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Quest-based Learning for KSSM Physics of Android: Godot Design and User Acceptance Study

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ABSTRACT

This paper presents the design, development, and evaluation of a quest-based mobile game engineered to enhance the learning experience of KSSM Physics for high school students. Existing physics learning games often lack in-depth conceptual explanations, primarily targeting basic concepts for younger audiences. To address this gap, conceptual learning is integrated with engaging puzzles aligned with KSSM Form 4 and Form 5 Physics topics, such as force, motion, and electromagnetism. Adopting a quest-based learning model, the game immerses players in a narrative-driven adventure where physics concepts are interwoven with the storyline, requiring them to solve related tasks and puzzles to progress. Development utilised the Godot game engine to create an accessible Android mobile game tailored for Malaysian secondary students aged 15-17. The methodology followed a DevOps model, ensuring a streamlined and efficient development cycle. The performance of the educational game was rigorously evaluated through functionality and usability testing. Functionality tests confirmed that the game operated as intended, while usability tests involving high school students yielded positive feedback and satisfaction with the overall gameplay. These results suggest that the quest-based learning model effectively structures educational content, provides engaging tasks, goals, and rewards that motivate students to progress, and creates a more enjoyable learning experience. This work contributes an effective approach to making KSSM Physics more engaging, understandable, and enjoyable through an educational mobile game.

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1. INTRODUCTION

Malaysian secondary Physics education under KSSM struggles with students' ability to connect formulas to real-world intuition, especially in topics such as Newton's laws, momentum, and electromagnetism. Malaysian secondary Physics, under the 'Kurikulum Standard Sekolah Menengah' (KSSM), emphasises conceptual understanding, scientific inquiry, and the application of principles to authentic contexts. Yet, many students struggle to connect formulas, textbook diagrams, and real-world intuition, particularly across topics such as Newton's laws, momentum, and electromagnetism (Soleha et al., 2025). While game-based learning (GBL) offers motivational benefits, many existing physics-themed mobile games fall short due to prioritising entertainment over explicit conceptual instruction, poor alignment with KSSM curriculum and terminology, shallow scaffolding that offers binary feedback, and practical issues like high device specifications or internet connectivity (Rye et al., 2025; Bandewar, 2025). Methodological gaps in research also show limited evidence of conceptual transfer and a lack of embedded micro-lessons or telemetry for teachers (Saxena & Parivara, 2025). Additionally, local language support and culturally relevant contexts are often missing. This project addresses these needs by developing a quest-based mobile game for KSSM Physics (Form 4 and 5), focusing on force, motion, and electromagnetism. Its objectives include identifying a suitable GBL approach, constructing a robust educational game, and evaluating its performance. The study aims to advance physics game designs through detailed conceptual explanations, engaging story-based elements, and intricate problem-solving challenges, thereby making physics more understandable, relatable, and enjoyable for Malaysian students and enhancing their problem-solving skills within the KSSM curriculum.

2. BACKGROUND AND RELATED WORK

Game-based learning consistently boosts motivation and engagement, but its effectiveness in learning outcomes hinges on strong instructional alignment and well-designed feedback. Meta-analyses in STEM fields suggest that games offer the most reliable conceptual benefits when they incorporate explicit guidance, worked examples, and formative feedback, rather than relying solely on discovery (Arztmann et al.,2022). In physics, specific mechanisms, such as visualisations that externalise invisible quantities (e.g., forces, fields) and opportunities to manipulate parameters, are crucial for supporting the formation of robust mental models (Low, 2025). Within the GBL design space, quest-based or mission-structured approaches are effective for scaffolding complexity while maintaining engagement. Studies indicate that clear goals, progressive difficulty, and micro-rewards in branching quest structures can reduce cognitive overload and help learners connect immediate actions to long-term learning objectives. However, it's crucial to avoid poorly designed quest chains that might lead to mere goal-chasing without genuine reflection, especially when feedback is binary (win/lose) or when hints simply reveal answers rather than diagnose misconceptions (Sun et al., 2023). Interactive simulations and microworlds in physics education, particularly when paired with expository explanations, prediction-observation-explanation cycles, and reflective prompts, have been shown to promote conceptual change, whereas purely puzzle-driven games can foster superficial trial-and-error without deep understanding (Horvath & Pietriková, 2023).

The mobile learning context emphasises accessibility, short practice bursts, and integration with classroom routines, while also presenting challenges such as limited screen real estate and device heterogeneity (Shortt et al., 2023). For secondary STEM education in Southeast Asia, crucial factors for adoption include offline access, modest hardware requirements, and minimal setup time. Furthermore, alignment with local curricula (e.g., Malaysia's KSSM), bilingual interfaces, and teacher-ready materials are vital for sustained classroom use. Recent research also highlights the importance of assessment through telemetry (e.g., time-to-solution, hint usage) to infer misconceptions and provide targeted scaffolds (Low et al.,2024). Usability studies for secondary learners recommend simple controls, consistent iconography, minimal text, and accessibility features like high-contrast UIs and captioned audio, especially for smartphone-based learning (Daud et al., 2024; Fante, 2024). This collective understanding points to key design imperatives for physics GBL: coupling interactive tasks with concise explanations, structuring play through quests, providing diagnostic feedback, aligning with local contexts, and prioritising mobile-first usability for school deployment.

3. METHODOLOGY

The development of the quest-based mobile game for KSSM Physics adhered to a DevOps-inspired (Jayakody & Wijayanayake, 2025), iterative lifecycle, designed to facilitate continuous integration and provide rapid feedback directly on target devices. This workflow, as shown in Fig. 1, systematically progresses through five recurring phases: ideation and story, concept and design, technical analysis, development, testing and iteration.

Fig. 1 *DevOps-inspired development workflow*

3.1 Ideation and Story

Project goals, target learners, and curricular scope were defined in this phase. The experience was framed as a quest-based mobile game for KSSM Physics (Form 4–5), delivered as an offline-first Android app. Narrative scaffolding established a parallel-world setting in which progress depends on solving physics-grounded tasks, supported by a non-player character (NPC) mentor who provides micro-lessons and reflective prompts. Topic coverage prioritised mechanics (force, motion, momentum) and introductory electromagnetism to represent both dynamics and fields, ensuring immediate curricular relevance and manageable production scope.

Table 1
Concept mechanic mapping for KSSM physics quests

KSSM Topic	Physics Concept	Game Mechanic	Learning Outcome	Quest
Force & Motion	Newton's First Law (Inertia)	Push the heavy cart to overcome the rest	Explain inertia and unbalanced force	Quest 1
Momentum	Acceleration & Collision	Adjust cart acceleration to break the barrier	Relate momentum and force	Quest 2
Electromagnetism	Magnetic field direction	Rotate the conductor to open the gate	Predict motion due to magnetic forces	Quest 3

3.2 Concept and Design

Learning objectives were translated into playable interactions using a structured content-authoring protocol designed to support a quest-based learning framework. For each targeted concept, the authoring pipeline comprised

(i) a concise micro-lesson script,
(ii) an interaction sketch translating the concept into manipulable parameters, and
(iii) a puzzle specification detailing success criteria, common failure modes, and tiered hinting, as depicted in Fig. 2.

A concept–mechanic matrix, as shown in Table 1, ensured that game actions such as push, time, orient, and tune magnitude mapped to the intended mental models (e.g., net force, change in momentum, field direction). Representative quests included inertia (apply an unbalanced force to move a heavy cart), momentum/acceleration (tune acceleration to overcome a barrier), and electromagnetism (manipulate current/field direction to unlock a magnetically sealed gate). Interface design emphasised Malay-first text, high-contrast iconography, and progressive tutorial prompts to minimise split attention on small screens; audio cues were optional and mirrored visually.

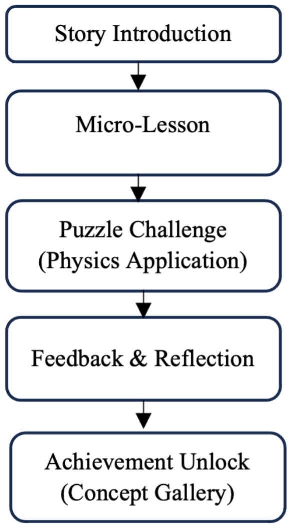

Fig. 2 *In-game learning flow for a quest episode*

3.3 Technical Analysis

Feasibility and performance budgets were defined for mid-range Android devices (e.g., Snapdragon 7xx-class), with targets of ≤50 ms input latency and a stable 60 FPS. The application architecture was formalised in Godot 4 (GDScript) using a 2D scene component approach. Core services such as GameState, UIManager, and AudioManager were exposed as autoload singletons to centralise state, UI routing, and audio buses. Gameplay entities were composed of nodes such as CharacterBody2D (player movement) and Area2D (interaction volumes), with behaviour coordinated via signals to decouple the interface, logic, and scene transitions. Physics relied on Godot's 2D engine with a 60 Hz timestep target. The key parameters (e.g., friction, acceleration thresholds) were exposed as exported variables for design-time tuning. Assets (sprites, tilemaps), save and load via the platform user, and centralised UI strings were selected to support an offline-first deployment with Malay-first localisation and a planned English toggle. Planned analytics hooks defined non-identifying events such as hint requests, failure reasons, and time-to-solution.

3.4 Development

The application employs a scene-component architecture within Godot 4 using GDScript, with core functionalities managed by autoloaded singletons for global state, UI, and audio. Game entities encapsulate behaviours via scripts attached to nodes (e.g., CharacterBody2D for movement; Area2D for triggers), while a lightweight finite-state machine controls state transitions to enable deterministic control and simplify testing. Physics interactions leverage Godot's 2D engine at a 60 Hz timestep, with tuned parameters for predictable motion, and electromagnetism scenarios visualise field directions and force vectors to aid understanding. The interface prioritises Malay-first text with planned English toggles, high-contrast icons, progressive tutorial disclosure, and optional audio cues, all supported by centralised language strings for streamlined localisation. The game's narrative immerses players in a parallel world where progress is driven by physics-based quests, guided by an NPC mentor, and completed quests unlock achievement artefacts to reinforce concepts. Representative quests (e.g., Inertia, Momentum, Electromagnetism) integrate micro-lessons with puzzles operationalising target principles, supported by tiered hints. The implementation stack comprises Godot 4 (2D), GDScript, and modular .tscn scenes, featuring touch-first controls, music/SFX toggles, persistent save/load, and mobile-optimised assets. The Android export pipeline generates offline-first builds (APK/AAB) for reliable school deployment, and planned analytics hooks will capture non-identifying events for future teacher dashboards.

3.5 Testing and Iteration

Each sprint concluded with hallway playtests and structured defect triage. Functional verification followed predefined test cases: application launch and return-to-foreground; main-menu navigation and scene transitions; save/load integrity; audio toggles with icon synchronisation; joystick and action-button responsiveness; and stability over typical play sessions. Outcomes were logged against acceptance criteria to prioritise fixes. User acceptance testing involved upper-secondary students (ages 15–17) in ~60-minute guided sessions, followed by a 5-point Likert questionnaire on Perceived Usefulness, Ease of Use, and Satisfaction. Descriptive summaries of item/construct responses, alongside observations of navigation issues, error recovery, and hint usage, informed iterative refinements to controls, prompts, and puzzle difficulty.

4. RESULT AND DISCUSSION

The functionality testing phase confirmed the intended operation of the quest-based mobile game for KSSM Physics. This involved rigorous application of test cases to verify each game function and feature, assessing system reactions across anticipated and unexpected scenarios, response times, and overall reliability. Identified errors were promptly rectified, followed by re-testing to ensure quality improvements. The successful completion of these tests demonstrated that the game's core mechanics, including puzzle interactions for the First Law of Motion, Second Law of Motion, and electromagnetism, were robust and fully operational.

Usability testing, conducted with Malaysian high school students aged 15-17, utilised a User Acceptance Test approach, in which participants tested a beta version and provided feedback via a Malay-language Google Form questionnaire with a five-point Likert scale. Overall, the testing yielded positive results, as summarised in Table 2. For Perceived Usefulness, the game achieved a mean score of 4.6, indicating that participants gained a better understanding of physics concepts. Ease of Use registered a mean score of 4.4, suggesting that controls and the user interface were easy to learn. Satisfaction was high, with a mean score of 4.5, reflecting fun gameplay and a clear storyline. This led to an Overall Acceptance mean score of 4.5, signifying a positive learner response.

Table 1
Concept mechanic mapping for KSSM physics quests

Evaluation Aspect	Mean Score	Remarks
Perceived Usefulness	4.6	Enhanced understanding of physics concepts
Ease of Use	4.4	Controls and UI easy to learn
Satisfaction	4.5	Fun gameplay and clear storyline
Overall Acceptance	4.5	Positive learner response

While detailed feedback showed varied results for specific items, such as 75% of respondents being unsure about the game's ability to provide awareness of Physics concepts, a strong consensus emerged regarding its ability to highlight the importance of Physics in daily life (100% agreement) and help in understanding concepts (75% strongly agreed, 25% agreed). Perceived ease of use was notably high, with 100% strongly agreeing that the game controls were effective and the user interface was simple and easy to understand. An example of the game's intuitive interface is depicted in Fig.3. User satisfaction was also high, with 75% having fun and finding the storyline interesting, and 100% strongly agreeing that "Pengembaraan Fizik" was overall interesting and satisfying, further supporting the effectiveness of the quest-based learning model. Thus, while there's an opportunity to enhance the explicit presentation of core physics concepts, the game effectively engages students and provides an enjoyable, easy-to-use platform for KSSM Physics learning through its quest-based model and engaging narrative.

Fig. 3 *Few Interfaces of "Pengembaraan Fizik" Game*

5. CONCLUSION

The project successfully developed and evaluated a quest-based mobile game designed to enhance KSSM Physics learning for high school students. This initiative addressed identified gaps in existing physics educational games by integrating core physics concepts, specifically force and motion, and electromagnetism, into an engaging adventure gameplay with narrative elements. The selected quest-based model proved effective in structuring educational content and fostering an enjoyable learning experience through motivating tasks, goals, and rewards. Rigorous evaluation, encompassing both functionality and usability testing, affirmed the game's operational integrity and positive reception. Functionality tests confirmed all game features operated as intended, while a user acceptance test with high school students yielded positive feedback. This testing highlighted the game's success in achieving user satisfaction and educational objectives, underscoring the efficacy of the quest-based learning approach in promoting student engagement and interest in physics. Despite its successes, the project encountered several limitations, including a focused scope on a few physics topics, a specific target age group, and constraints related to time, resources, and graphic design. These limitations occasionally led to challenges such as perceived puzzle difficulty due to insufficient in-game guidance. Consequently, future work should prioritise expanding content coverage, enhancing user engagement through advanced graphics and interactive elements, improving in-game instructions, integrating comprehensive feedback and assessment tools, and broadening platform compatibility and language localisation to maximise the game's educational impact.

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8. AUTHOR CONTRIBUTIONS

Khairunnisa Abd Halim handled technical game development and all testing. Norzilah Musa conceived the project, conducted the literature review, and prepared the manuscript. Norzehan Sakamat designed the game's educational content, storyline, quest structure, and physics puzzles. Nurul Hijja Mazlan contributed to usability data analysis, method refinement, and final manuscript review. All authors have read and agreed to the published version of the manuscript

9. CONFLICT OF INTEREST DECLARATION

We certify that the article is the Authors' and Co-Authors' original work. The article has not received prior publication and is not under consideration for publication elsewhere. This research/manuscript has not been submitted for publication, nor has it been published in whole or in part elsewhere. We attest that all Authors have contributed significantly to the work, the validity and legitimacy of the data, and its interpretation for submission to IJELHE.

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During the preparation of this work, the author(s) used [Quillbot] in order to [improve the clarity, grammar and readability of the manuscript]. After using this tool/service, the author(s) reviewed and edited the content as needed and took full responsibility for the publication's content.

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