

The Effectiveness of the Flipped Classroom Strategies in Teaching Statistics and Probability Among the Senior High School Learners in Ragay District 2, Division of Camarines

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Abstract

The study determined the effectiveness of flipped classroom strategies in teaching Statistics and Probability among Senior High School learners in Ragay District 2, Division of Camarines Sur, for School Year 2024–2025. Specifically, it assessed the extent to which teachers employed flipped classroom strategies in terms of Pre-Class Video Lectures and Interactive Content, In-Class Problem-Solving and Collaborative Activities, Online Quizzes and Formative Assessments, Project-Based Learning, and Blended Learning with Technology Integration. It also examined the effectiveness of these strategies in relation to learners' academic performance, engagement and participation, critical thinking, and problem-solving skills, as well as the significant differences in the rank orders of the strategies and effectiveness dimensions. The study was anchored on cognitive theory, social learning theory, constructivist theory, brain-based learning theory, and the Input-Process-Output model. It used the descriptive-evaluative-inferential method of research. Purposive sampling was used in selecting Ragay District 2 as the locale, while total enumeration was used in selecting thirty-eight Senior High School Mathematics teachers as respondents. A researcher-made questionnaire served as the main instrument, and the data were analyzed using weighted mean, rank, and the Wilcoxon Mann Whitney U Test at the 0.05 level of significance. Findings showed that flipped classroom strategies were generally Much Employed, with In-Class Problem-Solving and Collaborative Activities receiving the highest rating, followed by Project-Based Learning, Online Quizzes and Formative Assessments, Pre-Class Video Lectures and Interactive Content, and Blended Learning with Technology Integration. The strategies were also found Much Effective in improving engagement and participation, critical thinking, problem-solving skills, and learners' academic performance. Significant differences were found in Pre-Class Video Lectures and Interactive Content, Online Quizzes and Formative Assessments, and Critical Thinking, while the other areas showed no significant differences. The study concluded that flipped classroom strategies support quality instruction in Statistics and Probability, but implementation requires stronger teacher training, interactive instructional materials, digital access, connectivity, monitoring, and adoption of policy recommendations. The study aligns most directly with SDG 4 – Quality Education because it focuses on improving teaching practices, learner engagement, and mathematics learning outcomes. Its sustainability impact is institutional and educational, as it supports evidence-based instructional improvement, technology-supported learning, teacher development, and school-level policy enhancement.

Keywords: Blended Learning with Technology Integration, Critical Thinking, Flipped Classroom Strategies, Learners' Academic Performance, Online Quizzes and Formative Assessments, Problem-Solving Skills, Project-Based Learning, Senior High School, Statistics and Probability

1. Introduction

Innovative teaching strategies have become necessary in improving learner engagement, conceptual understanding, and problem-solving ability. In Statistics and Probability, traditional lecture-based instruction may limit active participation and higher-order thinking, especially because learners often encounter difficulty with abstract statistical concepts, probability distributions, and data interpretation. The Flipped Classroom Strategy addresses these concerns by reversing the usual classroom model: learners' study instructional content before class through pre-recorded lectures, videos, readings, and interactive materials, while class time is used for guided practice, discussion, collaboration, and problem-solving. Statistics and Probability is an essential component of the Senior High School mathematics curriculum because it develops analytical thinking and data-driven decision-making skills. However, its effectiveness depends not only on the content delivered but also on learners' adaptability to self-paced learning, teachers' readiness to use technology-driven instruction, availability of digital resources, internet accessibility, learner motivation, and appropriate assessment of learning outcomes. This study therefore evaluates the effectiveness of flipped classroom strategies in teaching Statistics and Probability among Senior High School learners in Ragay District 2, Division of Camarines Sur for School Year 2024–2025.

Related literature shows that learners commonly experience difficulty in Statistics and Probability because of misconceptions, weak conceptual understanding, and reliance on rote memorization. Batanero and Borovcnik (2016) emphasized students' difficulty in understanding independent and dependent events and recommended the use of real-world applications, statistical software, simulations, and inquiry-based instruction. Melencia and Coronel (2017) found that direct instruction is less effective in developing critical thinking and recommended active learning approaches such as collaborative problem-solving, real-world data analysis, and project-based learning. Gurat (2018) showed that blended learning improves performance, engagement, self-paced learning, and conceptual understanding through digital tools such as Google Classroom, Khan Academy, and GeoGebra. Calma et al. (2022) reported that students' knowledge, attitudes, mathematical background, and anxiety influence their performance in Statistics and Probability. Villavicencio et al. (2022) found that teachers' attitudes, instructional materials, pedagogical confidence, and professional development affect learner engagement and achievement.

Studies on flipped classroom strategies also indicate positive effects on learning outcomes, engagement, and classroom participation. Hew and Lo (2018) reported that flipped classrooms produced significant improvement in student learning compared with traditional teaching, especially when quizzes were used at the beginning of in-class sessions. Chen et al. (2018) found that student achievement was higher in flipped classrooms than in lecture-based classrooms. Li (2023) showed that pre-class video lectures support comprehension and allow more interactive in-class activities. Ayçiçek, (2021) found greater motivation, participation, improved classroom dynamics, and deeper discussions. Benigay, (2023) reported improved assessment performance and problem-solving skills in high school mathematics when flipped learning was used. Mendoza, (2022) noted that flipped learning supports self-directed study but requires attention to technology access and teacher guidance. Chevalier College (2023) showed that flipped learning can support flexible schedules and self-study, although time management remains a challenge. Ağırman, (2022) emphasized critical thinking, personalized learning, and learner autonomy, while noting the importance of teacher preparation and student motivation. Richards (2021) found that flipped learning increased opportunities for student practice but was affected by internet access and incomplete pre-class work. Jones (2021) reported improved preparedness and engagement but also the need for learner support in self-paced learning. Perin (2023) synthesized evidence showing gains in performance, engagement, and teacher-student interaction, provided that teacher training and digital resources are adequate. Rivera (2022) found that pre-recorded lessons help learners review difficult concepts but that live virtual discussions are needed to address the absence of immediate feedback.

The study is located in Ragay District 2, Division of Camarines Sur, which includes four Senior High Schools: Godofredo Reyes Sr. NHS, Ragay National Agricultural and Fisheries School, Sisa Feliciano NHS, and Simeon Tycangco. The study is delimited to public Senior High School teachers in the district and focuses on flipped classroom strategies in terms of Pre-Class Video Lectures and Interactive Content, In-Class Problem-Solving and Collaborative Activities, Online Quizzes and Formative Assessments, Project-Based Learning, and Blended Learning with Technology Integration. At the national level, the study is supported by the 1987 Constitution of the Republic of the Philippines (1987 Constitution of the Republic of the Philippines, art. XIV, § 1), which mandates the State to protect and promote the right of all citizens to quality education. It is also connected to Republic Act 9155, or the Governance of Basic Education Act, which emphasizes school head empowerment, school-based management, transparency, and local accountability. R.A. 10533, or the Enhanced Basic Education Act of 2013, supports the K to 12 curriculums by providing sufficient time for mastery of concepts and skills and preparing graduates for tertiary education, middle-level skills development, employment, and entrepreneurship. DepEd Memorandum 92, s.2013 supports the implementation of the enhanced curriculum through curriculum guides, teacher guides, and learner materials. The study also aligns with the Department of Education's MATATAG Agenda, which prioritizes basic education reforms, literacy and numeracy, inclusive education, digitized assessments, infrastructure improvement, electrification, connectivity, and stronger teaching approaches. It is further connected to the Basic Education Sector Reform Agenda (BESRA), the National Competency-Based Teacher Standards (NCBTS), Teacher Strengths and Needs Assessment (TSNA), the Schools First Initiative, Education for All (EFA), and the DepEd Computerization Program (DCP), which provides public schools with technologies that support 21st-century teaching and learning.

The study is anchored on cognitive, social learning, constructivist, and brain-based learning theories. Cognitive theory explains that learning is enhanced through the interaction of mental processes and technological tools, supporting the use of digital resources, recorded lessons, and technology-assisted instruction in flipped classrooms. Social learning theory highlights the importance of observation, modeling, motivation, retention, and self-efficacy, making it relevant to collaborative learning, peer interaction, teacher guidance, and confidence-building in mathematics instruction. Constructivist theory views learning as an active process in which learners construct knowledge through inquiry, collaboration, and meaningful experiences, promoting learner-centered instructional approaches. Brain-based learning theory emphasizes the value of authentic learning activities, continuous formative assessment, repeated practice, and constructive feedback to improve learning outcomes. Conceptually, the study is guided by the Input-Process-Output (IPO) model, which provides a systematic framework for examining the relationships among the study variables. The inputs include legal bases, theories, related literature and studies, respondents, research instrument, and statistical tools. The

process includes determining the extent of flipped classroom strategies, testing significant differences in rank orders, assessing effectiveness in terms of learners' academic performance, engagement and participation, critical thinking, and problem-solving skills, and formulating policy recommendations. The output is a set of policy recommendations for improving the effectiveness of flipped classroom strategies in teaching Statistics and Probability toward quality education.

Although existing literature discusses difficulties in Statistics and Probability and presents evidence on blended learning and flipped classroom strategies, the effectiveness of flipped classroom strategies in teaching Statistics and Probability among Senior High School learners in Ragay District 2 remains insufficiently explored. The reviewed studies provide support for active learning, technology-assisted instruction, teacher training, digital resources, self-paced learning, and learner engagement, but the local implementation of flipped classroom strategies requires further examination. The study addresses this gap by determining the extent to which teachers employ flipped classroom strategies in Statistics and Probability, assessing their effectiveness in relation to academic performance, engagement, critical thinking, and problem-solving skills, and identifying significant differences in the rank orders of these strategies and outcomes. Its rationale is to generate evidence-based policy recommendations that can improve instructional practice, support teachers, guide school heads and curriculum planners, assist DepEd officials, and strengthen learner-centered mathematics education.

The study directly aligns with SDG 4 – Quality Education because it focuses on improving teaching strategies, learner engagement, academic performance, critical thinking, and problem-solving skills in Senior High School Statistics and Probability. The manuscript specifically connects education to Sustainable Development Goal 4, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. The study also relates to SDG 9 – Industry, Innovation and Infrastructure because flipped classroom implementation depends on digital platforms, instructional technologies, online assessments, multimedia resources, connectivity, and technology integration. The DepEd Computerization Program (DCP), electrification, connectivity programs, digitized national assessments, and technology-supported instruction provide a direct connection between educational innovation and infrastructure. The study further supports SDG 17 – Partnerships for the Goals because the manuscript emphasizes that achieving the Sustainable Development Goals in basic education requires strong partnerships among government, private sector, civil society, local communities, schools, parents, and other stakeholders. This is consistent with the study's concern for school-community linkages, stakeholder participation, and policy recommendations.

The study contributes to educational sustainability by supporting instructional practices that improve learner participation, conceptual understanding, performance, critical thinking, and problem-solving in Statistics and Probability. Its findings can help teachers, school heads, curriculum planners, and DepEd officials strengthen Senior High School mathematics instruction through evidence-based approaches. It contributes to technological and digital sustainability by examining the use of pre-class videos, interactive content, online quizzes, formative assessments, blended learning, and digital tools. These elements help determine whether technology-supported instruction can be implemented effectively and sustainably in local classrooms. It contributes to institutional and policy sustainability by producing policy recommendations that can guide teacher training, instructional material development, curriculum improvement, professional development, and school-based management. It also supports governance-related reforms under RA 9155, R.A. 10533, BESRA, NCBTS, TSNA, and DepEd policy directions. It contributes to community sustainability by recognizing the role of parents, local government units, communities, and other stakeholders in supporting education beyond the classroom. Since the study is located in Ragay District 2, its findings may provide locally grounded evidence for improving Senior High School instruction, strengthening school-community collaboration, and promoting quality education in public schools.

2. Material and methods

2.1 Research Design

The study used the descriptive-evaluative-inferential method of research to describe and assess the effectiveness of flipped classroom strategies in teaching Statistics and Probability among Senior High School learners in Ragay District 2, Division of Camarines Sur. This design was used to examine existing conditions, relationships, opinions, processes, observable effects, and developing trends related to the implementation of flipped classroom strategies. It was also used to collect factual data necessary for answering the research questions and testing the hypotheses of the study.

2.2 Locale of the Study

The study was conducted in Ragay District 2, a first-class municipality in the province of Camarines Sur, Philippines. The district includes four Senior High Schools. The big schools were Godofredo Reyes Sr. NHS and Ragay National Agricultural and Fisheries School, while the medium schools were Sisa Feliciano NHS and Simeon Tycangco. The locale was selected because of its public Senior High School setting and its relevance to the study's focus on the use of flipped classroom strategies in teaching Statistics and Probability.

2.3 Respondents of the Study

The respondents of the study were Senior High School teachers teaching Mathematics in Ragay District 2, Division of Camarines Sur. A total of 38 teacher-respondents participated in the study. Of these, 10 came from Godofredo Reyes Sr. NHS, 14 from Ragay National Agricultural and Fisheries School, 4 from Sisa Feliciano NHS, and 10 from Simeon Tycangco.

2.4 Sample and Sampling Procedure

Purposive sampling was used in selecting Ragay District 2 as the locale of the study. Total enumeration sampling was used in selecting the Senior High School Mathematics teachers as respondents. This means that all qualified Senior High School teachers teaching Mathematics in the identified public schools of Ragay District 2 were included in the study.

2.5 Research Instrument

A researcher-made questionnaire served as the main instrument for gathering the needed data. The instrument underwent planning, item construction, submission to jurors, revision, modification, final printing, and dry-run administration. It was first presented to the adviser for comments, suggestions, and approval before undergoing the usual validation process. The questionnaire consisted of two parts. The first part measured the extent to which flipped classroom strategies were employed by teachers in teaching Statistics and Probability in terms of Pre-Class Video Lectures and Interactive Content, In-Class Problem-Solving and Collaborative Activities, Online Quizzes and Formative Assessments, Project-Based Learning, and Blended Learning with Technology Integration. The second part measured the effectiveness of the flipped classroom strategies in terms of Learners' Academic Performance, Engagement and Participation, Critical Thinking, and Problem-Solving Skills. The instrument used a five-point scale. For the extent of employment, the interpretations ranged from Not At All to Very Much Employed. For effectiveness, the interpretations ranged from Not At All to Very Much Effective. To measure the internal consistency of the instrument, Kuder-Richardson Formula 21 was used. The significance of the reliability coefficient was tested using the formula (Siegel & Castellan, 1988). The computed reliability coefficient was 1.1148, with a standard deviation of 27.39 and a computed significance value of $t = 26.51$; thus, the questionnaire was considered reliable. Standard deviation was determined using the formula.

2.6 Data Gathering Procedure

The researcher sought permission from the Schools Division Superintendent and the Public Schools District Supervisor of the secondary schools included in the study. After approval was granted, the researcher distributed the questionnaires to the respondents, conducted informal interviews and observations, and gathered additional data relevant to the study. The respondents were given five days to answer the research-made instrument without disrupting their classes. The completed questionnaires were retrieved, after which the data were tallied, tabulated, plotted, interpreted, analyzed, encoded, and prepared for presentation.

2.7 Data Analysis Techniques

The study used weighted mean, frequency count, percentage, and ranking to analyze the gathered data. Weighted mean was used to determine the average perception of the respondents, while frequency count and percentage were used to summarize the distribution of responses. Ranking was used to identify the order of importance or extent of the indicators. The Wilcoxon Mann Whitney U-test was used to determine the significant difference in the rank orders of the effectiveness of flipped classroom strategies in teaching Statistics and Probability among Senior High School learners in Ragay District 2. (Siegel & Castellan, 1988). The level of significance was set at 0.05.

3. Results and Discussion

3.1 Extent of Flipped Classroom Strategies Employed by Teachers

3.1.1 Pre-Class Video Lectures and Interactive Content

The results showed that Pre-Class Video Lectures and Interactive Content were Much Employed, with an average weighted mean of 3.95. The most emphasized practices were uploading supplementary reading materials to reinforce video lectures, encouraging learners to take notes and prepare questions, using multimedia presentations with animations and simulations, making pre-recorded lessons accessible for review, updating video lectures based on learner feedback, using online forums, providing short structured video segments, and using simulations or statistical tools. The least emphasized indicator was the inclusion of quizzes and checkpoints in interactive video content, which was rated only as Employed. This indicates that teachers used pre-class materials to prepare learners before classroom discussions, but formative checks within videos were not fully maximized. The result supports the flipped classroom principle that learners should engage with content before class to improve readiness and participation. Li (2023) emphasizes that pre-class video lectures improve learners' comprehension, allowing for more interactive in-class activities such as discussions and problem-solving.

3.1.2 In-Class Problem-Solving and Collaborative Activities

The results showed that In-Class Problem-Solving and Collaborative Activities were Much Employed, with an average weighted mean of 4.32. Group-based statistical problem-solving and teacher-guided problem-solving with immediate feedback received the highest ratings and were interpreted as Very Much Employed. Other practices, such as addressing misconceptions, using peer-assisted learning, promoting small-group participation, requiring learners to present solutions, applying differentiated instruction, using real-life statistical situations, designing competitive activities, and conducting hands-on exercises, were rated Much Employed. This means that teachers strongly emphasized active learning and peer collaboration during class time. The strategy allowed learners to apply statistical concepts, communicate solutions, and develop deeper problem-solving skills. Benigay (2023) found that flipped classroom strategies, particularly those involving in-class collaborative problem-solving, led to improved assessment scores and heightened problem-solving skills among high school learners.

3.1.3 Online Quizzes and Formative Assessments

The results showed that Online Quizzes and Formative Assessments were Much Employed, with an average weighted mean of 4.03. Teachers most strongly practiced giving constructive feedback based on quiz results, allowing self-paced assessments, using low-stakes assessments, providing immediate feedback, using adaptive quizzes, applying interactive platforms such as Google Forms and Kahoot, using peer-reviewed assessments, and using quiz data to guide instruction. However, conducting online quizzes to assess understanding of pre-class materials received the lowest rating and was interpreted as Employed. This shows that feedback-based assessment was present, but pre-class formative checking was not consistently used. This limits the ability of teachers to identify misconceptions before classroom activities. Hew and Lo (2018) reported that incorporating online quizzes at the beginning of in-class sessions enhances learning reinforcement and engagement. Their meta-analysis concluded that quizzes are effective in reviewing prior learning, increasing motivation, and encouraging learners to come prepared for classroom activities.

3.1.4 Project-Based Learning

The results showed that Project-Based Learning was Much Employed, with an average weighted mean of 4.16. Teachers highly emphasized the use of clear rubrics, peer evaluation, critical thinking and problem-solving in statistical analysis, real-world case studies, group critique of analytical approaches, statistical software, long-term retention of concepts, presentation of findings, and continuous feedback. The lowest-rated practices involved collaborative data collection, analysis, interpretation, and the application of statistical concepts to real-world problems, although these were still rated Much Employed. This suggests that project-based learning was used to guide learners in structured statistical inquiry, but authentic community-based or real-world statistical application could still be strengthened. Melencia and Coronel (2017) advocated for project-based learning in Statistics and Probability, noting its positive effects on critical thinking and learner engagement. When students are exposed to real-world applications through group projects and problem-solving tasks, they develop a more meaningful understanding of statistical concepts.

3.1.5 Blended Learning with Technology Integration

The results showed that Blended Learning with Technology Integration was Much Employed, with an average weighted mean of 3.92. Learning management systems such as Google Classroom received the highest rating because they provided easy access to resources. Recorded lessons, flexible pacing, practical application, online resources, discussion threads, digital communication, statistical software, online submissions, virtual models, simulations, collaboration tools, and the combination of face-to-face and online learning were also rated Much Employed. This indicates that technology was used to support flexible learning, resource access, and teacher-learner communication. However, synchronous and asynchronous integration, online collaboration, and simulation-based learning were less emphasized. Gurat (2018) demonstrated the effectiveness of blended learning through digital platforms such as Google Classroom and GeoGebra. These tools increased student participation, allowed for self-paced learning, and enhanced understanding of abstract probability concepts, making technology an essential component in implementing the flipped classroom model.

3.1.6 Summary of Strategies Employed

Overall, flipped classroom strategies were Much Employed, with an average weighted mean of 4.07. Among the five areas, In-Class Problem-Solving and Collaborative Activities ranked highest, followed by Project-Based Learning, Online Quizzes and Formative Assessments, Blended Learning with Technology Integration, and Pre-Class Video Lectures and Interactive Content. This means that teachers placed stronger emphasis on active classroom learning after learners had engaged with preparatory materials. However, the relatively lower rating of pre-class video lectures and interactive content suggests that the foundation of the flipped classroom still needs improvement. Gurat (2018) found that students exposed to blended learning, which includes components such as in-class problem-solving, project-based learning, and online quizzes, performed significantly better than those taught through traditional methods.

3.2 Significant Difference in the Rank Orders of Strategies Employed

The test of significant difference showed that Pre-Class Video Lectures and Interactive Content had a z-value of -1.93 with 0.0268($p < 0.05$), while Online Quizzes and Formative Assessments had a z-value of -1.66 with 0.0485($p < 0.05$). These results indicated significant differences in these two areas. In-Class Problem-Solving and Collaborative Activities, Project-Based Learning, and Blended Learning with Technology Integration had probability values greater than 0.05, indicating no significant difference in those areas. This suggests that while most flipped classroom strategies were implemented consistently, differences existed in the use of pre-class videos and online formative assessments. These areas require closer support because they are essential to learner readiness before classroom interaction. Melencia and Coronel (2017) examined various teaching methodologies used in teaching Statistics and Probability and highlighted the effectiveness of active learning strategies such as collaborative problem-solving. Their study revealed that while most teachers leaned toward direct instruction, those who incorporated group-based activities saw increased learner engagement and deeper understanding of statistical concepts.

3.3 Effectiveness of Flipped Classroom Strategies in Teaching Statistics and Probability

3.3.1 Learners' Academic Performance

The results showed that flipped classroom strategies were Much Effective in improving Learners' Academic Performance, with an average weighted mean of 4.04. Continuous assessments and analytical thinking tasks received the highest ratings. Other effective indicators included pre-class resources, active learning strategies, application-based learning, online tools, data-driven instruction, pre-class materials, self-paced learning, learner confidence, long-term retention, and comprehension of complex statistical concepts. This indicates that flipped classroom strategies supported academic performance by combining pre-class preparation, continuous assessment, and application-based learning. However, comprehension of complex concepts and long-term retention received lower ratings compared with other academic performance indicators. Chen et al. (2018) concluded that student achievement was higher in flipped classrooms compared to lecture-based settings. Their findings showed improved course grades and examination scores among students who were taught through flipped strategies, highlighting the model's capacity to raise academic outcomes.

3.3.2 Engagement and Participation

The results showed that flipped classroom strategies were Much Effective in improving Engagement and Participation, with an average weighted mean of 4.23. Self-paced videos and interactive lessons received the highest ratings because they helped prevent disengagement and sustain learner interest. Immediate feedback, digital tools, class preparation, group work, gamified quizzes, active learning, questioning, collaborative discussion, and peer collaboration were also rated Much Effective. This means that flipped classroom strategies encouraged learners to participate more actively by giving them control over pacing and by making classroom activities more interactive. However, peer collaboration and discussion participation were less emphasized than self-paced and interactive digital components. Ayçiçek (2021) found that learners showed greater motivation and classroom participation when pre-class videos were used. The flipped approach created a more dynamic classroom environment where students were more willing to participate and collaborate during in-person sessions.

3.3.3 Critical Thinking

The results showed that flipped classroom strategies were Much Effective in developing Critical Thinking, with an average weighted mean of 4.19. The highest-rated indicators were learners' ability to justify solutions, use statistical software for analytical precision, think independently, interpret data, and apply statistics to real-world situations. Inquiry-based activities, exploration of multiple solutions, reflective learning, hands-on problem-solving, and open-ended questioning were also rated Much Effective. This suggests that the flipped classroom model helped learners move from passive reception to active analysis. It strengthened logical reasoning, independent thinking, data interpretation, and analytical decision-making. However, reflective strategies and open-ended questioning were less emphasized. Perin (2023) synthesized evidence that flipped strategies improved learners' critical thinking and active participation during class. By engaging students in analytical tasks during classroom time, the model supports the development of higher-order thinking skills and better decision-making abilities.

3.3.4 Problem-Solving Skills

The results showed that flipped classroom strategies were Much Effective in improving Problem-Solving Skills, with an average weighted mean of 4.07. Learners were strongest in breaking down problems into logical steps and solving statistical problems after exposure to pre-class materials. They also showed confidence in solving complex problems, reflected on errors, demonstrated understanding of problem-solving strategies, selected formulas and strategies, practiced independent problem-solving, followed logical solution paths, applied reasoning and computation, and improved speed and accuracy. This indicates that flipped classroom strategies helped learners approach statistical problems more systematically. Pre-class exposure gave learners initial understanding, while classroom activities strengthened application. However, speed, accuracy, and computation-based reasoning were less emphasized. Benigay (2023) found that flipped classroom strategies significantly enhanced learners' problem-solving abilities in high school mathematics. Perin (2023) further supported this

by synthesizing studies showing that flipped learning fosters critical thinking by engaging learners in active tasks such as solving complex problems, interpreting data, and applying learned concepts in varied contexts.

3.3.5 Summary of Effectiveness

Overall, flipped classroom strategies were Much Effective, with an average weighted mean of 4.13. Engagement and Participation ranked highest, followed by Critical Thinking, Problem-Solving Skills, and Learners' Academic Performance. All areas were rated Much Effective. This means that flipped classroom strategies were effective in promoting learner engagement, analytical thinking, problem-solving, and academic performance. The strongest impact was on participation and critical thinking, showing that the model is particularly useful in creating a more active and learner-centered mathematics classroom. Chen et al. (2018) conducted a meta-analysis on the academic outcomes of flipped classroom learning and found that students in flipped settings consistently achieved higher grades and exam scores compared to those in traditional lecture-based classrooms.

3.4 Significant Difference in the Rank Orders of Effectiveness

The test of significant difference showed that Learners' Academic Performance had a z-value of -0.03 with 0.4880 ($p > 0.05$), Engagement and Participation had -1.28 with 0.1003 ($p > 0.05$), Critical Thinking had -1.93 with 0.0268 ($p < 0.05$), and Problem-Solving Skills had -0.68 with 0.32483 ($p > 0.05$). The null hypothesis was accepted for Learners' Academic Performance, Engagement and Participation, and Problem-Solving Skills, but not for Critical Thinking. This means that the perceived effectiveness of flipped classroom strategies was generally consistent across learner groups, except in Critical Thinking, where a significant difference was found. The finding suggests that flipped strategies were broadly effective, but the development of critical thinking may vary depending on implementation quality, task design, and classroom facilitation. Hew and Lo (2018) conducted a meta-analysis on the effectiveness of flipped classroom strategies in health professions education and found consistent improvements in student learning outcomes across different educational settings.

3.5 Policy Recommendations Derived from the Findings

The findings led to policy recommendations focused on strengthening pre-class content, online assessment, technology access, project-based learning, blended instruction, learner engagement, critical thinking, and problem-solving. The study recommended that curriculum writers, DepEd digital learning experts, school heads, ICT coordinators, teachers, parents, curriculum developers, local partners, instructional leaders, education supervisors, and assessment coordinators work together to improve video-based content, embed assessment tools, train teachers in online formative assessment, provide access to technology, design contextualized project tasks, support blended learning, promote peer interaction, include reflection prompts and higher-order questioning, and monitor problem-solving performance. These recommendations show that the effective implementation of flipped classroom strategies requires coordinated instructional, technological, administrative, and community support. The findings point to the need for stronger professional development, better digital tools, structured formative assessment, improved pre-class preparation, and continuous monitoring to sustain quality Statistics and Probability instruction.

4. Conclusion & Recommendations

The study concludes that flipped classroom strategies in teaching Statistics and Probability among Senior High School learners in Ragay District 2 were Much Employed by teachers and were found to be Very Much Effective in supporting learners' academic performance, engagement and participation, critical thinking, and problem-solving skills. The rank orders of the strategies showed no significant difference except in Pre-Class Video Lectures and Interactive Content and Online Quizzes and Formative Assessments, while the rank orders of effectiveness showed no significant difference except in Critical Thinking. Based on these findings, the formulated policy recommendations were considered necessary to strengthen the implementation and effectiveness of flipped classroom strategies in Senior High School Statistics and Probability instruction.

It is recommended that teachers receive regular training on flipped classroom strategies, particularly in in-class collaboration and digital integration; that interactive instructional materials and pre-made video lectures aligned with the Statistics and Probability curriculum be provided; that access to digital tools and internet connectivity be improved to support blended and flipped learning; that the implementation of flipped strategies be monitored and evaluated to ensure consistent and effective classroom practices; and that the policy recommendations developed from the findings be adopted. Future research should examine learners' perspectives on the effectiveness and challenges of flipped classroom strategies, investigate the long-term effects of flipped learning on academic retention and problem-solving abilities, compare outcomes across Senior High School tracks, study teacher readiness and digital competency, and explore equity and access issues in technology-supported flipped learning in rural and urban schools.

Compliance with ethical standards

The authors declare no conflict of interest. This study complied with recognized ethical standards for human-participant research by ensuring voluntary participation with informed consent, the right to withdraw without penalty, and strict confidentiality through anonymous, secure, and aggregated data handling. Given the focus on psychological well-being, procedures were non-invasive, and safeguards were observed to minimize discomfort, with guidance to appropriate support services when needed, and required institutional permissions were secured for instrument use and access to academic records.

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