zuccaro, and McCardle, 2020). Moreover, procedural struggles with fraction, decimal, and percentage conversions were evident, with students noting difficulties in manual calculations and reliance on calculators.

However, it is proposed that the versatility of comics can address these procedural challenges by visually representing complex conversions, thereby enhancing comprehension and engagement (Soper, 2022).

In conclusion, the study reveals that student mathematical reasoning is affected by prior knowledge, cognitive load, and external factors, with comics offering a potentially effective medium for mitigating these challenges through careful design and implementation. Therefore, it was concluded that the SIM needs to be used in conjunction with other teaching methods, as the complexities of

mathematical reasoning require more than visual aids.

Theme 3: Structured Learning Developed by the SIM

The SIM developed structured learning shown to be especially beneficial for students who struggle with recalling and applying strategies. The unique visual tools and narrative design of digital comics, as explored by Alvarado (2020), offer a theoretical basis for creating structured learning experiences within SIM, particularly beneficial for students who struggle with recalling and applying mathematical strategies. This approach leverages immersive visual storytelling to illustrate and reinforce strategy application, thereby enhancing recall and making complex mathematical concepts more accessible.

Consequently, the capacity of comics to convey complex narratives and concepts aligns with the goal of SIM with comics to provide structured learning that supports students in navigating challenging problems involving probability of random variables. The structured and explicit nature of SIM helped these students break down tasks into manageable steps, which reduced cognitive overload and improved their ability to apply learned strategies across different subjects.

Recalling and Applying Strategies Are Effective

The SIM emphasized the explicit teaching of strategies through modeling and guided practice, which helps students internalize the steps of a strategy.

Recalling and Applying Strategies Are Effective	*I was able to apply the concepts and strategies from the comics effectively to the post-test questions. (Participant 1)* *I adopted some of the strategies shown in the comics, which made solving problems more straightforward. (Participant 5)* *The strategies and examples in the comics were very effective and influenced the way I tackled the post-test questions. (Participant 8)* *The comics made it easier to recall and apply the strategies during the post-test. (Participant 3)* *The lessons from the comics were fresh in my mind, and I used them to tackle the post-test questions. (Participant 5)* *The comics prepared me well for the post-test, and I could use the learned strategies effectively. (Participant 6)* *I adopted some of the strategies shown in the comics, which made solving problems more straightforward. (Participant 5)* *The strategies and examples in the comics were very effective and influenced how I answered the post-test questions. (Participant 8)* *I found that the methods taught through the comics were very applicable to the post-test questions. (Participant 4)*

The narrative power of digital comics, as explored by King (2020) in the context of autographic selfies, provides a relevant framework for enhancing the recall and application of mathematical strategies within SIM. By employing relatable characters and scenarios, the SIM can effectively model and demonstrate guided practice, thereby aiding students in internalizing the steps of a strategy. This approach, mirroring the personal connections fostered by autographic selfies, enhances student engagement and makes abstract concepts, such as the probability of random variables, more accessible. Therefore, the use of relatable narratives reinforces the explicit teaching of strategies by placing them within a context that resonates with students, facilitating both recall and application.

Visual Explanations Are Easier to Understand

Visual explanations, such as those provided through comics, simplify abstract concepts and make them more relatable for students.

Visual Explanations Are Easier to Understand	*The visual explanations in the comics made it easier to understand and solve complex problems. (Participant 3)*

The assertion that visual explanations, particularly through comics, simplify abstract concepts and enhance comprehension is directly supported by Kirtley et al. (2020), who explored the pedagogical potential of comics across diverse subjects. Their findings validate the effectiveness of visual storytelling and accessible narratives in making complex concepts more comprehensible, reinforcing the idea that comics serve as a powerful tool for visual instruction, not merely entertainment. Consequently, the demystification of abstract mathematical concepts, such as probability of random variables, through visually engaging and narratively driven formats, aligns with and validates the current study's emphasis on the efficacy of visual explanations.

Structured Learning Developed by the SIM highlighted the efficacy of structured learning environments, particularly those employing comics, in enhancing students' mathematical strategy application and recall. It has been demonstrated that the unique visual tools and narrative design of digital comics, as evidenced by Alvarado (2020), provide a robust theoretical framework for creating structured learning experiences. This approach leverages immersive visual storytelling to illustrate and reinforce strategy application, thereby mitigating cognitive overload and facilitating the internalization of complex mathematical concepts.

The effectiveness of explicit strategy teaching through modeling and guided practice, a core component of the SIM, is further validated by participant feedback. Students reported that the strategies and examples presented in the comics significantly aided their performance on post-test questions, indicating that the visual narratives facilitated both recall and application. This finding aligns with King's (2020) exploration of autographic selfies, which underscores the power of relatable narratives in fostering personal connections and enhancing engagement. Consequently, the SIM's use of relatable characters and scenarios effectively translates abstract mathematical concepts into accessible and memorable learning experiences.

Furthermore, the simplification of abstract concepts through visual explanations, as provided by comics, is directly supported by Kirtley et al. (2020). Their research validates the pedagogical potential of comics, highlighting their ability to engage learners through visual storytelling and accessible narratives. Participant testimonials corroborate these findings, with students reporting that visual explanations in comics made complex problems easier to understand and solve. Therefore, it is concluded that the SIM, by incorporating structured learning, relatable narratives, and visual explanations, provides a powerful and effective pedagogical tool for demystifying abstract mathematical concepts and enhancing student learning.

Moreover, students were able to transfer learned strategies to different problem types, indicating a deeper understanding of the concepts; therefore, the SIM was determined to be effective for helping students apply concepts to new situations.

Theme 4: Suggested Development of the SIM Integrated with Comics

Educators can create an effective SIM integrated with comics that not only improves students' learning experiences but also deepens their understanding and fosters a love for learning.

The application of comics to communicate complex spatial concepts in architecture, as demonstrated by Tuset and Casale (2020), provides a relevant framework for developing effective SIM with comics in mathematics. This research suggests that the visual communication and conceptual understanding facilitated by comics in architecture can be translated to visually represent and explain abstract mathematical concepts, such as probability of random variables. By employing sequential visual narratives, as highlighted in the architectural study, educators can create SIM that enhances students' understanding and interpretation of complex probability problems, thereby improving their problem-solving abilities. Furthermore, the reinforcement that comics can effectively describe complex ideas visually underscores their relevance in teaching word problems in probability and highlights the importance of sequential visual narratives in presenting mathematical concepts in a comprehensible manner.

Suggested Development of the SIM Integrated with Comics	*Make The Comics More Colorful Include a Summary of Key Points Include Diverse problems Additional Practice Problems*

Make The Comics More Colorful

Incorporating vibrant, colorful illustrations into comics within the SIM framework makes learning more visually appealing, helping students focus better, process information more effectively, and develop a deeper understanding of the material.

Making the comics more colorful and visually appealing could further increase interest and engagement. (Participant 8)

Color plays a critical role in enhancing memory retention by making information more distinctive and easier to recall. The pedagogical effectiveness of comics in conveying complex concepts, as demonstrated by Hennig, Whitworth, and Macpherson (2020) in science education, directly supports the current study's recommendation for incorporating colorful illustrations into SIM. The study's emphasis on engagement and accessibility aligns with the notion that vibrant colors enhance visual engagement and facilitate enhanced information processing, making abstract concepts more relatable. Moreover, the successful simplification and clarification of scientific concepts through comics reinforces the importance of visual clarity, achievable through effective color use, and strengthens the argument for applying colorful comics in mathematics education to improve student focus and comprehension. The study concluded that color helps students differentiate between key elements of the strategies being taught, leading to stronger mental associations and easier retrieval of information during assessments or real-life applications.

Include a Summary of Key Points

Summaries help reinforce learning, enhance retention, and provide students with clear takeaways that can guide their application of strategies.

Including a summary of key points at the end of each comic would help reinforce learning. (Participant 4)

The principles of clear and effective communication, as emphasized by Osolen and Brochu (2020) in their study on comic book, can be directly applied to the inclusion of summaries in SIM with comics to reinforce learning for all students. By adapting visual elements into alternative formats, as suggested in their research, clear takeaways can be provided, enhancing retention and guiding students in the application of learned strategies. This approach ensures that the key learning points are accessible to diverse learning styles, mirroring the study's focus on making the visual narrative accessible to the widest audience possible. Ultimately, the importance of clear communication, as demonstrated in making comics accessible to visually impaired readers, reinforces the necessity of providing

concise summaries to enhance learning for all students within the SIM framework.

Include Diverse Problem

Diverse problems force students to engage with concepts in multiple ways, which deepens their understanding.

Including diverse problem types in the comics would prepare students better for a variety of questions. Participant 7

Including more examples with detailed explanations in the comics would be helpful. (Participant 1)

The development of varied process skills in education, as investigated by Bete (2020), provides a strong rationale for the inclusion of diverse problems in mathematics education to deepen student understanding. By requiring students to engage with concepts in multiple ways, similar to the varied skill development observed in chemistry, diverse problems enhance comprehension and reinforce transferable problem-solving abilities. This approach mirrors the study's emphasis on making complex subject matter accessible through varied application, suggesting that the inclusion of diverse mathematical problems can similarly enhance the accessibility of complex mathematical concepts within the SIM with comics framework. Ultimately, the parallel drawn between process skills in education in chemistry and problem-solving skills in mathematics underscores the value of varied engagement in deepening conceptual understanding.

Additional Practice Problems

Practice problems are essential for reinforcing the strategies students learned in the SIM with comics, through repetition of drills this helped students solidify their learning and master the skill in solving word problems.

Adding practice problems at the end of each comic section to reinforce the concepts would be beneficial. (Participant 2)

The emphasis on diverse problem-solving strategies, including visual representations, as highlighted by Szabo et al. (2020), directly supports the inclusion of additional practice problems within the SIM with comics framework. By incorporating varied practice problems, the visual narratives and sequential panels used in the comics can be reinforced, thereby solidifying student learning and enhancing skill mastery. This approach leverages the power of repetition to aid in the internalization of problem-solving strategies, ensuring that students are equipped to tackle complex mathematical challenges. Furthermore, additional practice helps reinforce the understanding of the sequential visual language used in the comics, leading to a more robust grasp of the subject matter.

Suggested Development of the SIM Integrated with Comics addresses the pedagogical enhancements possible through strategically designed comic-based learning materials. It has been established that the application of comics in visually representing complex concepts, as demonstrated in architecture (Tuset & Casale, 2020), provides a robust framework for developing effective SIM in mathematics. This framework emphasizes the use of sequential visual narratives to enhance student understanding and problem-solving abilities, particularly with abstract concepts like probability.

Furthermore, the incorporation of vibrant, colorful illustrations is deemed crucial for maximizing student engagement and information retention. Participant feedback supports the notion that color enhances visual appeal and aids in differentiating key elements, aligning with findings from science education (Hennig, Whitworth, & Macpherson, 2020). This suggests that color plays a significant role in making complex mathematical concepts more accessible and relatable.

To reinforce learning and ensure clear takeaways, the inclusion of concise summaries within the SIM is recommended. Drawing upon principles of accessible communication (Osolen & Brochu, 2020), the provision of clear summaries mirrors the adaptation of visual elements for diverse learners, ensuring that key learning points are effectively conveyed and retained.

Moreover, the integration of diverse problem types is advocated to deepen conceptual understanding and enhance transferable problem-solving skills. This approach, supported by research on varied process skill development (Bete,2020), ensures that students engage with mathematical concepts in multiple ways, mirroring the diverse applications observed in other disciplines.

Finally, the inclusion of additional practice problems is deemed essential for solidifying learning and mastering problem-solving strategies. Aligned with research on diverse problem-solving strategies (Szabo et al., 2020), this recommendation emphasizes the use of repetition to reinforce visual narratives and sequential panels, ultimately equipping students to tackle complex mathematical challenges with greater proficiency.

In conclusion, the strategic development of SIM integrated with comics, encompassing colorful visuals, concise summaries, diverse problems, and additional practice, is posited as a potent pedagogical tool for enhancing mathematical learning and fostering a deeper conceptual understanding among students.

Part VII. Proposed Enhanced Strategic Intervention Materials

Based on the findings from both quantitative and qualitative part of the research, a proposed enhanced Strategic Intervention Material (SIM) serves as the output of the study. This material is intended to be implanted for specific group of students to effectively learn a specific subject.

The SIM was originally composed of five parts, one of the suggested developments was to insert the Summary of Key Points at the last part; the Guide Card introduces the topic, objectives, and instructions, setting the stage for the lesson, this also serves as the motivation to capture students' interest with engaging questions and an introduction to the comic's characters and storyline. The Activity Card presents core activities through comic strips, embedding interactive tasks and providing immediate feedback within the narrative. The Assessment Card evaluates students' comprehension through formative along with self-assessment opportunities. The Enrichment Card offers advanced activities and extended storylines to deepen understanding and encourage critical thinking. The Answer Card provides the students and teachers with the solution and answer. The Reference Card presents additional resources, a glossary of key terms, and citations for further learning.

"Suggested Development of the SIM Integrated with Comics" provided valuable insights into potential enhancements of the instructional material. It was observed that the use of color significantly impacts learning by enhancing visual engagement and memory retention; therefore, the visual aspect of instructional materials should be carefully considered. Moreover, summaries of key points were deemed essential for consolidating learned information and improving retention, and consequently, effective learning materials should include mechanisms for reinforcing key concepts.

Furthermore, exposure to diverse problem types promotes a deeper understanding of concepts and facilitates the transfer of learning, and thus, instructional materials should offer varied problem-solving opportunities. Additionally, practice problems were found to be crucial for solidifying learned strategies and achieving mastery, and hence, adequate practice opportunities should be integrated into instructional design. Finally, the original SIM, with its five parts, can be further enhanced by incorporating the suggested changes, particularly the addition of the Summary of Key Points, and the student feedback provides valuable insight into the effectiveness of the SIM, and how it can be improved.

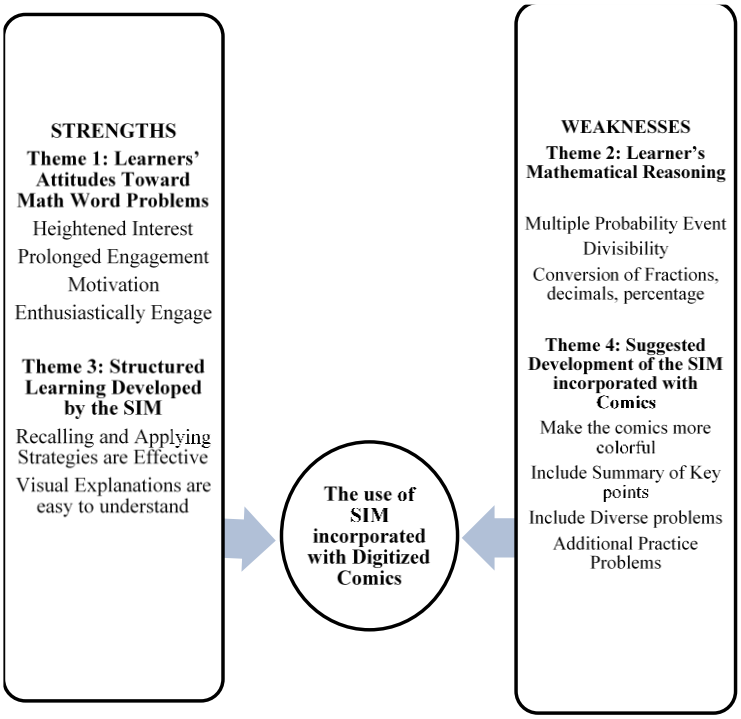


Figure 1. *Use of SIM incorporated with Digitized Comics*

It was observed in the Figure 1. Use of SIM incorporated with Comics that a significant positive impact on learner attitudes toward math word problems was clearly demonstrated by the study. Specifically, math anxiety was effectively mitigated through the integration of comics, transforming a traditionally stressful experience into an engaging one. Furthermore, a "heightened interest" was observed, which serves as a testament to the power of visual storytelling and humor in education, as students reported increased motivation, prolonged engagement, and an enthusiastic approach to math problems.

Consequently, the potential of innovative instructional design to address affective barriers to learning, making math more accessible and enjoyable, was highlighted. Additionally, the structured approach of the SIM proved particularly beneficial for students who struggled with recalling and applying mathematical strategies. In this context, deeper understanding and improved problem-solving skills were facilitated through the explicit teaching of strategies coupled with visual explanations.

Therefore, the importance of clear, organized instructional materials in supporting student learning, especially in complex subjects like mathematics, was underscored.

However, despite the positive impact on attitudes and learning structure, persistent challenges in mathematical reasoning were revealed.

Notably, students struggled with complex concepts like multiple probability events, divisibility, and the conversion of fractions, decimals, and percentages. Consequently, it was suggested that while comics can enhance engagement and understanding, they may not fully address the cognitive demands of advanced mathematical reasoning, implying that other teaching methods and scaffolding should be used in conjunction with the SIM.

Finally, the students' suggestions for improvement, such as incorporating more color, summaries, diverse problems, and practice exercises, highlighted areas for further refinement. Although the SIM was effective, these suggestions indicated that continuous improvement is essential to maximize its impact. Indeed, this weakness also serves as a strength, as it demonstrates that students are engaged with the material and willing to provide feedback on how to improve it, thus revealing their vested interest in the SIM.

The quantitative data reveal a statistically significant improvement in performance for the experimental group that used digitized comics, as shown in pre-test and post-test comparisons. The experimental group's post-test mean score of 20.07, categorized as "Very Satisfactory," stands out against the control group's mean of 11.67, which only reached "Fairly Satisfactory" (t-value=7.82, $p<0.001$). Additionally, the experimental group's larger mean gain score (14.93) further emphasizes the effectiveness of digitized comics on students' comprehension and problem-solving skills in mathematical contexts.

In the qualitative aspect, through thematic analysis of student interviews the study presents themes such as students' heightened motivation, prolonged engagement, and improved recall due to comics-based learning. Students described comics as enhancing their understanding and enjoyment, fostering enthusiasm, and making complex concepts more accessible.

The alignment of quantitative improvement (higher post-test scores and mean gains) with qualitative insights higher motivation and structured learning developed by the sim suggests that digitized comics don't just improve measurable performance but also enhance the learning experience. This dual impact statistically validated by test scores and experientially confirmed through student feedback indicates that comics are an effective tool for enhancing both cognitive and affective aspects of learning probability. Together, these data provide a richer, more nuanced understanding of how comics contribute to educational outcomes.

This study was designed to explore the effectiveness of using digitized comics as a strategic intervention material (SIM) to improve students' skills in solving probability-based word problems. A mixed-methods approach was employed, incorporating both quantitative and qualitative data to thoroughly examine the impact of comic-based SIMs on student learning outcomes.

Conclusion

In conclusion, the study revealed that digitized comics significantly enhanced students' mathematical problem-solving skills, as demonstrated by the experimental group's improved performance. Initially, it was established that both the control and experimental groups exhibited comparable, below-expectation performance levels in the pre-test, indicating initial homogeneity in mathematical ability. Subsequently, a significant improvement in post-test scores was demonstrated, with the experimental group utilizing digitized comics as a strategic intervention material, outperforming the control group, which relied on traditional learning activity sheets.

Statistically significant differences in post-test performance and mean gain scores were observed, thereby confirming the efficacy of digitized comics as an instructional tool. Furthermore, reduced math anxiety and heightened student engagement were evidenced through qualitative analysis of student interviews. Enhanced recall and application of problem-solving strategies were also highlighted as benefits of the comic-integrated materials.

However, challenges related to mathematical reasoning, particularly with complex probability events, divisibility, and fraction-decimal-percentage conversions, were identified. Consequently, suggestions for further improvement, including enhanced visual appeal, concise summaries, diverse problem types, and additional practice problems, were put forward.

Ultimately, it was concluded that the strategic intervention material incorporating digitized comics significantly improved the experimental group's mathematical word problem-solving abilities, demonstrating its potential as a valuable pedagogical resource.

References

Adams, K. L., Zuccaro, E. L., & Mccardle, J. R. (2020). FACT or FICTION: Developing Graphic Novels for Science. Science Scope, 44(2), 54–61. https://www.jstor.org/stable/27048104

Akcanca, N. (2020). An alternative teaching tool in science education. International Online Journal of Education and Teaching (IOJET), 1550-1570.

Akpan, B.B. (2020). Mastery Learning—Benjamin Bloom. https://api.semanticscholar.org/CorpusID:226741823

Arpilleda, A.J. (2021). Strategic intervention material: A tool in enhancing grade nine students' mathematical performance. International Journal of Research Studies in Education.

Bessis, D., & Frey, K. (2024). Mathematica: A Secret World of Intuition and Curiosity. Yale University Press. https://doi.org/10.2307/jj.14962448

Braun, V., & Clarke, V. (2020). One size fits all? What counts as quality practice in (reflexive) thematic analysis? Qualitative Research in Psychology, 18(3), 328–352. https://doi.org/10.1080/14780887.2020.1769238

Brunet, P., & Davis, B. (2022). Comic Book Women: Characters, Creators, and Culture in the Golden Age. University of Texas Press. https://doi.org/10.7560/324110

Byju Raveendran and Divya Gokulnath (2025) https://byjus.com/maths/probability-and-statistics/

Caudill, Allyson (2021). Teaching Math Word Problems with Pictures. https://www.weareteachers.com/word-problems-with-pictures/

Catan, W. (2020). [Review of Hemingway in Comics, by R. K. Elder]. Rocky Mountain Review, 74(2), 226–227. https://www.jstor.org/stable/26977713

Chu, Y.L., & Toh, T.L. (2020). A framework for designing mathematics instruction using comics at the primary school level.

Consortia Academy. (2025). Group of Journals: A partner of Network of Professional Researchers and Educators (NPRE) https://consortiacademia.org/tag/mixed-method-study/

Dimou, E. (2021). Systematic Review of the Effectiveness of Intervention Strategies for Teaching Mathematics to Secondary School Students. OALib.

Fawaz, R., Streeby, S., & Whaley, D. E. (Eds.). (2021). Keywords for Comics Studies. NYU Press. http://www.jstor.org/stable/j.ctv27ftvj2

Gareth James • Daniela Witten • Trevor Hastie • Robert Tibshirani 2023 An Introduction to Statistical Learning with Applications in R https://www.statlearning.com/

GeeksforGeeks (2025) https://www.geeksforgeeks.org/probability-and-statistics/Guidelines on the Conduct of Regional Mid-Year Assessment (2023). Regional Memorandum No. 099 s. 2023

Khoshaim, H. B. (2020). Mathematics teaching using word problems: Is it a phobia? International Journal of Instruction, 13(1), 855–868. https://doi.org/10.29333/iji.2020.13155a

Krebiel, K. (2023). National Council of Teachers of Mathematics (NCTM) Joint Conference, NCTM goals and mission. November 16, 2023.

Lavrakas, P. J. (2008). Encyclopedia of Survey Research Methods. SAGE Publications Incorporation,volume 1 and 2. Retrieved fromhttps://www.scribd.com/document/.DepEd Division Memorandum No. 304 series 2018

Manalo, L. G. (2024). Comics as an assessment tool for learning mathematics. Diversitas Journal, Volume 9, Issue 2 (apr./jun. 2024) p. 0711 – 0729.

Marribay, J. (2022). The effect of strategic intervention materials on English language proficiency among high school students. Ignatian International Journal for Multidisciplinary Research, 2(1), 167-175. https://icceph.com/journals/IIJM/2022/2.1/11.pdfMath Project (2025) Empowering Minds https://mathproject.ca/word-problems-in-math/

Prakash Chand, S. (2023). Constructivism in Education: Exploring the Contributions of Piaget, Vygotsky, and Bruner. Internationa Journal of Science and Research (IJSR).

Reumont, F. v., & Budke, A. (2021). Spatial Thinking With Comics in Geography Education. Frontiers in Education, Volume 6 - 2021 | https://doi.org/10.3389/feduc.2021.702738.

Rina, N. S. (2020). Character Education Based On Digital Comic Media. International Journal of Interactive Mobile Technologies, pp. 107–127. https://doi.org/10.3991/ijim.v14i03.12111.Oxford Owl. (2024). Graphic novels and comics in education: Why are they important? Oxford University Press. Retrieved from https://home.oxfordowl.co.uk/reading/graphic-novels-and-comics-in-education/

Schnepel, S., & Aunio, P. (2021). A systematic review of mathematics interventions for primary school students with intellectual disabilities. European Journal of Special Needs Education, 37, 663 - 678.

Scott, D. (2021). On Learning: A general theory of objects and object-relations. UCL Press. https://doi.org/10.2307/j.ctv1b0fvk2

Seelow, D. (2020). Using comics to teach the 4 Cs. George Lucas Educational Foundation: Edutopia. https://www.edutopia.org/article/using-comics-teach-4-cs

Sentürk, M., & Simsek, U. (2021). Educational comics and educational cartoons as teaching material in the social studies course. African Educational Research Journal, 515-525.

Sinco, L. P. N. (2020). Strategic intervention materials: A tool in improving students' academic performance. International Journal for Research in Applied and Natural Science, 6(5), 12–19.

Sheldon, Ross (2020) “A first course in probability” 10th Edition. Pearson Education Limited

Soper, K. D. (2022). [Review of The Comics of R. Crumb; R. Crumb: Literature, Autobiography, and the Quest for Self, by D. Worden & D. S. Calonne]. Studies in American Humor, 8(1), 213–219. https://www.jstor.org/stable/48763697

Tsuma, L. (2020). The Language Issue in the Teaching of Mathematics in South Africa: Intermediate Phase research from one province (1st ed.). African Sun Media, http://www.jstor.org/stable/j.ctv1nzfzbw.

Verschaffel, L. S. (2020). Word Problems in Mathematics Education: a survey. ZDM Mathematics Education, 52, 1-16.

Villaran, R., Cabot, M., & Panes, M. L. (2023). The use of strategic intervention materials in improving the academic performance in science of selected grade 6 pupils in Sta. Cruz Elementary School. Psychology and Education: A Multidisciplinary Journal, 15(8). https://ejournals.ph/doi/10.59244/pe.v15i8.1745

Affiliations and Corresponding Information

Rima R. Bestil
Baruya High School
Department of Education – Philippines

Ronaldo A. Punla
Department of Education – Philippines