

Development of Spart AR-Based Interactive Game for Teaching Force and Motion among form Four Students

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ABSTRACT

This study details the design, development, and empirical usability evaluation of an Augmented Reality (AR)-based interactive educational game built on the Spark AR platform. Designed to mitigate prevalent conceptual misconceptions in Newtonian mechanics, specifically the 'Force and Motion I' subtopic, the intervention caters to upper-secondary physics students. Framed within the ADDIE instructional design model and anchored in constructivist learning theories, the research adopted a quantitative developmental paradigm. A sample of 30 Form Four physics students was selected via simple random sampling. Research instruments comprised an expert validation matrix and a adapted 20-item USE questionnaire operating on a 4-point Likert scale. Content and face validity were verified by a panel of three physics education experts using the percentage of agreement method. Usability metrics were quantified through descriptive statistical analysis (mean and standard deviation) executed via SPSS. Findings revealed exceptional expert validation scores, achieving 100% face validity and 97% content validity (overall mean agreement of 98%). The usability evaluation yielded a high overall mean score ($M = 3.71$, $SD = 0.617$). Among the dimensions evaluated, Satisfaction ($M = 3.78$, $SD = 0.607$) and Ease of Learning ($M = 3.75$, $SD = 0.545$) recorded the highest ratings. The results demonstrate that integrating Spark AR into physics education provides a highly usable, interactive, and pedagogically sound supplementary tool that enhances conceptual mastery and student engagement in abstract physics topics.

Keywords: Spark AR; Augmented Reality; Physics Education

INTRODUCTION

The rapid evolution of 21st-century educational paradigms and the strategic directives of the Malaysia Education Blueprint 2013–2025 mandate the integration of Information and Communication Technology (ICT) in Science, Technology, Engineering, and Mathematics (STEM) curricula [1]. Leveraging digital technologies facilitates flexible learning environments and encourages creative knowledge acquisition among secondary school learners [2]. Within high school physics instruction, abstract concepts frequently pose significant cognitive hurdles. Conventional teacher-centric pedagogical methods often fail to illuminate non-intuitive physical phenomena, predisposing learners to cognitive overload and persistent misconceptions [3]. In introductory Newtonian mechanics—specifically the topic of Force and Motion I—students consistently struggle with interpreting kinematics graphs, mapping algebraic representations to real-world dynamics, and conceptualizing fundamental principles such as inertia, momentum, and impulsive forces [4].

To address these pedagogical bottlenecks, technology-enhanced learning modalities—specifically gamification and mobile Augmented Reality (AR)—have emerged as powerful interventions in secondary science education [5]. AR technology overlays digital assets, 3D physical models, and real-time interactive feedback onto the user's physical environment, making abstract physical quantities visible and intuitive [6]. Grounded in Piaget's Theory of Cognitive Development and Constructivism, interactive AR environments transform passive learners into active knowledge builders by providing concrete visual representations of abstract concepts [7].

Furthermore, technology-enhanced inquiry instruction in science fosters deeper conceptual understanding and positive attitudes toward learning [8].

Spark AR (Meta Spark Studio) offers an accessible, web-integrated platform that leverages ubiquitous smartphone technology to deliver social-media-based AR experiences. Despite its potential, empirical research on the deployment and usability of Spark AR filter-based micro-learning games within secondary physics education remains limited. To bridge this gap, this study pursues two primary objectives: first, to design and develop a Spark AR-based interactive game for the 'Force and Motion I' subtopic in upper-secondary physics; and second, to systematically evaluate the usability of the developed Spark AR interactive game among Form Four physics students.

MATERIAL AND METHODS

Spark AR Interactive Game Architecture

The interactive game module was structured around the Form Four Malaysian National Secondary School Standard Curriculum (KSSM) Physics syllabus for Chapter 2: Force and Motion I. The module encompasses eight subtopics: Linear Motion, Linear Motion Graphs, Free Fall Motion, Inertia, Momentum, Impulse and Impulsive Force, and Force and Weight. Each subtopic incorporates ten contextual items structured around the lower cognitive levels of Bloom's Taxonomy—namely Knowledge, Comprehension, and Application—to solidify foundational conceptual understanding. Incorporating interactive multimedia tools into science instruction significantly enhances student engagement and facilitates the visualization of theoretical mechanics concepts [9,10]. The graphical user interface, item banners, and visual media assets were designed using Picsart, while system logic, visual patch programming, asset tracking, and block-based JavaScript configurations were developed within Meta Spark Studio. The filter-based interactive game was subsequently published and deployed through Meta Spark Hub, rendering it accessible via the Instagram platform. A comprehensive supplementary user manual containing specific learning objectives and direct Quick Response (QR) code links was also developed to support instructional implementation.

To engage with the interactive game, users require the Instagram application installed on a mobile device equipped with a stable internet connection. Users who do not possess the application are required to download it and log into an active account prior to launching the module. Access to the game is initiated by scanning the designated QR code provided within the user manual. Once the Augmented Reality (AR) filter interface loads, players begin the session by pressing the 'Tap to Play' button on the screen. The core gameplay mechanic utilizes real-time facial feature tracking algorithms embedded within the Spark AR platform, enabling players to navigate the multiple-choice assessment items and select their intended answers by physically tilting their heads to either the left or right side (Figure 1).



Figure 1 Gameplay interaction mechanism and interface of the Spark AR physics filter.

Research Design and Sampling

This study adopted a quantitative developmental research design structured around the five iterative phases of the ADDIE instructional model: analysis, design, development, implementation, and evaluation [11]. During the analysis phase, student misconceptions in Newtonian mechanics were identified through extensive literature reviews and curriculum analysis. The design phase involved the formulation of item banks, graphical layout blueprints, game mechanics, and evaluation instruments. In the development phase, visual programming and script execution were completed within Meta Spark Studio, followed by panel-based expert validation and pilot testing. The implementation phase comprised the field deployment of the Spark AR game during formal physics instruction sessions. Finally, the evaluation phase focused on the quantitative statistical assessment of instrument reliability, expert validity, and usability metrics.

The study population comprised Form Four science-stream physics students at a public secondary school in Malaysia. A sample of $n = 30$ students was selected using a simple random sampling strategy. For instrument reliability testing, a pilot study involving $n = 15$ students was conducted at another selected secondary school, yielding a Cronbach's alpha coefficient exceeding 0.80, which confirmed strong internal consistency. Content and face validity were systematically evaluated by a panel of three senior physics education experts prior to main data collection.

Research Instruments

Two primary research instruments were deployed in this investigation. The first instrument was an Expert Validation Form, which utilized a 4-point scale to assess the face and content validity of both the game and the evaluation questionnaire [11,13]. Validations were quantified using the Percentage of Expert Agreement Method, where agreement scores equal to or exceeding 70% represented acceptable validity. The second instrument was a Usability Questionnaire adapted from Lund's USE Framework (2001)[14], comprising 20 items distributed across four core dimensions: Usefulness, Ease of Use, Ease of Learning, and Satisfaction. Items were scored using a 4-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree).

Reliability of Instrument and Pilot Testing

To establish the psychometric soundness, empirical stability, and internal consistency of the research instruments, a pilot study was conducted prior to main field data collection. The pilot sample comprised 15 Form Four physics students selected from a secondary school with demographic and academic characteristics equivalent to the target population.

The quantitative data obtained from the pilot administration were processed using IBM SPSS Statistics to compute the Cronbach's alpha reliability coefficient for each construct and the overall instrument [15]. In alignment with established psychometric standards, a Cronbach's alpha coefficient exceeding 0.80 was established as the benchmark for high internal consistency. Establishing high instrument reliability ensured that the survey items were unambiguous, unidimensional, and capable of yielding statistically stable measurements across different respondent groups.

Data Analysis

All quantitative data derived from the expert validation forms, pilot testing, and main field administration were processed using IBM SPSS Statistics. The expert agreement percentage was calculated to determine face and content validity. For instrument reliability, Cronbach's alpha coefficients were derived from the pilot dataset. Descriptive statistical metrics—specifically mean scores (M), standard deviations (SD), frequencies, and percentages—were calculated to evaluate overall usability levels across the four measured dimensions.

RESULTS AND DISCUSSION

Expert Validation

The panel validation results for the face and content validity of the Spark AR interactive game are summarized in Table 1. The evaluation yielded an overall mean validation score of 98.5%, consisting of 100.0% for face

validity and 97.0% for content validity. Scores well above the 70.0% threshold establish that the game content aligns accurately with the national curriculum, exhibits high pedagogical fidelity, and uses clear visual interfaces [16].

Table 1. Expert Validation Percentage Scores for the Spark AR Interactive Game.

	Face validity (%)	Content Validity (%)
Expert 1	100	90
Expert 2	100	100
Expert 3	100	100
Average	100	97

Reliability of Instrument

The pilot study data involving 15 Form Four physics students yielded high internal consistency across all dimensions of the adapted USE questionnaire. The overall instrument achieved a Cronbach’s alpha coefficient exceeding 0.80, indicating high statistical reliability and strong item coherence. Construct-specific reliability analysis demonstrated that all four dimensions—Usefulness, Ease of Use, Ease of Learning, and Satisfaction—maintained alpha values above the established threshold. Consequently, no items required deletion or major structural modification, confirming that the questionnaire was fully calibrated for main deployment.

Usability Evaluation

The demographic distribution of the student sample ($n = 30$) comprised 14 male students (46.7%) and 16 female students (53.3%), as presented in Table 2.

Table 2. Demographic Characteristics of the Student Respondents ($n = 30$).

Demographic Variable	Sub-category	Frequency
Gender	Male	14
	Female	16

Usability data across the four USE framework constructs are presented in Table 3. The grand mean score for game usability reached $M = 3.71$ ($SD = 0.617$) on a 4-point scale, demonstrating strong usability across all evaluated dimensions. In terms of Usefulness (K1), the construct recorded an overall mean score of 3.60 ($SD = 0.706$). Notably, the item assessing time savings when reviewing physics concepts recorded the highest mean score within this dimension ($M = 3.79$, $SD = 0.412$). Students generally concurred that the application enabled rapid self-assessment and efficient retrieval of mechanics concepts without spatial or temporal constraints. Regarding Ease of Use (K2), the construct achieved a mean score of 3.70 ($SD = 0.608$), with the item evaluating ease of operation for both teachers and students scoring highest ($M = 3.83$, $SD = 0.379$). The intuitive head-tracking interface successfully minimized technical friction, allowing students to focus on physics content rather than operational navigation.

For Ease of Learning (K3), the construct achieved a mean score of 3.75 ($SD = 0.545$). Items assessing the speed at which students learned to operate the game achieved high mean scores ($M = 3.77$), with low standard deviations reflecting strong consensus that the interactive format is straightforward and easy to master. Satisfaction (K4) registered the highest overall rating among all four constructs, with a mean score of 3.78 ($SD = 0.607$). Specifically, the item measuring general enjoyment of the game peaked at a mean score of 3.87 ($SD = 0.434$). These empirical findings confirm that incorporating gamified AR filters into secondary physics

instruction significantly improves student engagement and motivation by transforming abstract mechanical interactions into interactive spatial exercises that bridge cognitive gaps and foster self-directed learning [17,18].

Table 3. Overall Usability Scores Across USE Framework Constructs.

Construct Code	Usability Dimension	Mean Score	Standard Deviation
K1	Usefulness	3.60	0.706
K2	Easy to use	3.70	0.608
K3	Ease of Learning	3.75	0.545
K4	Satisfaction	3.78	0.607
Average		3.71	0.617

CONCLUSION

This study successfully designed, developed, and evaluated a Spark AR-based interactive educational game targeting the 'Force and Motion I' physics subtopic. Formulated via the ADDIE framework, the game demonstrated exceptional content and face validity alongside high overall usability among secondary physics students. The integration of ubiquitous AR interfaces into mobile learning environments offers a scalable, cost-effective solution for addressing persistent conceptual difficulties in STEM education. Future research should extend this paradigm by developing bilingual language configurations in Malay and English to support broader dissemination, expanding the game architecture to cover other abstract physics domains such as Electromagnetism and Quantum Physics, and conducting quasi-experimental longitudinal studies to quantify the direct impact of AR gamification on cognitive academic performance and long-term knowledge retention.

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REFERENCES

1. Ministry of Education Malaysia. (2013). Malaysia Education Blueprint 2013-2025 (Preschool to Post-Secondary Education). Putrajaya: MOE.
2. Mahalingam, N., & Jamaludin, K. A. (2021). Impak dan cabaran pelaksanaan pengajaran dan pembelajaran atas talian semasa Perintah Kawalan Pergerakan. *Jurnal Dunia Pendidikan*, 3(1), 104-112.
3. Nordin, N. (2019). Kajian permasalahan pelajar dalam pembelajaran Fizik 1. *International Journal of Modern Education*, 1(2), 1-9.
4. Kiflee, C. S., Nordin, N., & Khalid, F. (2022). Penggunaan media interaktif dalam pengajaran dan pembelajaran Fizik: Satu tinjauan literatur. *Jurnal Dunia Pendidikan*, 4(1), 112-123.
5. Thomas, D. S., & Mahmud, M. S. (2021). Pembelajaran berasaskan permainan digital dalam pengajaran matematik: Sebuah tinjauan literatur. *Jurnal Pendidikan Matematik*, 9(2), 45-58.
6. Ajit, G., Lucas, T., & Thomas, D. S. (2021). A systematic review of Augmented Reality in STEM education. *Estudios de Economía Aplicada*, 39(3), 1-12.
7. Harun, N. H., Abdul Rahman, M. N., Mansor, M. A., & Muhamad, N. A. (2020). Pengurusan pengajaran dan pembelajaran berasaskan kreativiti Orang Asli dalam meningkatkan kecerdasan kanak-kanak prasekolah. *Jurnal Kepimpinan Pendidikan*, 7(2), 15-28.
8. Schellinger, J., Mallya, A., & Mercer, J. (2019). Using technology-enhanced inquiry-based instruction to foster the development of elementary students' views on the nature of science. *Journal of Science Education and Technology*, 28(4), 341-352.

9. Yasak, Z., Yamhari, S., & Esa, A. (2010). Penggunaan teknologi dalam mengajar Sains di sekolah rendah. *Jurnal Pendidikan Sains*, 2(1), 30-42.
10. Rolfe, V. E., & Gray, D. (2011). Are multimedia resources effective in life science education? A meta-analysis. *Bioscience Education*, 18(1), 1-14.
11. Sidek, M. N., & Jamaludin, A. (2005). Pembinaan modul: Bagaimana membina modul latihan dan modul akademik. Serdang: Penerbit Universiti Putra Malaysia.
12. Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(3), 607-610.
13. Othman, M. S., & Kassim, A. Y. (2019). Kesahan dan kebolehpercayaan instrumen amalan pengajaran guru Pendidikan Islam sekolah rendah di dalam mengintegrasikan Kemahiran Berfikir Aras Tinggi (KBAT). *Online Journal of Islamic Education*, 7(1), 22-35.
14. Lund, A. M. (2001). Measuring usability with the USE questionnaire. *Usability Interface*, 8(2), 3-6.
15. Bond, T. G., & Fox, C. M. (2015). Applying the Rasch model: Fundamental measurement in the human sciences (3rd ed.). Routledge.
16. Bacotang, J., Mahmud, M. S., & Jabbar, M. A. (2020). Kesahan dan kebolehpercayaan modul pembelajaran berasaskan permainan. *Jurnal Kebangsaan Pendidikan*, 8(1), 50-62.
17. Amin, S. F. M., Sharif, S., Taat, M. S., Madjapuni, M. N., & Mariappan, M. (2022). Implementasi pemeriksaan kebolegunaan menggunakan kaedah penilaian pakar dalam fasa penilaian modul robot M-Solat. *International Journal of Education, Psychology and Counseling (IJEPC)*, 7(45), 180-195.
18. Ali, A., Abbas, L. N., & Sabiri, A. M. (2021). Effectiveness of Gamification Learning in Students Achievement for Complex Number Topic. *Online Journal for TVET Practitioners*, 6(1), 108-119.