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Enhancing statistical literacy: Developing and implementing Android-based performance tasks in mathematics

Analyn M. Gamit *

Graduate School, Nueva Ecija University of Science and Technology, Cabanatuan City, Philippines

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ABSTRACT

This study addressed knowledge gaps in Statistics and Probability among college students at Nueva Ecija University of Science and Technology by designing, developing, and evaluating an Android-Based Performance Tasks (APT) application. Using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) instructional design model, the researchers identified the least understood statistical topics and created eight performance tasks covering areas such as hypothesis testing, correlation, and regression. The application was reviewed by mathematics and Information and Communication Technology (ICT) experts for content accuracy and functionality before being implemented with selected students over eight weeks. Qualitative interviews showed that the APTs positively influenced student engagement, teamwork, and the practical application of statistical concepts. While some students initially struggled with solving tasks and navigating the app, they found it engaging, user-friendly, and effective for practical learning. The findings highlight the importance of integrating technology into teaching to support deeper understanding and improve mathematical literacy. The APT application serves as a useful tool to boost student motivation and performance in Statistics and Probability.

1. Introduction

In today's educational environment, teaching mathematics plays a critical role in preparing students with higher-order thinking, creativity, and critical analysis skills for real-world challenges. For students to develop these skills, they need authentic classroom assessments that simulate real-world scenarios (Wigglesworth and Frost, 2008). Performance tasks are essential in this context, as they help students demonstrate knowledge, understanding, and skills through application-based activities (Wiggins and McTighe, 2012). Instead of relying on rote memorization, such tasks encourage students to apply what they learn in practical settings, fostering a more student-centered and meaningful learning experience (Wiggins and McTighe, 2012).

However, Galman (2019) and Galman and Del Rosario (2021) found that students often struggle with the complexity of mathematical concepts, leading to gaps in foundational knowledge. In the Philippines, this was evident in the 2018 Program for International Student Assessment (PISA), where Filipino students averaged 353 points in mathematics, significantly lower than the OECD average of 489 points. Only 19.7% of Filipino students achieved the minimum proficiency level in mathematical literacy, ranking behind other ASEAN countries (Galman and Del Rosario, 2021).

The COVID-19 pandemic further exacerbated these challenges, disrupting the educational system and shifting learning modalities to distance or blended formats. In response, the Department of Education (DepEd) implemented the Basic Education Learning Continuity Plan (BE-LCP), prioritizing performance tasks in assessments to motivate students to demonstrate and apply their competencies in real-world contexts. Performance tasks now account for 50-70% of a student's grade.

Statistics and probability, a core subject in the K-12 curriculum, is particularly important due to its applications in research and various other fields. However, students often lack opportunities to apply these concepts in practical contexts during assessments, making it difficult for them to appreciate their relevance. Many students face challenges with basic mathematics, show low

* Corresponding Author.
Email Address: philippinesamgamit2000@ineust.ph.education
https://doi.org/10.21833/ijaas.2024.12.024
Corresponding author's ORCID profile:
https://orcid.org/0000-0003-4266-0851

interest in the subject, or struggle to connect mathematical concepts to real-world situations.

In response, this study aims to design and develop an Android-based application that links classroom assessments to real-world scenarios. This innovative tool will help students grasp mathematical concepts in meaningful ways, fostering engagement and knowledge retention. It is hoped that this application will enable students to apply mathematical principles to their day-to-day activities, ultimately improving their comprehension and interest in the subject.

2. Literature review

Performance tasks are effective in promoting higher-order thinking skills (HOTS), such as analysis, evaluation, and creation, which are crucial for mastering mathematical proficiency. Recent studies have emphasized that performance tasks not only enhance cognitive skills but also improve students' abilities to solve complex problems in real-world scenarios (Cao et al., 2022; Astuti et al., 2022). Integrating these tasks with technology, such as mobile applications, can further strengthen student engagement and performance (Sinha et al., 2021; Ghafar et al., 2022).

Integrating technology into instructional design further enhances the effectiveness of performance tasks. Several studies have demonstrated the benefits of using Information and Communication Technology (ICT) in educational contexts, particularly in improving accessibility, engagement, and academic performance (Santos, 2023; Nissa et al., 2021; Ali and Inayah, 2022; De Lara and Santos, 2024). For example, Nissa et al. (2021) developed Android-based learning tools that provided students with interactive practice exercises and real-time feedback, making learning more engaging and effective. Ali and Inayah (2022) found that using mobile applications for assessments in mathematics enhanced students' motivation and problem-solving skills, validating the potential of Android-based tools in facilitating effective learning. The integration of ICT in mathematics education has become a pivotal strategy in improving student outcomes. Contemporary educational technologies, such as Android-based learning applications and interactive e-modules, have been shown to enhance learning experiences by making content more accessible and interactive (Gamit, 2023; Lu et al., 2021). These tools provide immediate feedback, promote self-paced learning, and allow students to apply mathematical concepts in various contexts, which is particularly beneficial in developing HOTS (Koelsch et al., 2016; Lu et al., 2021). Recent studies have validated the use of mobile learning platforms to bridge the gap between traditional teaching methods and modern educational demands. For instance, Astuti et al. (2022) developed an Android-based statistics e-module that significantly improved students' conceptual understanding and problem-solving skills. Similarly, Sinha et al. (2021) explored the role of mobile applications in facilitating active learning environments where students interact with content dynamically and receive personalized guidance.

Moreover, research has highlighted the critical role of technology-aided performance tasks in bridging the gap between theoretical knowledge and practical application. A study conducted by Suddin and Deda (2020) showed that incorporating technology in mathematics education not only improved student performance but also made complex topics more accessible. These findings align with the overarching goal of this study—to develop an Android-based performance task application that enables students to apply mathematical principles in real-world scenarios.

The integration of performance tasks and technology in education has been supported by multiple frameworks, such as the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model, which offers a structured approach to instructional design (Branch, 2014). Using this model, Galman and Del Rosario (2021) developed real-life performance tasks in Business Mathematics and urged educators to explore similar methods in other subjects. These studies provide a solid foundation for designing effective learning interventions, making them particularly relevant to the development of this study's Android-based application for Statistics and Probability.

Overall, the use of technology-based performance tasks has shown promise in enhancing student engagement, understanding, and application of mathematical concepts (McTighe and Wiggins, 2013; Galman and Del Rosario, 2021; Ali and Inayah, 2022). This study builds on these findings by developing an innovative Android-based learning tool that integrates authentic performance tasks to support student learning in Statistics and Probability.

3. Methodology

The study utilized a developmental research design to create and evaluate instructional materials. Following the five phases of the ADDIE model—Analysis, Design, Development, Implementation, and Evaluation—the study focused on developing instructional materials for college students at Nueva Ecija University of Science and Technology. The process allowed for continuous refinement at each stage to ensure the effectiveness of the materials (Branch, 2014).

Five mathematics experts, three ICT experts, and 42 college students participated in the study. Purposive sampling was used to ensure that each group of participants met specific criteria. The Android-based performance tasks (APT) application was developed using the Apps Geyser platform and included eight tasks designed based on the Goal, Role, Audience, Situation, Product/Performance, and Standards for Success (GRASPS) model. A self-designed 4-point Likert scale questionnaire was used to evaluate the content and functional quality of the

application. Students assessed the acceptability of the APT, while interview guides were used to gather their feedback and experiences. To ensure the validity and reliability of the evaluation instruments, five experts, including master teachers and ICT coordinators, reviewed the tools. These instruments achieved an average validity score of 4.85. Reliability testing using Cronbach's alpha resulted in scores of 0.90 for mathematics experts, 0.77 for ICT experts, and 0.83 for student evaluations, indicating high reliability.

The teacher-made test was designed following contemporary assessment guidelines to ensure it aligned with the Most Essential Learning Competencies (MELCs) and targeted HOTS. The test development process included item analysis and review by a panel of five experts specializing in mathematics education and educational technology (Lee and Reeves, 2007). This panel verified the alignment of each test item with the learning objectives and assessed its relevance and clarity, ensuring high content validity (Cao et al., 2022; Ghafar et al., 2022).

After the initial review, the test was piloted with a sample group of students not involved in the main study to evaluate the clarity of the instructions and the suitability of the test length and difficulty (Astuti et al., 2022). Reliability was confirmed through Cronbach's alpha, yielding a high internal consistency score of 0.90. This high reliability indicates that the test items consistently measured the intended learning outcomes across different student groups (Lu et al., 2021).

The researcher followed the ADDIE framework to guide the data collection process. First, student performance data were analyzed to identify the topics that were least understood. Based on expert feedback, the content of the APT was refined, and the tasks were delivered through an eBook application. Students used the app over an eight-week period. Descriptive qualitative analysis was conducted to examine the least learned topics, while a Likert scale was used to calculate the grand mean scores for quality evaluation. Ethical considerations were carefully addressed throughout the study. Permissions were secured from the Division Superintendent and school administrators. Participation was voluntary, data confidentiality was strictly upheld, and students were free to withdraw from the study at any time.

4. Findings and results

4.1. Challenges in learning statistics and probability: Needs, difficulties, and solutions performance

A 50-item summative test was administered to college students at Nueva Ecija University of Science and Technology, revealing an average mean percentage score (MPS) of 40.79. This indicates "average" mastery according to the Department of Education's Standards in 2012, implying that students answered only 4 out of 10 questions correctly on average. The lack of mastery was emphasized during Learning Action Cell (LAC) sessions with mathematics teachers, highlighting issues such as insufficient student effort, lack of prior knowledge, and difficulties connecting concepts to real-world problems. Students also struggled to grasp mathematical principles, a challenge exacerbated by the COVID-19 pandemic. These findings align with international assessments like the PISA, where only 19% of Filipino students met the minimum benchmark for mathematical knowledge, while 81% fell below this standard. These results underscore the significant curriculum and learning gaps within the Philippine education system, demanding attention from the Department of Education. The analysis identified the least learned topics in Statistics and Probability, including hypothesis testing about population means, solving problems involving population mean hypotheses, testing proportions, and understanding correlation and regression concepts. These challenges highlight the complexity of the concepts, as emphasized by Galman (2019) and Galman and Del Rosario (2021). Struggling with foundational skills hampers students' ability to grasp advanced concepts. The lack of practical experience with real-world scenarios underscores the need for authentic assessments like APT, designed to simulate real-world scenarios involving these eight least learned topics. Students can access these tasks through their Android smartphones without needing internet access. By aligning with the curriculum and essential learning competencies, these performance tasks enable students to demonstrate their knowledge and skills more effectively while offering meaningful learning experiences.

4.2. Design and development of APT

The design phase of the APT meticulously planned the structure and format, incorporating background information, essential competencies, objectives, GRASPS performance tasks, scoring rubrics, and conclusions. Each APT began with an engaging title page and summary to guide students. The GRASPS model sets the context, defining the problem, the student's role, the audience, and the situational framework. Evaluation criteria were provided through scoring rubrics, with conclusions helping students summarize their learning. Developed with input from an adviser, master teacher, and five mathematics experts, the content was reviewed and revised before being finalized as PDFs and uploaded to the AppGeyser website, creating an Android app. Three ICT experts ensured the app's functionality and user-friendliness. Covering complex topics like hypothesis testing and correlation, which Galman (2019) and Galman and Del Rosario (2021) highlighted as challenging, the APT simulated real-world scenarios accessible via Android smartphones without the internet, aligning

with the curriculum to provide meaningful learning experiences.

4.3. Implementation of the APT

The implementation phase of the APT for college students at Nueva Ecija University of Science and Technology spanned eight weeks. Students with Android smartphones received the application via Google Drive and other sharing apps, while the subject teacher facilitated its use, and the researcher observed the tasks. In the first task, "Hypo-Testing," groups of three conducted surveys among local workers to analyze wage data using hypothesis testing. Despite two groups making errors in their calculations, all completed the conclusions satisfactorily, showing enthusiasm for the collaborative effort. "Paired T's Getting Real," the second task, required students to analyze pre and post-test data individually, where 34 out of 42 provided accurate solutions and thoroughly answered the guide questions. For "Significantly Different," students surveyed 400 classmates to test the hypothesis that no significant difference existed between local and national Facebook usage proportions. While initially hesitant due to the sample size, students appreciated its connection to the Central Limit Theorem, and six out of nine groups produced accurate results. The fourth task, "Pro-4-nation," involved analyzing hypothesis testing between two proportions. Thirty-five out of 42 students answered correctly, with some errors in computation. In "It's Pearson R," groups surveyed 10 college students to investigate the relationship between gaming habits and grades. They calculated Pearson's r coefficient successfully, identifying a strong positive correlation between gaming and academic performance. The sixth task, "Watch Your BP," involved analyzing the correlation between systolic and diastolic blood pressure, which 37 out of 42 students answered accurately. In "Regression on Absences," groups surveyed younger students to identify the relationship between absences and academic performance. Eight of the nine groups created accurate regression models. Finally, due to suspended classes, "Disaster Predictions" was completed remotely, with students monitored through social media. They developed linear regression models to predict the impact of typhoons, and five out of the nine groups produced accurate solutions.

4.4. Assessment of the developed APT by mathematics experts

Five mathematics experts assessed the APTs and provided a comprehensive evaluation of the application's various components. The experts rated the Background Information very satisfactory, with a score of 3.99, highlighting its alignment with the MELCs and its insightful overview of the tasks and real-world applications. The MELCs themselves received a rating of 3.97, reflecting their adherence to national standards as outlined by the Department of Education. Objectives were found to be clear, specific, measurable, and attainable, effectively connecting to real-world applications and earning a score of 3.92. The GRASPS model (Goal, Role, Audience, Situation, and Performance) was praised for its alignment with essential competencies and its ability to present well-defined tasks. The Goal aspect clarified the problem or challenge, while the Role provided relevant responsibilities connected to real-life situations. The Audience and Situation aspects presented real-world people and scenarios, although there was some room for improvement in helping students organize their content and skills. Overall, the GRASPS model achieved a rating of 3.99, allowing students to demonstrate their knowledge and relate the content to real-world situations. The Standards/Scoring Rubric was rated highly at 3.93 for its clear definition of evaluation criteria, though some aspects could be improved for greater precision and objectivity. The Conclusion component, with a grand mean rating of 3.98, enabled students to infer insights and generalize their understanding of the tasks effectively, wrapping up the APTs meaningfully. The experts' assessment reflected a robust educational tool that was well-designed, aligning with essential learning competencies and offering a clear, real-world application for college students.

4.5. Assessment of APT by ICT experts

The functional quality of the APT application was evaluated by three ICT experts using a 4-point scale, focusing on format and language, and usefulness. The format and language received a score of 3.88 (Very Satisfactory), praised for its visually appealing design, logical layout, clear fonts, easy-to-follow instructions, and motivating language, though images and clip art were rated at 3.33, suggesting a need for resizing and better placement. Usefulness scored 3.83 (Very Satisfactory), highlighted by its simple installation, efficient storage use, offline functionality, and user-friendly design, but scored 3.00 (Satisfactory) for one aspect, indicating that some students might require teacher guidance to understand tasks. Overall, with an average score of 3.85 (Very Satisfactory), the application demonstrated its potential to engage students effectively while identifying areas for refinement.

4.6. Assessment of APT by students

College students evaluated the APT application across four key areas: usefulness, format, language used, and content, using a 4-point scale. Their assessments provided insightful feedback on how well the application met their needs. Usefulness received an average score of 3.51 (Very Satisfactory). Students found the application easy to install, access, and navigate, describing it as user-friendly and noting that it worked effectively without internet access. The highest score in this aspect was 3.62 for

accessing and reading the app offline, highlighting a major advantage. Format garnered an average score of 3.20 (Satisfactory). While students appreciated the mathematical symbols and strategically placed images, they suggested minor revisions for the layout, instructions, and font style. Some required their teacher's assistance to understand the instructions and had to zoom in on words to read them clearly. Language Used scored an average of 3.31 (Very Satisfactory). The language was generally clear, concise, and relevant. However, a few students struggled to follow the instructions and understand key concepts due to English being their second language. Content was rated at 3.38 (Very Satisfactory). The performance tasks were seen as relevant and valuable for studying Statistics and Probability, with students appreciating the application's ability to motivate them and connect concepts to real-world situations. Overall, this assessment reflected the application's strong acceptability among students while identifying areas for refinement.

4.7. Experiences of the respondents in doing the APT in statistics and probability

The APT application was implemented as an assessment tool among college students at Nueva Ecija University of Science and Technology for eight weeks in their Statistics and Probability coursework. Qualitative interviews with 30 students revealed a mix of positive and negative experiences while working with the application. The students found the application both engaging and enjoyable due to the ease of accessing the performance tasks via their mobile phones, even without internet connectivity. They also appreciated the opportunity to conduct surveys and interview their neighbors and peers for data collection. Collaborative learning emerged as another positive theme, as students found teamwork with their groupmates made tasks easier to complete while fostering a sense of collaboration. The students also valued the opportunity to apply their statistical knowledge to real-world scenarios, creating their own surveys and appreciating the application's convenience since it was accessible without the need for printed modules or an internet connection. Despite the positive feedback, some students experienced challenges in solving tasks due to unfamiliarity with the material and a lack of proficiency in critical thinking and problem-solving skills. Additionally, a few students were initially puzzled by the application and required extra effort to zoom in on text or navigate unfamiliar features. The implementation of the APT application provided students with a unique and collaborative learning experience while revealing areas for improvement to ensure seamless navigation and comprehension.

5. Discussion

Addressing the significant knowledge gaps among college students in Statistics and Probability at Nueva Ecija University of Science and Technology necessitates the implementation of performance-based tasks that mirror real-world applications. The APT aim to motivate students by providing practical assessments through familiar technology. By emphasizing process-oriented learning and connecting directly to real-world scenarios, these tasks shift the focus from rote memorization to deeper comprehension and application, enhancing mathematical literacy and preparing students for real-world challenges (Jiang, 2018).

Incorporating technology in learning, such as digital smart book learning media, can facilitate the learning process for students and enhance their motivation (Hidayati and Elmunsyah, 2021). Moving towards student-centered learning in a digital environment can personalize the learning experience and improve engagement (Abdigapbarova and Zhiyenbayeva, 2022). Virtual learning environments enable learners to develop their skills and engage in experiential learning, involving experience, reflection, experimentation, and application (Ng et al., 2019). Integrating interactive learning media and real-world scenarios in education can increase students' understanding, self-confidence, and engagement with the material (Gong and Yan, 2023).

Utilizing personalized educational models and activity-oriented approaches stimulates students' interest and maintains their engagement (Morris et al., 2021). Performance-based feedback and formative assessment strategies help identify knowledge gaps and provide targeted support. Additionally, technology-based instructional tools can be tailored to meet individual learning needs, improving educational outcomes (Hidayati and Elmunsyah, 2021).

The APT application was meticulously designed and developed to encompass eight tasks, each targeting specific statistical concepts. Tasks such as "Hypo-Testing," "Paired T's Getting Real," "Significantly Differ," "Pro-4-nation," "It's Pearson R," "Watch Your BP!," "Regression on Absences," and "Disaster Predictions" focus on various statistical techniques like hypothesis testing, correlation, and regression. By aligning these tasks with real-world applications and essential learning competencies, the APT application fosters deeper engagement and understanding among students (Astuti et al., 2022).

Leveraging technology in education has been shown to enhance learning experiences and improve student performance. The development of Android-based learning media, as seen in the "MBARENGI" Statistics E-Module, has laid the groundwork for innovative approaches in statistics education (Koelsch et al., 2016). Additionally, the use of multimedia systems, blended learning environments, and instructional sequences can optimize learning and enhance educational interventions (Krishnasamy et al., 2020).

Research on statistical learning and implicit learning abilities highlights the importance of regularities in space and time for sensory input

processing (Sinha et al., 2021). Understanding how individuals learn implicitly and the impact of various factors on learning outcomes is crucial for designing effective educational interventions (Mirza et al., 2022). The role of innovation, creativity, and experiential learning in education underscores the significance of pedagogical approaches that promote active participation, exploration, and discovery (Bieraugel and Neill, 2017). The design and development of the APT application represent a significant step towards enhancing statistical literacy and mastery of key concepts among college students. By integrating technology, real-world applications, and essential learning competencies, the APT application provides an innovative and practical learning experience that can transform statistics education and better prepare students for future challenges.

The successful implementation of APT in engaging students through real-world applications in statistical analysis aligns with research findings that performance tasks can enhance academic performance (Sabijon, 2021). The high enthusiasm and effective collaboration displayed by students during the tasks resulted in gaining practical skills in statistical concepts while connecting them to relevant real-life scenarios. Despite encountering some computation errors, most student groups demonstrated a strong comprehension of the concepts and were able to complete the tasks with minimal guidance. This successful implementation underscores the potential of APT to not only improve students' academic understanding but also enhance their engagement in statistics.

While the findings highlight the potential of APTs to improve student engagement and comprehension in a specific educational context, the results may differ when implemented in other settings or among students with diverse backgrounds. For instance, students in rural or under-resourced schools with limited access to digital devices may face challenges in utilizing the full features of the APTs, potentially diminishing their effectiveness. Similarly, cultural differences and variations in students' familiarity with technology-based learning could influence their attitudes toward the use of APTs, affecting overall learning outcomes. Consequently, future research should consider these contextual variables to adapt and optimize the use of APTs across different educational environments.

The utilization of performance tasks in education has been shown to have a positive impact on academic performance and student engagement (Uluçınar and Dinç, 2021). By simulating real-world scenarios and emphasizing practical skills, students can develop a deeper understanding of complex concepts. Additionally, the integration of technology, such as the Android platform, can further enhance the learning experience and provide students with innovative ways to interact with the material. Research on cognitive processes related to learning, memory, and task performance highlights the importance of creating meaningful and engaging learning experiences (Li and Wang, 2018). By incorporating real-world applications and practical tasks, educators can facilitate better comprehension and retention of information among students. The ability to connect theoretical concepts to practical scenarios not only enhances learning outcomes but also fosters a deeper level of engagement and interest in the subject matter.

The successful implementation of APT in engaging students through real-world applications in statistical analysis demonstrates the potential of performance tasks to enhance academic performance and student engagement in statistics. By providing practical skills and connecting concepts to relevant scenarios, educators can create a more meaningful and effective learning experience for students.

The APTs were rated very satisfactory by mathematics experts, indicating that each component met or exceeded their expectations in terms of content quality. This aligns with prior research emphasizing the benefits of performance tasks, such as Albay and Eisma (2021) and Arhin (2015), who both highlighted how these tasks can enhance creativity, problem-solving, and critical thinking. The scoring rubrics and clearly defined objectives supported the creation of an authentic assessment experience. These findings echo Iter's (2017) recommendation that GRASPS performance tasks be used as authentic assessment tools to make students more interactive and reflective. Furthermore, this study supports the work of Nissa et al. (2021) and Funa and Ricafort (2019), who stressed the importance of content validity and the careful consideration of language in learning materials. The APTs developed for this study show promise in enhancing mathematics instruction, providing relevant real-world applications that engage students and help them see the value of statistical concepts.

The high ratings given by ICT experts emphasize the APT application's effectiveness in providing a practical and intuitive assessment tool. These results align with studies by Ali and Inayah (2022), which highlight the value of Android-based assessments in motivating students and improving their academic performance. Ali and Inayah (2022) demonstrated how using an Android-based test (ABT) can help students solve problems more efficiently while remaining engaged and motivated. Similarly, Etcuban and Pantinople (2018) found that mobile applications enhanced students' learning experiences and achievement in mathematics. The APT application thus offers a promising way to make learning mathematics enjoyable, accessible, and effective. Its ability to provide an authentic assessment framework aligns with McTighe (2016) and Nissa et al. (2021), who noted that learning modules based on Android technology can significantly enhance students' performance. These findings emphasize that Android-based assessment tools can be used as a strategic means of engaging students, making learning more interactive and

effective while offering teachers new ways to assess learning in a technologically advanced environment.

The student's evaluation of the APT application highlights its overall success as a learning tool. With an overall score of 3.35 (Very Satisfactory), they recognized the application's user-friendliness, relevance, and effectiveness in presenting concepts. Their perception aligns with research by Funa and Ricafort (2019), which emphasized the importance of considering student interests when developing instructional materials. In their study on gamified learning tools for genetics, students highly valued the integration of game elements, finding the learning experience engaging and motivating. Similarly, Kurniawan et al. (2020) showed that an Android-based assessment for vector topics was effective in improving students' concept acquisition. The APT application's success in motivating students, simplifying mathematical tasks, and supporting their learning processes validate the potential of technology-based tools. Despite minor revisions needed in the format and language aspects, the APT application remains a valuable and effective learning resource for students in Statistics and Probability.

The feedback from students regarding the APT application highlights the positive impact it had on their learning experiences. Students found the APT application to be interesting, collaborative, and practical, emphasizing the importance of collaborative learning and the user-friendly nature of the app. This positive feedback resonates with studies such as Garrison (2007) and Asiedu (2023), which underscore the value students place on learning materials that incorporate their interests and innovative engagement methods. While the overall experiences were positive, some students initially struggled with performance-based assessments and navigating the app, leading to minor challenges. These negative experiences were mitigated by providing detailed guidance on using the app and familiarizing students with such assessment methods. By addressing these challenges, educators can ensure a smoother transition to performance-based learning approaches and technology-enhanced learning environments. The APT application's ability to link real-world scenarios to classroom assessments aligns with the GRASPS principles, enabling teachers to contextualize learning and foster critical thinking among students. By simulating authentic learning scenarios, Android-based innovations like the APT application enhance student engagement and allow them to apply their skills in practical and impactful ways. In conclusion, the feedback from students regarding the APT application underscores its effectiveness in creating engaging and practical learning experiences. By incorporating collaborative learning, real-world applications, and user-friendly technology, the APT application not only enhances student engagement but also facilitates a deeper understanding of statistical concepts in a meaningful context.

6. Conclusion

The study results indicate several key conclusions that highlight the strengths and impact of the research. First, the performance of Grade 11 students at Manacsac High School was assessed as average, indicating a need for improvement toward mastery in Statistics and Probability. Despite this, the implementation of the ADDIE model in designing and developing the APT application proved highly effective. The ADDIE model's structured approach facilitated the creation of a robust instructional tool that significantly enhanced the learning experience.

The successful implementation of the APT application in classroom instruction received high praise from experts. Mathematics experts rated the content quality of the APT application as excellent and highly acceptable, while ICT experts commended its format, language, and overall usefulness. Students also provided positive evaluations, noting the application's user-friendliness, relevance, and effectiveness in presenting complex statistical concepts. These assessments underscore the application's potential to make learning more interactive, engaging, and effective.

However, the study also revealed some challenges faced by students in using the APT application, such as initial difficulties in navigation and understanding performance-based assessments. These findings emphasize the importance of continuous user feedback to refine and improve the application, ensuring it meets the diverse needs of all learners.

The APT application represents a significant advancement in educational technology for teaching Statistics and Probability (Lee and Reeves, 2007). Its development and successful deployment demonstrate the value of integrating technology with pedagogical strategies to enhance student learning outcomes. This study not only contributes to the existing body of knowledge but also lays the groundwork for future research to further explore and expand the use of technology-based performance tasks in education. By addressing identified challenges and building on the positive outcomes, educators can continue to innovate and improve instructional methods, ultimately leading to better educational experiences and outcomes for students.

6.1. Recommendations

Based on the study's findings, several recommendations are proposed to enhance the effectiveness of teaching and learning in mathematics through technology-based performance tasks. Teachers should regularly perform diagnostic analyses to assess students' needs, challenges, and initial competencies, helping to prepare learning materials tailored to address specific gaps and enhance understanding. Future teacher-researchers are encouraged to employ instructional design models, such as the ADDIE model, when creating

educational materials, ensuring the development of comprehensive and effective instructional tools.

Mathematics teachers should consider incorporating ICT into performance-based tasks across various math subjects, making learning more interactive and engaging. Collaboration between teachers and administrators is essential to facilitate the implementation of these innovative instructional materials in the classroom, ensuring resources are effectively utilized and integrated into the curriculum. Additionally, teachers should work closely with ICT experts to develop Android-based instructional resources that are not only educational but also engaging and enjoyable for students, leading to the creation of high-quality learning tools that enhance student motivation and participation.

For the APT application specifically, Statistics and Probability teachers should utilize and continuously refine its content through peer assessment and collaboration, maintaining the relevance and effectiveness of the application. Researchers are encouraged to replicate the implementation of APT in other Grade 11 classes and educational settings, validating the reliability and effectiveness of the tasks and providing further insights into their impact on student performance, achievement, and behavior. To further explore the potential of APTs in varied contexts, future research should examine their implementation in low-resource settings where access to technology may be limited. Researchers should also consider customizing APTs for students with different learning needs, incorporating assistive technologies and differentiated instruction strategies. Cross-cultural comparisons are necessary to understand how students from different cultural backgrounds respond to technology-based performance tasks. Additionally, longitudinal studies are recommended to assess the long-term impact of APTs on students' academic performance and interest in mathematics. Finally, future research should investigate the role of teacher facilitation in enhancing the effectiveness of APTs, as instructional support may significantly influence learning outcomes.

Exploring broader implications, future studies should investigate how these technology-based performance tasks can be adapted and applied across different subjects and educational contexts. By addressing the identified challenges and building on the positive outcomes, educators can continue to innovate and improve instructional methods, ultimately leading to better educational experiences and outcomes for students.

6.2. Limitations

This study had several limitations that influenced its outcomes. First, the research focused exclusively on Grade 11 students at Manacsac High School, restricting the generalizability of its findings to broader student populations with different contexts. The sample size, though adequate for a pilot implementation, may not fully represent the diverse range of students and learning environments across different regions. Second, the study required participants to have access to Android smartphones with adequate functionality and memory, which may have inadvertently excluded students without such resources, potentially impacting the accessibility and applicability of the APT. Furthermore, some students faced difficulties navigating the new technology, suggesting that prior familiarity with mobile apps and digital learning tools varied. Finally, while the study assessed qualitative experiences and acceptability, it did not quantitatively measure the direct impact of the APT application on students' academic performance in Statistics and Probability.

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Compliance with ethical standards

Ethical considerations

The research adhered to the highest ethical standards, guided by the academic advisors and the ethics committee of the College of Education, Nueva Ecija University of Science and Technology. The participation of students and faculty was entirely voluntary, and all data was collected, stored, and analyzed with strict attention to confidentiality. Participants were fully informed of the study's objectives and were free to withdraw at any stage without academic repercussions.

Conflict of interest

The author declares no conflict of interest in preparing and executing this study. The research was conducted with complete adherence to academic integrity and objectivity.

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