



Usability and Preliminary Learning Outcomes of a Visual Novel Game on the Circulatory System for Grade V Students

Julius Victor Manuel Bata^{1*}, Paelina Charmelita²

^{1,2}Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia

ARTICLE INFO	ABSTRACT
Article history: Submitted: Juny 10, 2026 Final Revised: Juny 25, 2026 Accepted: July 07, 2026 Published: July 31, 2026 Keywords: Circulatory System; Elementary Science Education; Game-Based Learning; System Usability Scale; Visual Novel.	Purpose: This study reports the classroom implementation and student-perceived usability of SIRKULASIKU, a visual novel game developed with the ADDIE model for fifth-grade IPAS (natural science) learning on the human circulatory system, and examines preliminary learning outcomes as indicative evidence of its instructional potential. Methods: A descriptive quantitative design with a one-group pretest–posttest component was used. Eighteen fifth-grade students (aged 10–11) from a private elementary school in Bekasi Regency participated in a single 70-minute session. Usability was measured with the Indonesian adaptation of the System Usability Scale (SUS); learning outcomes were measured with a 10-item multiple-choice test analysed using N-gain and the Wilcoxon signed-rank test. Findings: The mean SUS score was 73.75 (SD = 15.58), within the Good rating, with acceptable internal consistency (Cronbach's $\alpha = 0.78$), and learnability and ease of use as the strongest items. As preliminary single-group evidence, scores rose from 66.11 at pre-test to 90.56 at post-test, giving a mean N-gain of 0.725 (Wilcoxon $W^+ = 153.0$, $p < 0.001$; effect size $r = 0.85$). An exploratory analysis found no significant link between usability and learning gain (Spearman's $\rho = 0.22$, $p = 0.37$). Research Implications: The results offer preliminary, non-causal indications that a simple narrative-driven visual novel can support elementary science learning, and they suggest concrete design refinements, including an embedded tutorial and optional voice narration. Two measurement limitations should be acknowledged: the reliability and item characteristics of the knowledge test could not be assessed because item-level responses were not retained, and the SUS, which was developed for adult populations, may carry interpretive bias when used with children. Originality: This study advances the SIRKULASIKU project from expert-validated design to authentic classroom implementation, and provides a joint evaluations of usability and preliminary learning outcomes for a visual novel on the human circulatory system at the elementary level, an underexamined pairing in Indonesian IPAS research, where usability is rarely treated as a precondition for instructional value.
	
 	Doi: https://doi.org/10.61255/jupiter.v4i3.1338

INTRODUCTION

In Indonesian elementary schools, natural and social science is taught through the integrated IPAS (Ilmu Pengetahuan Alam dan Sosial) subject of the Merdeka Curriculum, which combines science and social studies to foster a holistic, inquiry-based understanding of natural and social phenomena and to strengthen students' scientific literacy and critical and analytical thinking (Waseso et al., 2024). The teaching of biological concepts at the primary level, in particular, aims to enhance students' scientific and biological literacy and to prepare learners to make informed decisions as active citizens (Tzovla & Kedraka, 2020). Among the biological topics in the fifth-grade IPAS curriculum, the human circulatory system occupies a central position: it connects cellular functions to organ-level processes and provides a concrete context for learning about health, homeostasis, and the interdependence of bodily structures (Conceição et al., 2019; Gnidovec et al., 2020). Mastery of this topic is not only required by the national curriculum but is also foundational to students' long-term biological literacy and health awareness.

Despite its curricular importance, the circulatory system is consistently identified as one of the most difficult topics for students to master. Much of this difficulty stems from the abstract and largely invisible nature of internal physiological processes, which cannot be directly observed in the classroom; students consequently struggle with cardiovascular concepts and frequently hold persistent misconceptions, such as viewing blood flow as a single continuous loop (Ittikitpaisarn & Jittivadhna, 2025). Maryani et al. (2018) documented that fifth-grade students in Indonesian elementary schools experience significant learning difficulties with human organ systems, attributing these to the high conceptual complexity of the content and the inadequacy of conventional instructional media. Conversely, structured, activity-based lessons have been shown to improve students' meaningful learning of blood circulation (Cengiz, 2024), indicating the value of moving beyond passive, lecture-based delivery toward more interactive and experiential media. This pedagogical challenge underscores the need for innovative, technology-enhanced learning media for IPAS (Kirana et al., 2025; Yaumi & Rohmah, 2024).

The integration of digital interactive media into elementary IPAS learning has gained considerable momentum. Research in the Indonesian context suggests that interactive digital and augmented reality media can enhance student engagement, motivation, and science concept understanding (Kirana et al., 2025; Yaumi & Rohmah, 2024). Meta-analytic evidence confirms that game-based learning produces significant learning gains relative to non-game conditions across K–16 populations (Clark et al., 2016), with effects extending to early childhood and elementary science contexts (Alotaibi, 2024). Jayanti & Setyasto (2024) demonstrated that a flipbook-based digital medium on the circulatory system for Grade V students produced an N-gain of 0.56 (moderate), while Rahman & Setyasto (2025) reported an N-gain of 0.76 (high) for an augmented reality-assisted e-teaching material on the same topic.

Among digital learning media formats, visual novel games represent a distinctive approach with specific advantages for elementary IPAS instruction. Their sequential narrative structure scaffolds complex content into manageable, interconnected episodes, and their character-driven storytelling helps sustain motivation (Fenici & Mosca, 2023; Gunawan et al., 2026). Prayogi & Prihatin (2024) found that visual novel games improved self-directed learning in elementary IPAS students, while Chau & Nasir (2021) reported improvements in biology learning motivation among secondary students. A survey of educational visual novels has identified a range of design and teaching strategies through which the genre delivers subject matter within an interactive narrative (Camingue et al., 2020). Its characteristic interface conventions: tap-to-advance dialogue, static character illustrations, and a persistent text box, build on familiar interaction patterns, which in principle limits the extraneous cognitive load imposed by the interface. Critically, however, for a visual novel game to deliver instructional value, it must first be usable: when learners must divert cognitive resources to navigating an unfamiliar interface, learning efficiency decreases (Sweller, 1988).

Most of this work, however, evaluates either learning gains or, less often, user experience, and seldom both for the same medium. Usability in particular is rarely treated as a condition for a medium's instructional value rather than a separate concern, and few studies pair the two for a visual novel at the elementary level. The present study addresses that gap. It evaluates SIRKULASIKU, a visual novel developed and expert-validated in an earlier ADDIE study (Charmelita et al., 2024) for fifth-grade IPAS learning on the human circulatory system. The present study constitutes the implementation and evaluation phase, in which usability is the primary focus and learning outcomes are examined as preliminary evidence. It addresses two complementary aspects: (1) student-perceived usability via the System Usability Scale (SUS), and (2) preliminary learning outcomes from a pretest–posttest session, interpreted as indicative evidence of instructional potential rather than proof of effectiveness. The research addresses the following question: How do fifth-grade elementary students perceive the usability of SIRKULASIKU as a visual novel game-based learning medium, and how do they perform on IPAS knowledge of the circulatory system after using it? Because the design is descriptive and exploratory rather than comparative, no directional hypothesis was set; the aim is to characterise usability and initial learning, not to test a predicted effect.

METHOD

Research Design

This study employed a descriptive quantitative design with a one-group pretest–posttest component. The primary aim was to document the classroom implementation and student-perceived usability of SIRKULASIKU in a naturalistic IPAS classroom setting, with learning outcomes examined as preliminary, non-causal evidence. No control group was employed; therefore, all claims regarding learning effects are presented as preliminary and non-causal. This study represents the implementation and evaluation phase of an ADDIE-based development project; the design, development, and expert validation phases have been reported in Charmelita et al. (2024)

The SIRKULASIKU Visual Novel Game

SIRKULASIKU is a narrative-driven visual novel game developed to teach the human circulatory system to fifth-grade students. The game places the player in the role of an elementary school student who must prepare for a biology quiz on the circulatory system. A teacher character guides the player through the material via structured dialogue sequences displayed in a text box at the bottom of the screen. Educational content covering the structures and functions of the heart, blood vessels, and blood is delivered through dialogue supported by illustrations and embedded short educational videos (Figure 1). After the instructional sequences, the player responds to embedded quiz questions to reinforce content. A complete gameplay session lasts approximately 30 minutes. The game was designed to minimise interface complexity, requiring only basic tap or click interactions, with the intent of reducing extraneous cognitive load and ensuring accessibility for students with limited prior gaming experience.

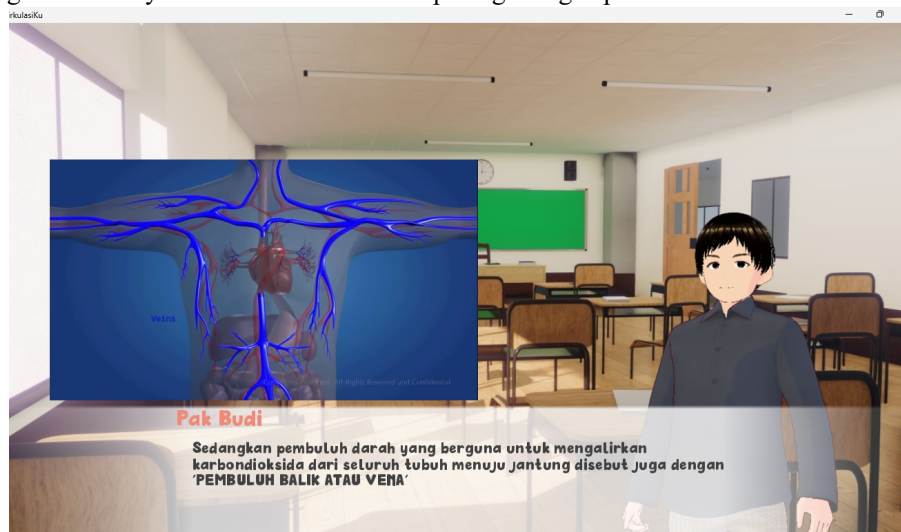


Figure 1. The teacher's character explains the circulatory system

Research Context and Participants

The study was conducted at a private elementary school in Bekasi Regency, West Java, Indonesia. Participants consisted of 18 fifth-grade students (10 male, 56%; 8 female, 44%; aged 10–11 years). All enrolled students in the target class participated using a total sampling technique. The classroom teacher was present throughout the session for instructional oversight and offered informal contextual feedback on the game; this feedback was not collected or analysed as a formal research instrument. School administration approval was obtained prior to data collection.

Instruments

Two main instruments were used. First, a 10-item multiple-choice knowledge test targeting curriculum-aligned factual knowledge of the human circulatory system (structures, functions, and associated health conditions relevant to Grade 5 IPAS); items were reviewed by the classroom IPAS teacher to ensure content validity (Table 1). Each correct response was awarded one point (maximum: 10). Second, the Indonesian adaptation of the System Usability Scale (SUS) (Brooke, 2013; Sharfina & Santoso, 2016) was used to assess perceived usability. The SUS consists of 10 Likert-scale items (1–5) alternating between positively and negatively worded statements, yielding a score from 0 to 100 (Table 2). In this sample its internal consistency was acceptable (Cronbach's $\alpha = 0.78$). Because the SUS was originally validated for adults (Putnam et al., 2020), each item was read aloud and explained by the researcher before students responded. The classroom IPAS teacher also provided informal contextual feedback on the alignment of the game with the Grade 5 IPAS curriculum, though this was not analysed as a formal instrument.

Table 1. Knowledge Assessment Items

Nu.	Question
1	One of the organs responsible for pumping blood throughout the body is
2	Which one is NOT a function of blood?
3	Blood cancer is also known as
4	The largest artery is called
5	The blood vessel carrying blood from the heart to the body is

Nu.	Question
6	The component of blood that eliminates germs is
7	The human circulatory system consists of
8	The vessel transporting CO ₂ -rich blood to the heart is
9	The smallest blood vessels are called
10	The disease caused by a deficiency of red blood cells is

Table 2. Indonesian version of the SUS questionnaire

Nu.	Statement (Indonesian)
1	Saya berpikir akan menggunakan sistem ini lagi
2	Saya merasa sistem ini rumit untuk digunakan
3	Saya merasa sistem ini mudah untuk digunakan
4	Saya membutuhkan bantuan dari orang lain atau teknisi dalam menggunakan sistem ini
5	Saya merasa fitur-fitur sistem ini berjalan dengan semestinya
6	Saya merasa ada banyak hal yang tidak konsisten pada sistem ini
7	Saya merasa orang lain akan memahami cara menggunakan sistem ini dengan cepat
8	Saya merasa sistem ini membingungkan
9	Saya merasa tidak ada hambatan dalam menggunakan sistem ini
10	Saya perlu membiasakan diri terlebih dahulu sebelum menggunakan sistem ini

Data Analysis

Learning outcome data were analysed using the Wilcoxon signed-rank test ($\alpha = 0.05$) following confirmation of non-normality via the Shapiro–Wilk test. The normalised gain (N-gain) was calculated for each student and interpreted using standard criteria: high ($g > 0.70$), medium ($0.30 \leq g \leq 0.70$), and low ($g < 0.30$) (Hake, 1998). The effect size for the Wilcoxon test was reported as $r = z/\sqrt{N}$. SUS scores were calculated and interpreted following standard procedures (Brooke, 1996, 2013), using the adjective rating scale of Bangor et al. (2009), and internal consistency was estimated with Cronbach's α . The relationship between usability and learning gain was examined with Spearman and Pearson correlations. All analyses were conducted using Python with standard statistical libraries.

RESULTS

This study evaluated the learning outcomes and usability of the SIRKULASIKU visual novel game with eighteen fifth-grade students from a private elementary school in Bekasi Regency. As shown in Table 3, the mean pre-test score was 66.11 (SD = 11.95), which increased to 90.56 (SD = 9.38) at post-test. Table 4 presents the individual N-gain scores, yielding a mean N-gain of 0.725 (SD = 0.287; 95% CI [0.582, 0.868]), which falls within the High category according to Hake's criteria. The Wilcoxon signed-rank test confirmed a statistically significant pre–post difference ($W^+ = 153.0$, $p < 0.001$), with a large effect size ($r = z/\sqrt{N} = 0.85$). Nine students achieved high gains, eight achieved medium gains, and one student (STD14) showed no gain.

Table 3. Descriptive statistics for pre-test and post-test scores (N = 18)

Test	N	Min	Max	Mean	SD	95% CI
Pretest	18	50	80	66.11	11.95	[60.17, 72.05]
Post-test	18	70	100	90.56	9.38	[85.89, 95.22]

Table 4. N-gain scores per student (N = 18)

Student	Pretest	Post-test	N-gain	Category
STD01	80	100	1.000	High
STD02	80	100	1.000	High
STD03	70	90	0.667	Medium
STD04	50	90	0.800	High
STD05	70	80	0.333	Medium
STD06	50	100	1.000	High
STD07	50	100	1.000	High
STD08	70	90	0.667	Medium
STD09	60	80	0.500	Medium
STD10	70	90	0.667	Medium

Student	Pretest	Post-test	N-gain	Category
STD11	60	90	0.750	High
STD12	50	70	0.400	Medium
STD13	70	100	1.000	High
STD14	80	80	0.000	Low
STD15	80	100	1.000	High
STD16	70	90	0.667	Medium
STD17	80	100	1.000	High
STD18	50	80	0.600	Medium
Mean	66.11	90.56	0.725	High

The student-perceived usability yielded an overall mean System Usability Scale (SUS) score of 73.75 (SD = 15.58) with a median of 75.00, as shown in Table 5. This falls within the Good rating on the adjective rating scale of Bangor et al. (2009) and exceeds the widely accepted threshold of 68 (Sauro & Lewis, 2016). Internal consistency in this sample was acceptable (Cronbach's $\alpha = 0.78$). Table 6 presents the individual SUS scores and usability categories, showing that three students rated the game Best Imaginable, five Excellent, seven Good, two OK, and one Poor, and twelve of the eighteen students scored above 70.

Table 5. Descriptive statistics for SUS scores (N = 18)

Mean	SD	Median	Q1	Q3	IQR	95% CI
73.75	15.58	75.00	67.5	82.5	15.0	[66.00, 81.50]

Table 6. Individual SUS scores and usability categories (N = 18)

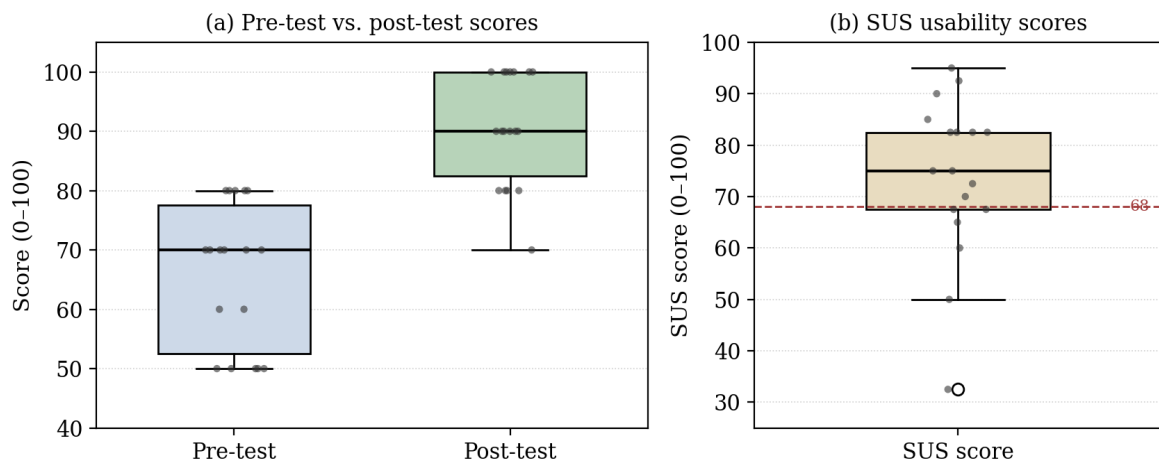
Student	SUS Score	Rating (Bangor et al., 2009)
STD01	82.5	Excellent
STD02	70.0	Good
STD03	60.0	OK
STD04	85.0	Excellent
STD05	67.5	Good
STD06	75.0	Good
STD07	82.5	Excellent
STD08	32.5	Poor
STD09	65.0	Good
STD10	82.5	Excellent
STD11	90.0	Best Imaginable
STD12	82.5	Excellent
STD13	72.5	Good
STD14	67.5	Good
STD15	92.5	Best Imaginable
STD16	95.0	Best Imaginable
STD17	50.0	OK
STD18	75.0	Good
Overall	73.75	Good

Table 7 reports the mean of each SUS item. Because a single item is not a usability construct in its own right, these means are given only as item-level descriptives and are not read as separate dimensions. The most positively rated items concerned ease of learning (item 7, M = 4.39), ease of use (item 3, M = 4.28), and the integration of functions (item 5, M = 4.17). The two negatively worded items on complexity and inconsistency drew correspondingly low scores (item 8, M = 1.78; item 6, M = 1.83), which means students did not find the game confusing. The two weaker points were the need for technical help (item 4, M = 2.06) and the need to get used to the game first (item 10, M = 3.00), both of which point to the start-up phase rather than the interface as a whole.

Table 7. Item-level SUS descriptive statistics (N = 18)

Item	Type	Item content (abbreviated)	Mean	SD
7	+	Others would learn it quickly	4.39	0.70
3	+	Easy to use	4.28	0.75
5	+	Functions well integrated	4.17	0.99
8	–	System cumbersome	1.78	1.00
6	–	Too much inconsistency	1.83	0.99
9	+	Felt confident using it	3.78	1.26
1	+	Would use it again	3.72	1.27
2	–	System complex	2.17	1.15
4	–	Needed technical help	2.06	1.16
10	–	Needed to get used to it	3.00	1.24

Figure 2 summarises both distributions. The post-test box sits well above the pre-test box and the two barely overlap (panel a), while most SUS scores fall above the 68 acceptability line, with one low outlier at 32.5 (panel b).

**Figure 2.** Distribution of (a) pre-test and post-test scores and (b) SUS usability scores (N=18)

DISCUSSION

SIRKULASIKU's mean N-gain of 0.725 falls within the high category and is broadly comparable with results from other digital IPAS media on the same topic in the Indonesian elementary context. The two most directly comparable studies both addressed the human circulatory system for Grade V students: Jayanti & Setyasto (2024) reported an N-gain of 0.56 (moderate) for a Kvisoft flipbook, and Rahman & Setyasto (2025) reported 0.76 (high) for an augmented reality-assisted e-teaching material. Game-based and edugame formats for integrated science at the elementary level have likewise been reported to improve learning achievement (Paradisa & Ratnaningrum, 2025). These studies differ in design, instruments, and length, and no direct comparison was made here. Thus, the parallels are intended solely as contextual benchmarks and do not substantiate any claim of comparative effectiveness or superiority of the visual novel over other media. The single student who showed no gain (STD14) had already scored at the upper end of the pre-test (80) and remained there, a pattern more consistent with a ceiling effect than with a failure of the medium, and a reminder that aggregate gain scores can mask individual starting points.

Several design features plausibly account for the observed engagement and knowledge gains. The visual novel format segments complex circulatory-system content into short, character-driven dialogue units, an arrangement consistent with the segmenting and multimedia principles, under which learners comprehend integrated words and pictures better than words alone and benefit when dense material is broken into learner-paced parts (Mayer, 2020). By keeping interaction minimal and the interface predictable, the format also limits extraneous cognitive load, leaving more working-memory capacity for the material itself (Sweller, 1988). In addition, the quiz questions embedded after each instructional segment function as low-stakes retrieval practice with immediate feedback, design elements associated with engagement and retention in game-based learning (Plass et al., 2015). Consistent with this account, STD08, who recorded the lowest usability score in the session, still achieved a medium N-gain of 0.667, suggesting

that the narrative scaffolding supplied enough contextual support for knowledge acquisition even when interface fluency was limited. These mechanisms are offered as plausible interpretations rather than tested pathways, since the present design isolates neither individual features nor their interaction.

The mean SUS score of 73.75 sits within the Good rating and exceeds the cross-study benchmark of 70.09 that Vlachogianni & Tselios (2022) derived from 104 educational-technology studies, indicating that SIRKULASIKU's usability is competitive with mature educational technology despite being a first-iteration prototype. The item-level profile is internally coherent and diagnostically useful. High ratings on learnability, ease of use, and functional integration, together with low ratings on cumbersomeness and inconsistency, point to an interface that students found clear and predictable. The comparatively less favourable ratings concentrated on two specific items: the need for technical assistance (item 4) and the need for prior familiarisation (item 10). Read together, this pattern locates the weakness in initial onboarding rather than in the coherence of the interface itself: students did not find the system confusing, but a subset needed help getting started. Distinguishing onboarding friction from interface incoherence matters for design, because the two call for very different remedies. The wide spread of individual scores (32.5 to 95.0) is consistent with this reading and likely reflects differences in students' prior experience with digital devices and games, a factor not formally measured here and worth recording directly in future work.

It would be natural to expect that students who found the game easier to use also learned more from it, but the data do not show that. Across the class, SUS scores and N-gains were essentially unrelated (Spearman's $\rho = 0.22$, $p = 0.37$; Pearson's $r = 0.15$, $p = 0.57$). STD08 makes the point again, pairing the lowest usability score (32.5, Poor) with a medium gain of 0.667. Two readings are possible, and they are not exclusive. The sample is small ($n = 18$), and both measures bunch near their ceilings, with most gains high and most SUS scores in the Good-to-Excellent rating, which leaves little spread for a correlation to surface. More substantively, usability may work as a threshold rather than a dial: once a game is usable enough not to get in the way, further gains in perceived usability need not buy further learning. On that reading, good usability earns its place by removing an obstacle, not by lifting outcomes in proportion. Either way, the present design cannot settle the question, and a larger controlled study would be needed to test it directly.

For practice, the findings suggest that a simple, narrative-driven visual novel can be deployed in a regular IPAS lesson with minimal infrastructure, and that most Grade V students can operate it independently after a brief orientation. The onboarding friction identified above, however, has direct practical consequences: in a full classroom a teacher cannot provide simultaneous one-to-one technical support, so the most actionable design response is an embedded interactive tutorial that orients students to the navigation before the science content begins. Optional voice narration for all dialogue would further reduce the reading-fluency demands that may underlie the lowest usability scores, widening access for students with limited literacy. Until learning effectiveness is established under controlled conditions, the medium is best positioned as a supplement that reinforces teacher-led instruction rather than a stand-alone replacement, with the teacher facilitating onboarding and connecting the on-screen content to classroom discussion.

Several limitations qualify these interpretations. The sample was drawn from a single private school in Bekasi Regency, which constrains generalisability to settings with different infrastructure or student demographics. The single-session design cannot establish whether usability perceptions or knowledge gains are stable over time. The SUS was validated for adults, and although each item was read aloud and explained, this is only a partial mitigation of the known limits of self-report usability measures with children (Putnam et al., 2020). For the knowledge test, item-level responses were not retained, so its internal-consistency reliability, item difficulty, and discrimination could not be computed; content validity rested on the class teacher's review. Finally, the design is pre-experimental: the same items were used at pre-test and post-test in one session, which invites a testing effect, and without a control group the gains cannot be attributed to the game. Future research should therefore employ larger and more diverse samples, controlled designs with parallel-form assessments, longitudinal usability measurement across multiple sessions, and qualitative methods such as think-aloud protocols to examine how elementary students actually interact with game-based IPAS media.

CONCLUSION

This study reported the classroom implementation and student-perceived usability of SIRKULASIKU, a visual novel game for fifth-grade IPAS learning on the human circulatory system, and examined its learning outcomes as preliminary evidence. The mean SUS score of 73.75 fell within the Good rating with acceptable reliability ($\alpha = 0.78$), indicating that most fifth-grade students could operate SIRKULASIKU independently in a naturalistic classroom setting; item-level analysis identified learnability and ease of use as usability strengths and the need for technical

assistance and prior familiarisation as actionable design gaps for future development cycles. The pre-post knowledge gain (mean N-gain = 0.725; Wilcoxon $W^+ = 153.0$, $p < 0.001$; $r = 0.85$) is interpreted strictly as preliminary, indicative evidence of instructional potential rather than proof of effectiveness, given the single-group, pre-experimental design with identical pre- and post-test items administered within one session. Additionally, the reliability and item characteristics of the knowledge test could not be examined because item-level responses were not retained, which further tempers the interpretability of the observed learning gains. Usability and learning were assessed as separate constructs, and an exploratory analysis found no significant correlation between them ($\rho = 0.22$); consequently, any causal or conditional linkage remains empirically untested. The contribution is twofold. Practically, the study demonstrates that a low-cost visual novel can be effectively deployed within a standard IPAS lesson and offers developers a concrete direction for refinement, particularly regarding embedded tutorials and optional narration. Theoretically and methodologically, it posits usability as a necessary precondition for a learning medium's pedagogical value rather than an ancillary concern, and proposes the hypothesised usability - learning relationship as a testable framework for future controlled investigations. Subsequent research should pursue controlled experimental evaluations with larger samples, parallel-form assessments, and qualitative methods to establish the learning effectiveness and long-term usability of SIRKULASIKU more definitively.

REFERENCE

- Alotaibi, M. S. (2024). Game-based learning in early childhood education: a systematic review and meta-analysis. *Frontiers in Psychology*, 15. <https://doi.org/10.3389/fpsyg.2024.1307881>
- Bangor, A., Kortum, P., & Miller, J. (2009). Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale. *Journal of Usability Studies*, 4(3), 114–123.
- Brooke, J. (1996). *SUS: A 'Quick and Dirty' Usability Scale*. CRC Press. <https://doi.org/10.1201/9781498710411>
- Brooke, J. (2013). SUS: A Retrospective. *Journal of Usability Studies*, 8(2), 29–40.
- Camingue, J., Melcer, E. F., & Carstendottir, E. (2020). A (Visual) Novel Route to Learning: A Taxonomy of Teaching Strategies in Visual Novels. *International Conference on the Foundations of Digital Games*, 1–13. <https://doi.org/10.1145/3402942.3403004>
- Cengiz, E. (2024). The Effectiveness of a Lesson Taught with a Worksheet on Major and Minor Blood Circulation. *The American Biology Teacher*, 86(7), 420–425. <https://doi.org/10.1525/abt.2024.86.7.420>
- Charmelita, P., Bata, J., & W Pandjaitan, M. L. (2024). Pengembangan Media Interaktif Pada Materi Peredaran Darah Menggunakan Metode ADDIE. *Jurnal Elektro*, 15(2), 83–90. <https://doi.org/10.25170/jurnalelektro.v15i2.5114>
- Chau, K. T., & Nasir, N. A. S. B. A. (2021). The Effect of A Visual Novel Application on Students' Learning Motivation in Biology for Secondary School in Malaysia. *2021 6th International Conference on Multimedia and Image Processing*, 83–88. <https://doi.org/10.1145/3449388.3449399>
- Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis. *Review of Educational Research*, 86(1), 79–122. <https://doi.org/10.3102/0034654315582065>
- Conceição, K., Lemos, R., Fiuza, P., Cechinel, C., & Rudolph, C. (2019). Serious Game for the Cardiovascular System Anatomy. *International Journal for Innovation Education and Research*, 7(12), 115–128. <https://doi.org/10.31686/ijier.vol7.iss12.2018>
- Fenici, M., & Mosca, I. (2023). Gamebooks and branching narratives in education: fostering sustainability competences to promote positive social change. *Frontiers in Education*, 8. <https://doi.org/10.3389/feduc.2023.1335605>
- Gnidovec, T., Žemlja, M., Dolenc, A., & Torkar, G. (2020). Using Augmented Reality and the Structure–Behavior–Function Model to Teach Lower Secondary School Students about the Human Circulatory System. *Journal of Science Education and Technology*, 29(6), 774–784. <https://doi.org/10.1007/s10956-020-09850-8>
- Gunawan, E., Theodora, C. F., Bachtar, B. M., Masse, A. F. H., Biring, G. J., & Prasetyo, H. D. (2026). Visual novel game as a new breakthrough in dental health education media for stunted children in Indonesia. *Journal of Clinical Pediatric Dentistry*, 50(1), 245–254. <https://doi.org/10.22514/jocpd.2026.023>
- Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1), 64–74. <https://doi.org/10.1119/1.18809>
- Ittikitpaisarn, V., & Jittivadhna, K. (2025). Building connections: promoting meaningful learning of the human circulatory system through leading questions. *Advances in Physiology Education*, 49(3), 749–757. <https://doi.org/10.1152/advan.00053.2025>

- Jayanti, W., & Setyasto, N. (2024). Development of Kvisoft-Based Flipbook Learning Media on Learning Outcomes in Natural Sciences on the Human Circulatory System. *Jurnal Penelitian Pendidikan IPA*, 10(5), 2511–2520. <https://doi.org/10.29303/jppipa.v10i5.7025>
- Kirana, C. R., Sopandi, W., Sujana, A., & Febrialita Salma Dwinandha Putri. (2025). Transformation of Elementary Science Education through the RADEC Model and Digital Learning Based on Augmented Reality for Human Digestive System. *International Journal of Elementary Education*, 9(1), 30–37. <https://doi.org/10.23887/ijee.v9i1.87630>
- Maryani, I., Husna, N. N., Wangid, M. N., Mustadi, A., & Vahechart, R. (2018). Learning Difficulties of the 5th Grade Elementary School Students in Learning Human and Animal Body Organs. *Jurnal Pendidikan IPA Indonesia*, 7(1), 96–105. <https://doi.org/10.15294/jpii.v7i1.11269>
- Mayer, R. (2020). *Multimedia Learning*. Cambridge University Press. <https://doi.org/10.1017/9781316941355>
- Paradisa, F. C., & Ratnaningrum, I. (2025). Nature Ninja Edugame as an interactive learning solution for improving integrated science and social studies learning achievement in primary school. *Indonesian Journal of Science and Mathematics Education*, 8(1), 170. <https://doi.org/10.24042/ij sme.v8i1.26292>
- Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of Game-Based Learning. *Educational Psychologist*, 50(4), 258–283. <https://doi.org/10.1080/00461520.2015.1122533>
- Prayogi, M. D., & Prihatin, T. (2024). Improving Students' self-directed learning through visual novel games: its effectiveness and potential. *Indonesian Journal of Curriculum and Educational Technology Studies*, 12(1), 45–56. <https://doi.org/10.15294/ijcets.v12i1.15307>
- Putnam, C., Puthenmadom, M., Cuerdo, M. A., Wang, W., & Paul, N. (2020). Adaptation of the System Usability Scale for User Testing with Children. *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–7. <https://doi.org/10.1145/3334480.3382840>
- Rahman, T. A., & Setyasto, N. (2025). E-Learning Materials Assisted by Augmented Reality in the Subject of Natural Sciences, Circulatory System Material for Grade V Elementary School. *Jurnal Penelitian Pendidikan IPA*, 11(2), 1079–1092. <https://doi.org/10.29303/jppipa.v11i2.10318>
- Sauro, J., & Lewis, J. R. (2016). *Quantifying the User Experience: Practical Statistics for User Research*. Elsevier.
- Sharfina, Z., & Santoso, H. B. (2016). An Indonesian adaptation of the System Usability Scale (SUS). 2016 *International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, 145–148. <https://doi.org/10.1109/ICACSIS.2016.7872776>
- Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. *Cognitive Science*, 12(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4
- Tzovla, E., & Kedraka, K. (2020). Teaching Biology in Primary Education. *International Journal of Educational Technology and Learning*, 8(2), 91–97. <https://doi.org/10.20448/2003.82.91.97>
- Vlachogianni, P., & Tselios, N. (2022). Perceived usability evaluation of educational technology using the System Usability Scale (SUS): A systematic review. *Journal of Research on Technology in Education*, 54(3), 392–409. <https://doi.org/10.1080/15391523.2020.1867938>
- Waseso, H. P., Sekarinasih, A., & Prasetyo, S. (2024). Implementasi Pembelajaran Sains dalam Kurikulum Merdeka: Membangun Kemandirian Berpikir Siswa Sekolah Dasar. *Nusantara: Jurnal Pendidikan Indonesia*, 4(4), 1001–1016. <https://doi.org/10.14421/njpi.2024.v4i4-8>
- Yaumi, Y., & Rohmah, M. (2024). Application of Augmented Reality in Learning the Circulatory System: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, 9(2), 73–77. <https://doi.org/10.26740/jppipa.v9n2.p73-77>

ACKNOWLEDGEMENT

The authors would like to thank the teachers of the participating elementary school in Bekasi Regency for their cooperation during data collection, and the students who took part in the study.

AUTHOR CONTRIBUTION STATEMENT

JB contributed to conceptualization, methodology, supervision, formal analysis, and writing original draft preparation. PC contributed to game design and development, data collection, and investigation. All authors reviewed and approved the final manuscript.

AI DISCLOSURE STATEMENT

The authors used Google Gemini during the preparation of this manuscript to assist with language refinement, grammar correction, and structural improvement. The AI tool was used solely to enhance the clarity and readability of the text and did not contribute to the research design, data collection, data analysis, interpretation of results, or the formulation of conclusions. After using the tool/service, the authors thoroughly reviewed and edited the content as needed and take full responsibility for the content of the publication.

***Julius Victor Manuel Bata (Corresponding Author)**

Department of Information Systems School of Bioscience, Technology, and Innovation,
Atma Jaya Catholic University of Indonesia,
Jl. Jenderal Sudirman RT 02 RW 04 No. 51, Karet Semanggi, Jakarta 12930, Indonesia
Email: julius.victor@atmajaya.ac.id

Paelina Charmelita

Department of Information Systems School of Bioscience, Technology, and Innovation,
Atma Jaya Catholic University of Indonesia,
Jl. Jenderal Sudirman RT 02 RW 04 No. 51, Karet Semanggi, Jakarta 12930, Indonesia
Email: pauelin.201904560024@student.atmajaya.ac.id
