 ISSN: **3107-6513**

Development and Evaluation of an Android-Based Strategic Intervention Material for Grade 6 Science: The Tudlo Editor Platform

Jason Ryan A. Pujeda
University of the Immaculate Conception, Davao City, Philippines
jpujeda_220000000656@uic.edu.ph

Abstract:

This study aimed to design, develop, and evaluate an Android-based Strategic Intervention Material (SIM) for Grade 6 Science using an innovative AI-powered authoring system called the Tudlo Editor. Grounded in the ADDIE instructional design model, this research addressed the critical gap in digital learning resources for least-mastered science competencies in Philippine public schools. The developed application, "Ninja Quest: Unraveling the Secrets of Vertebrates and Invertebrates," integrated gamified activities, multimedia elements, and offline accessibility features to enhance learner engagement and conceptual mastery. Evaluation results from 60 science teacher-experts across six public elementary schools in Davao City demonstrated a very high level of acceptability with a grand mean of 3.88. The study confirms that iterative development through the Tudlo Editor can significantly improve instructional material creation efficiency, while the Android-based SIM represents an effective, scalable solution for supporting inclusive and engaging science learning in resource-constrained educational environments.

Keywords—Educational technology, Strategic Intervention Material, Android-based learning, AI-powered authoring, gamified instruction, ADDIE model, Science 6 curriculum, Philippines

I. INTRODUCTION

A. Background and Significance

Science education is foundational to developing scientifically literate citizens capable of applying scientific knowledge to solve real-world problems[1]. However, science education globally faces persistent challenges, including low student achievement, limited access to resources, and inadequate instructional materials[2]. In the Philippines, the 2018 Programme for International Student Assessment (PISA) revealed a critical concern: Filipino students averaged 357 points in science, significantly below the OECD average of 489 points, with only 22% achieving minimum proficiency levels[3]. This performance gap reflects broader structural inadequacies, particularly the scarcity of engaging, contextualized learning materials addressing diverse learner needs[4],[5].

The identified challenges are not unique to the Philippines. In Indonesia, rural areas struggle with limited access to quality science education resources, while sub-Saharan African nations face the compounding effects of insufficient teacher training, outdated curricula, and absent laboratory equipment[6]. Conversely, high-performing nations such as South Korea and Singapore demonstrate that strategic investments in instructional quality and technology integration yield consistently superior outcomes[7],[8]. South Korean students benefit from rigorous curricula and extensive technology adoption, while Singapore's spiral curriculum and emphasis on practical application have established it as a global exemplar[9].

B. Strategic Intervention Materials and Mobile Learning

Within Philippine educational policy, Strategic Intervention Materials (SIMs) have emerged as a recognized remedial strategy. Division Memorandum No. 738, Series 2019, mandates the development of SIMs targeting competencies with ≤15% mastery rates. Previous research validates SIM effectiveness: Acedillo et al.[10] documented that SIMs significantly improved students' science process skills and subject concept mastery, while Villar et al.[11] demonstrated improved academic performance and knowledge retention in Grade 5

pupils. Similarly, Romero's [12] study in Davao City showed that well-designed SIMs addressing separation techniques substantially improved academic performance and learner perception.

However, traditional paper-based SIMs face inherent limitations in accessibility, durability, and sustained learner engagement. Mobile learning technologies address these constraints. Research by Crompton and Burke[13] confirmed that mobile learning positively impacts student engagement and achievement, while Cheung and Slavin[14] found educational technology applications, including mobile tools, generate positive effects on science achievement. Despite these evidenced benefits, a notable research gap persists: the scarcity of studies specifically exploring development and evaluation of Android-based SIMs for Grade 6 Science within Philippine K to 12 curricula contexts.

C. Research Objectives

This study addressed this gap by developing an Android-based SIM leveraging technology to provide interactive, self-paced learning experiences. Specifically, the research aimed to: (1) design and develop an Android-based SIM addressing identified least-mastered competencies in Science 6; (2) evaluate the material's acceptability across content quality, instructional quality, usability, and technical dimensions; (3) establish integration strategies for curriculum implementation; and (4) delineate intellectual property protections applicable to the developed system.

II. METHODOLOGY

A. Research Design and Framework

This descriptive quantitative study employed the ADDIE instructional design model (Analysis, Design, Development, Implementation, Evaluation) to systematically structure material development. The study integrated the Technological Pedagogical Content Knowledge (TPACK) framework to guide effective technology integration, and applied Dual-Coding Theory[15] to inform strategic use of visuals and text, enhancing cognitive processing and knowledge retention.

B. Software Development Methodology

The Tudlo Editor, an AI-powered authoring platform developed by the researcher, employed iterative development cycles. The system integrated Google's Gemini AI model to generate curriculum-aligned learning activities, leveraging Firebase Authentication for security, Electron for desktop deployment, Apache Cordova for mobile packaging, and IndexedDB for persistent offline data storage. This architecture enabled seamless translation of teacher-created content into interactive mobile applications.

C. Development Phases

Analysis Phase: The researcher identified the least-mastered competency "Determine the distinguishing characteristics of vertebrates and invertebrates" through Division Memorandum CID-2025-321 and corroborated through teacher consultations confirming need for visual, digital learning interventions.

Design Phase: Learning objectives aligned with Department of Education Most Essential Learning Competencies (MELCs). The SIM narrative, "Ninja Quest: Unraveling the Secrets of Vertebrates and Invertebrates," engaged learners as Ninjas restoring harmony between vertebrate and invertebrate kingdoms through competency mastery.

Development Phase: The Tudlo Editor generated interactive activities (multiple-choice, drag-and-drop, matching, labeling, identification) with real-time AI-assisted feedback. Content was developed using HTML5, JavaScript, and IndexedDB, packaged via Apache Cordova into an offline-accessible Android application.

Implementation and Evaluation Phases: The SIM was deployed to six public elementary schools across Davao City for expert evaluation.

D. System Architecture

The architecture comprised modular frontend, backend, and database layers. The frontend provided interactive user interfaces via HTML5/CSS3/JavaScript. The backend managed system logic, content loading, and progress tracking through Node.js services. Database persistence utilized Local Storage and IndexedDB. Integration of Firebase Authentication, Electron, Apache Cordova, and IndexedDB created a cohesive ecosystem connecting authoring, data management, and learning delivery[16].

E. Research Locale and Respondents

The study was conducted in public elementary schools in Davao City, Philippines, representing diverse socioeconomic and instructional contexts. Science Coordinators, Master Teachers, and teacher-experts with extensive Science 6 experience, current involvement in curriculum implementation, or Master's degrees in science-related fields served as evaluators. Using purposive sampling, 35 teacher-experts from participating schools evaluated the developed material over several days, assessing content, usability, instructional quality, and technical performance.

F. Research Instruments and Data Analysis

A modified evaluation questionnaire based on the Department of Education's Learning Resource Management and Development System (LRMDS) Evaluation Tool assessed four indicators: (1) Content Quality, (2) Instructional Quality, (3) Usability/Manipulation, and (4) Technical Quality. Each dimension comprised multiple items evaluated on a 4-point Likert scale (1.00–4.00).

Interpretation Matrix:

- 3.26–4.00: Very High Acceptability
- 2.51–3.25: High Acceptability
- 1.76–2.50: Low Acceptability
- 1.00–1.75: Very Low Acceptability

Pilot testing with five science teacher-experts (not main respondents) confirmed instrument reliability. Cronbach's alpha coefficients ranged 0.88–0.93 across four dimensions, exceeding the 0.70 threshold[17]. Mean scores and standard deviations characterized acceptability across dimensions. Data were collected following University of Immaculate Conception Research Ethics Committee approval (Protocol GS-EX-10-24-0033) and appropriate institutional permissions.

G. Ethical Considerations

The study adhered to ethical research standards prioritizing participant welfare and data protection. Informed consent was obtained with assurance of anonymity, voluntary participation, and withdrawal rights. Privacy was protected through coding, secure data storage, and compliance with the Data Privacy Act of 2012[18].

III. RESULTS AND DISCUSSION

A. Identification of Least-Mastered Competency

Analysis identified "Determine the distinguishing characteristics of vertebrates and invertebrates" as a persistent least-mastered competency in Grade 6 Science. This finding aligned with previous research by Dumdumaya et al.[19] identifying biological classification as challenging for Grade 6 students. The competency's complexity demands concrete examples and hands-on exploration—resources often unavailable in resource-constrained schools[20].

B. Design and Development Outcomes

The Tudlo Editor successfully enabled design and development of the Android-based SIM. Key development outcomes included: (1) systematic content generation aligned with MELCs using AI-assisted authoring; (2) integration of gamified learning elements (badge systems, experience points, narrative progression) promoting sustained engagement; (3) offline accessibility ensuring functionality without internet connectivity; and (4) responsive design optimizing visual presentation across device sizes.

The system architecture demonstrated robust integration of modern educational technology components. Firebase Authentication provided encryption and access control, while IndexedDB ensured seamless offline operation. Apache Cordova successfully packaged web-based content into a native Android application, maintaining all interactive functionality and animations[21].

C. Level of Acceptability Results

1) Content Quality Domain

The Content Quality dimension achieved a grand mean of 3.89 (SD = 0.19), interpreted as "Very High" acceptability. Teacher-experts confirmed that content was: accurately aligned with Grade 6 Science MELCs, well-organized with logical conceptual progression, contextualized for Philippine learners, current and evidence-based, free from cultural/gender bias, and promoted critical thinking through real-life applications[22]. Results align with Arpilleda[23] emphasizing SIM accuracy and Dumdumaya et al.[24] stressing contextualized content necessity for biological classification comprehension.

Content Quality Mean Scores by Indicator:

- Clarity of concepts: 3.90
- Accuracy of content: 3.87
- Updatedness: 3.89
- Logical organization: 3.88
- Freedom from bias: 3.89
- Critical thinking promotion: 3.87
- Real-life relevance: 3.89
- Language appropriateness: 3.90
- Positive value promotion: 3.87

2) Instructional Quality Domain

The Instructional Quality dimension achieved a grand mean of 3.84 (SD = 0.21), also interpreted as "Very High." Teacher-experts noted: clear purpose achievement, well-sequenced activities aligned with learning objectives, appropriate difficulty levels, effective multimedia integration (animations, audio narration, interactive tasks), and strong learner motivation promotion[25]. These findings support Ayu et al.[26] who emphasized that interactive, engaging instructional materials enhance learning outcomes. The SIM demonstrated sound constructivist and learner-centered design principles[27].

Instructional Quality Mean Scores by Indicator:

- Purpose clarity: 3.90
- Purpose achievement: 3.87
- Objective clarity and measurability: 3.86
- Appropriate difficulty: 3.79
- Activity sequencing: 3.82
- Objective alignment: 3.83
- Multimedia effectiveness: 3.86
- Feedback quality: 3.85

3) Usability and Manipulation Domain

The Usability/Manipulation dimension achieved the highest grand mean of 3.91 (SD = 0.18), "Very High" acceptability. Evaluators confirmed intuitive interface design, minimal navigation complexity requiring limited supervision, effective visual hierarchy, responsive design across devices, and—critically—offline accessibility addressing connectivity limitations prevalent in Philippine public schools[28]. The learner-centered interface design proved particularly effective for Grade 6 age groups[29].

Usability/Manipulation Mean Scores by Indicator:

- Interface clarity: 3.92
- Navigation intuitiveness: 3.93
- Minimal supervision requirement: 3.91
- Visual hierarchy effectiveness: 3.89
- Responsive design: 3.90
- Offline accessibility: 3.92

4) Technical Quality Domain

The Technical Quality dimension achieved a grand mean of 3.82 (SD = 0.22), "Very High" acceptability. Teacher-experts confirmed: stable performance without crashes or errors, efficient loading speeds, compatibility across Android device types, reliable offline functionality, secure data protection, and compatibility with existing school technology infrastructure[30]. These technical validations address critical deployment concerns in resource-limited settings[31].

Technical Quality Mean Scores by Indicator:

- System stability: 3.84
- Loading speed: 3.80
- Device compatibility: 3.81
- Offline functionality: 3.84
- Data security: 3.82
- Infrastructure compatibility: 3.81

Overall Acceptability: The comprehensive evaluation yielded a grand mean of 3.88 across all dimensions, indicating very high acceptability and confirming the Android-based SIM's suitability for classroom implementation. This result surpasses previous digital SIM evaluations in Philippine contexts[32].

D. Integration and Implementation Framework

The integration strategy comprised two phases:

Phase 1—Teacher Empowerment: Orientation and hands-on workshops trained Science teachers in Tudlo Editor usage, including AI-based question generation, customization, and HTML export. This approach addresses the longstanding need for contextualized, accurate instructional materials while supporting DepEd's mandate for localized resource development[33].

Phase 2—Classroom Implementation: The Android-based SIM was integrated into lesson

plans, remediation sessions, and enrichment activities targeting the identified least-mastered competency. Previous research confirmed that integrating technology-based interventions directly into curriculum structures ensures sustainable adoption and maximizes impact[34].

Collaboration among teachers, ICT coordinators, and curriculum implementers proved essential for successful integration, ensuring the SIM complemented existing instructional strategies and promoted learner-centered innovation.

E. Intellectual Property Protection Framework

The developed system qualifies for multi-layered intellectual property (IP) protection:

1) Copyright Protection: Automatic protection applies to original software code and creative works (lesson narratives, interactive quizzes, illustrations) fixed in tangible medium. Registration through the Intellectual Property Office of the Philippines (IPOPHL) establishes legal ownership presumption and enhances enforceability[35].

2) Patent Protection: Novel algorithmic processes including AI-assisted content generation, offline database synchronization via IndexedDB/Firebase, and adaptive feedback mechanisms may satisfy patentability criteria (novelty, inventive step, industrial applicability) following IPOPHL evaluation. Copyright remains the most reliable protection, with patents serving supplementary roles[36].

3) Industrial Design Protection: The UI design encompasses original aesthetic and functional aspects—visual layout, interactive element arrangement, iconography, and overall system appearance. Registration prevents unauthorized copying or imitation of the system's distinctive visual identity[37].

4) Trademark Protection: Distinctive branding elements ("Tudlo Editor," "Ninja Quest," associated logos) secure exclusive use rights in educational technology sectors, preventing unauthorized third-party use[38].

This multi-layered approach protects developer rights, encourages ethical dissemination, and supports long-term sustainability and potential commercialization within the Philippine educational technology landscape.

IV. IMPLICATIONS AND RECOMMENDATIONS

A. Pedagogical and Policy Implications

The study demonstrates that systematic integration of AI-assisted authoring, gamified instruction, and mobile technologies can effectively address persistent learning gaps in science education. The findings provide empirical evidence supporting policy initiatives promoting technology integration in curriculum implementation. For administrators and policymakers, results affirm that investing in teacher-capacity development and learning resource infrastructure yields measurable returns in instructional material quality and student learning outcomes.

B. Recommendations for Stakeholders

1) Department of Education: Formally adopt the Android-based SIM as supplemental learning material for Grade 6 Science. Integrate the Tudlo Editor within Learning Resource Development efforts to empower teachers as content creators, aligning with strategic objectives for digital transformation and equitable educational access.

2) Schools and Division Offices: Conduct capacity-building initiatives including seminars, workshops, and Learning Action Cells equipping teachers with AI-assisted content development skills, gamified instructional strategies, and mobile learning technology proficiency. Establish continuous feedback mechanisms monitoring implementation and enabling iterative improvement.

3) School Administrators and LGUs: Ensure adequate ICT infrastructure (Android-compatible devices, reliable connectivity, offline content delivery systems). Formally embed the Android-based SIM into Grade 6 Science curricula, remediation programs, and enrichment activities. Designate dedicated ICT coordinators for technical maintenance and system updates.

4) IP and Research Community: Pursue comprehensive IP protections (copyright registration, patent evaluation, industrial design

safeguards, trademark registration) for the Android-based SIM and Tudlo Editor. Establish institutional repositories enabling ethical dissemination, commercialization opportunities, and sustainable long-term adoption.

5) Researchers and Developers: Conduct longitudinal studies measuring learner performance improvements and engagement changes. Explore Tudlo Editor adaptability across other subject areas and grade levels. Investigate integration of advanced AI models (large language models, computer vision) for enhanced content generation and learner analytics.

V. CONCLUSION

This study successfully designed, developed, and evaluated an innovative Android-based Strategic Intervention Material addressing least-mastered competencies in Grade 6 Science. The Tudlo Editor platform demonstrated that AI-assisted authoring can democratize instructional material development, enabling teachers to create pedagogically sound, technically robust, and engaging learning resources. Expert evaluation confirmed very high acceptability (grand mean 3.88) across content, instructional, usability, and technical dimensions, establishing the material as suitable for widespread classroom implementation.

The Android-based SIM exemplifies how contemporary educational technologies can support inclusive, engaging, and effective science learning in resource-constrained Philippine public schools. By integrating gamified narratives, multimedia elements, and offline accessibility, the platform addresses both pedagogical and practical constraints hindering science education quality. The proposed multi-layered IP protection framework ensures developer rights protection while supporting sustainable dissemination and potential commercialization.

As the Philippines advances its digital transformation agenda in education, innovations like the Tudlo Editor and Android-based SIM demonstrate the feasibility and impact of technology-mediated instructional improvement. Future research extending these approaches across curricula and exploring advanced AI integration will further advance the field.

ACKNOWLEDGMENT

The author acknowledges the Department of Education—Division of Davao City for institutional support, participating school administrators and Science teachers for their collaborative engagement, and the University of Immaculate Conception Graduate School for research oversight and ethical guidance.

REFERENCES

[1] National Research Council, "A framework for K-12 science education: Practices, crosscutting concepts, and core ideas," National Academies Press, Washington, DC, 2012.

[2] Gusti, M., Hartini, S., & Supriyadi. (2023). "Challenges in science education: A comparative analysis of developed and developing countries," *International Journal of Science Education*, 45(12), 2156-2174.

[3] OECD, "PISA 2018 Results (Volume I): What students know and can do," OECD Publishing, 2019. https://doi.org/10.1787/5f07c754-en

[4] Mupa, P., Chinembiri, T. K., & Mutambudzidzo, O. (2015). "The role of instructional materials in science education," *Journal of Education and Practice*, 6(15), 142-151.

[5] Gronseth, S. L., Brush, T. A., Ottenbruch, M., & Soine, K. (2021). "Teacher readiness to integrate mobile learning in K-12 classrooms: A regional study," *Technology, Knowledge and Learning*, 15(3), 401-418.

[6] UNESCO, "Global monitoring report on education: Building resilience during times of uncertainty," UNESCO Press, Paris, 2021.

[7] Tan, C. (2019). "The Southeast Asia educational excellence model: Policy implications from Singapore and South Korea," *Comparative Education Review*, 63(2), 234-252.

[8] Spindelman, D. (2023). "Investing in foundational skills first: A case from South Korea," *RISE Brief*, NBER Working Paper. https://doi.org/10.35489/bsg-rise-ri2023052

[9] Tan, C. (2019). "Singapore's mathematics curriculum: History, policy and practice," *Journal of Curriculum Studies*, 48(3), 349-369.

[10] Acedillo, R., Lagahit, J., Macusang, A., & Bacatan, J. (2022). "Students and teachers' perception of the effectiveness of using strategic intervention material in science," *International Journal of Research and Innovation in Social*

Science, 6(3), 60-68. https://doi.org/10.47772/IJRISS.2022.6304
[11] Villar, A., Gabriel, E., & Farin, E. (2022). "Academic performance of grade V pupils using science strategic intervention material in Zambales, Philippines," *Asian Journal of Education and Social Studies*, 33, 27-35. https://doi.org/10.9734/ajess2022v33i130783
[12] Romero, M. L. (2021). "Development and evaluation of strategic intervention material for grade 6 science: Focus on techniques in separating mixtures," *Davao City Education Journal*, 12(2), 156-172.
[13] Crompton, H., & Burke, D. (2018). "The use of mobile learning in higher education: A systematic review," *Computers & Education*, 123, 53-64.
[14] Cheung, A. C., & Slavin, R. E. (2013). "Effects of educational technology applications on reading outcomes for struggling readers: A best-evidence synthesis," *Reading Research Quarterly*, 48(3), 277-299.
[15] Paivio, A. (1971). "Imagery and verbal processes," Holt, Rinehart and Winston, New York.
[16] Pujeda, J. R. A. (2025). "Development and evaluation of an Android-based strategic intervention material for science 6," *Doctoral Dissertation*, University of the Immaculate Conception.
[17] Van Teijlingen, E. R., & Hundley, V. (2001). "The importance of pilot studies," *Social Research Update*, 35, 1-4.
[18] Republic Act No. 10173, "Data Privacy Act of 2012," Official Gazette of the Philippines, 2012.
[19] Dumdumaya, V., Santos, M., & Reyes, P. (2024). "Effect of strategic intervention materials on the learning competencies of learners in science 6," *International Journal of Innovative Teaching and Learning Research*, 7(1), 112-128.
[20] Verano, F. C., Comighud, S. M. T. (2020). "Level of science achievement: Basis for the production of strategic intervention materials," *UBT International Conference Proceedings*, 260, 1-12.
[21] Arpilleda, M. C. (2021). "Strategic intervention materials in science education: Development and evaluation practices," *Journal of Educational Technology & Society*, 24(3), 198-215.
[22] Department of Education, "DepEd Order No. 42, Series 2016: Policy guidelines on the K to 12 curriculum," DepEd, Philippines, 2016.
[23] Arpilleda, M. C. (2021). "Strategic intervention materials in science education: Development and evaluation practices," *Journal of Educational Technology & Society*, 24(3), 198-215.
[24] Dumdumaya, V., Santos, M., & Reyes, P. (2024). "Effect of strategic intervention materials on the learning competencies of learners in science 6," *International Journal of Innovative Teaching and Learning Research*, 7(1), 112-128.
[25] Ayu, S. P., Ridwan, A., & Amalina, F. (2021). "Designing interactive multimedia learning environment to enhance students' learning motivation," *International Journal of Interactive Mobile Technologies*, 15(4), 4-18.
[26] Ayu, S. P., Ridwan, A., & Amalina, F. (2021). "Designing interactive multimedia learning environment to enhance students' learning motivation," *International Journal of Interactive Mobile Technologies*, 15(4), 4-18.
[27] Ristika, A., Prasetya, Y., & Sudrajat, E. (2020). "Gamification in learning design: Promoting student engagement and retention," *Journal of Educational Technology and Innovation*, 6(2), 157-171.
[28] Weng, F., Ho, H.-J., Yang, R.-J., & Weng, C.-H. (2019). "The influence of learning style on learning attitude with multimedia teaching materials," *Eurasia Journal of Mathematics, Science and Technology Education*, 15(1), em1659. https://doi.org/10.29333/ejmste.100389
[29] Cheung, A. C., & Slavin, R. E. (2013). "Effects of educational technology applications on reading outcomes for struggling readers: A best-evidence synthesis," *Reading Research Quarterly*, 48(3), 277-299.
[30] Haleem, A., Javaid, M., & Qadri, M. A. (2022). "Understanding the role of digital technologies in education: A review," *Sustainable Operations and Computers*, 3, 275-285.
[31] Statista Search Department, "Number of smartphone users in the Philippines from 2020 to 2029," Statista, 2024. https://www.statista.com/statistics/467186/forecast-of-smartphone-users-in-the-philippines
[32] Sumandala, A. H., & De Gracia, R. S. (2023). "Utilization of electronic strategic intervention material (E-SIM) in teaching general biology for STEM students," *International Journal of Research Publication and Reviews*, 4(10), 1061-1070.

ISSN: **3107-6513**

[33] Rice, K. L., & Ortiz, K. R. (2021). "Strategic use of instructional materials in online and blended learning," *Computers & Education*, 167, 104-118.
[34] Wang, E. L., Tuma, A. P., Lawrence, R. A., Kaufman, J. H., Woo, A., & Henry, D. (2021). "School leaders' role in selecting and supporting teachers' use of instructional materials: An interview study," *RAND Corporation Report*, RR-1344.
https://www.rand.org/pubs/research_reports/RRA134-9.html
[35] Guadamuz, A. (2006). "The public domain and the Commons: The question of public ownership in the digital age," *First Monday*, 11(5). https://doi.org/10.5210/fm.v11i5.1332
[36] Al-Madhoun, I., & Kabir, A. (2023). "Software patentability in the digital economy: Challenges and opportunities," *Journal of Intellectual Property Law*, 29(1), 45-68.
[37] World Intellectual Property Organization, "WIPO Intellectual Property Handbook," WIPO Publishing, Geneva, 2004.
[38] World Intellectual Property Organization, "Trademark guidelines and procedures," WIPO Publishing, Geneva, 2024.