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Development and Evaluation of a Gamified LMS for Computer Systems Learning: Student Practicality and Learning Outcomes

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ABSTRACT

This study developed and evaluated an interactive Computer Systems application for Grade X Informatics at SMA Negeri 1 Kota Besi. The study used ADDIE as a development framework and a one-group pretest–posttest design with 24 students. Pretest, classroom use, and posttest took place on October 16, 2025; the exact instructional duration was not documented. Students used their own smartphones while the teacher presented the application on an interactive television and explained the material. One material expert and two media experts assessed the product after classroom use. Material and combined media assessments yielded 94.55% and 83.64%, respectively; student responses yielded 77.08% of the maximum questionnaire score. A Wilcoxon signed-rank test indicated a difference between paired scores ($Z = -4.208$, $p < .001$). The application combines content exploration with game-based practice and may support teacher-led instruction. However, different pretest and posttest questions of unestablished equivalence, limited test reliability, and the absence of a comparison group restrict interpretation of the score difference. Further product refinement and evaluation with stronger instruments are needed before drawing conclusions about effectiveness.

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1. INTRODUCTION

Computer Systems learning requires students to understand system components, data flow, and hardware–software interaction. Connecting theoretical explanations with the internal operation of a computer is an important instructional challenge. In computer organization and architecture education, Prasad et al. (2016) reported that simulation tools helped students understand computer structure and internal functioning. This finding provides a rationale for exploring visual and interactive representations in Computer Systems instruction.

At SMA Negeri 1 Kota Besi, baseline learning data were collected through a Computer Systems pretest administered via Google Forms on October 16, 2025. The 24 recorded responses from Grade X Room 2 students yielded a mean score of 52.92 out of 100, with scores ranging from 30 to 100. The test covered component functions, input and output devices, and basic processor and memory concepts. These results indicated variation in students' initial knowledge and informed the need for instructional support addressing foundational Computer Systems concepts. However, the overall scores alone did not establish specific misconceptions about relationships among system components.

Gamification refers to the use of game design elements in non-game contexts (Deterding et al., 2011). Feedback offers a theoretical explanation for how practice within such activities may support learning. Hattie and Timperley (2007) explain that feedback can help learners identify discrepancies between their current understanding and a learning goal, although its effectiveness depends on the information provided and how it is used. In Computer Systems learning, this perspective suggests that quiz activities should help students recognize incorrect responses and identify concepts requiring further study. Scores alone should not be treated as evidence that students have understood the underlying concepts. Evidence from gamified learning contexts is heterogeneous: Díaz-Ramírez (2020) examined engineering coursework, Legaki et al. (2020) evaluated challenge-based gamification in statistics, and Ratinho and Martins (2023) reviewed findings related to learner motivation across secondary and higher education. These settings provide useful context, but they do not establish outcomes for the present classroom.

Previous studies have developed digital learning media for Informatics in Indonesian senior high schools. Sujatniko et al. (2025) developed a Canva website-based e-comic for Grade X Computer Systems learning using the ADDIE model. Andriani et al. (2025) developed gamified media using Articulate Storyline 3 for computer network topology and evaluated expert assessments, student practicality, and pretest–posttest outcomes. These studies provide established examples of applying ADDIE and combining product assessment with classroom evaluation. The present study extends this work by examining a Canva-based interactive Computer Systems application at SMA Negeri 1 Kota Besi, with attention to expert assessments, student responses, and changes in paired learning scores. Its contribution is a classroom-based evaluation of this application rather than a new development model.

Research syntheses provide further context while underscoring the distinction between a teaching resource and evidence of its independent effect. Sailer and Homner (2020) found a positive average association between gamification and cognitive learning outcomes across studies, whereas Bai et al. (2020) emphasized that intervention characteristics and learners' experiences vary. Balalle (2024) reviewed student engagement in technology-supported education, and Garcia-Iruela and Hijon-Neira (2020) examined students' perceptions of gamification elements. These findings support

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studying user responses and learning scores separately rather than assuming that favorable interface ratings demonstrate conceptual improvement.

Accordingly, this study aimed to develop interactive media for Computer Systems learning using the ADDIE model, examine its feasibility through expert assessments, assess its practicality based on student responses, and examine changes in learning outcomes through a paired pretest–posttest comparison. The study provides evidence concerning the developed media and its classroom use among Grade X students at SMA Negeri 1 Kota Besi.

Studies in computing and adjacent disciplines demonstrate both promise and limits of transferability. Imran (2023) evaluated levels of gamification in introductory programming, Pratama et al. (2021) examined motivation and performance in programming, and Ojonuba et al. (2025) studied engagement, motivation, and performance in web-development education. Their populations, curricular content, and implementations differ from Grade X Computer Systems learning. The present article therefore contributes a descriptive, single-class evaluation rather than replicating causal findings from these settings.

2. METHODS

2.1 Research design

This study employed a Research and Development (R&D) approach using the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) as the instructional development framework (Branch, 2009). Changes in learning outcomes were examined using a one-group pretest–posttest design, in which the same students completed assessments before and after classroom use of the media. Because no comparison group was included, the analysis examined within-group changes in learning scores rather than establishing a causal effect of the media. In the actual implementation, expert assessment followed the classroom trial and the recommendations had not yet been implemented; therefore, the development process had not completed a revision and re-evaluation cycle.

2.2 Research Setting and Participants

The classroom trial was conducted at SMA Negeri 1 Kota Besi, Kotawaringin Timur Regency, Indonesia, in Grade X Room 2 during Computer Systems instruction in the Informatics subject. The class was selected through convenience sampling because the researcher had a scheduled teaching assignment in that class, which facilitated access for classroom implementation and data collection. The paired learning-outcome analysis included 24 students with complete pretest and posttest records. Responses were matched using students' names after verification of spelling differences and abbreviations.

2.3 Analysis Phase

The analysis phase included a baseline assessment administered through Google Forms on October 16, 2025. This assessment preceded development of the media. The 24 responses yielded a mean score of 52.92 out of 100, with scores ranging from 30 to 100. The assessment covered computer component functions, input and output devices, and basic processor and memory concepts. These results provided an initial description of students' knowledge. The learning objectives were to enable students to identify computer system components and explain their functions.

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2.4 Design Phase

The design phase translated the learning objectives into a storyboard and navigation flowchart. The main menu provided three options: "Mulai Jelajah" (Start Exploring), "Cyber Pilot," and "Keluar" (Exit). The exploration pathway linked interactive component illustrations, a data-flow diagram, and a comprehension quiz. The Cyber Pilot pathway provided a separate game activity in which students answered Computer Systems questions through a space-themed interface. The storyboard specified instructions, ten game questions, a time limit of 30 seconds per question, response feedback, and a final score display. The storyboard describes the intended design; implemented interface features are shown in Figures 1–3.

Table 1. Documented application design

Component	Design specification
Learning objectives	Identify computer system components and explain their functions.
Main navigation	Start Exploring, Cyber Pilot, and Exit.
Content exploration	Component illustrations, a data-flow diagram, and a comprehension quiz.
Cyber Pilot	A space-themed game; the storyboard specifies ten questions and 30 seconds per question.
Feedback and results	The storyboard includes response feedback, progress information, and a final score display.

The comprehension quiz is distinct from the Cyber Pilot game and from the research pretest and posttest. The documented quiz interface displays a sequence of 15 questions, whereas each research test contains 10 questions.

2.5 Development Phase

The "Sistem Komputer Interaktif" application was developed using Canva's website features. The prototype included a main menu, interactive computer component illustrations, a data-flow diagram, a comprehension quiz, and the Cyber Pilot game. Following the classroom trial, one material expert, an Informatics teacher at SMA Negeri 2 Sampit, and two media experts with expertise in educational technology and evaluation assessed the product. The assessments addressed content suitability, language, visual presentation, navigation, interactivity, and technical performance.

Table 2. Expert feedback and revision status

Source	Recorded recommendation	Status
Material expert	Add difficulty levels and explanations after questions; consider a final score summary and class ranking.	Not yet implemented
Media expert 1	Provide instructions for completing and scoring the evaluation questionnaire.	Not yet implemented

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Media expert 2	Positive feedback without a specific technical revision request.	No specific revision requested

Material assessment was recorded on October 17, 2025, and media assessments on November 3 and November 8, 2025. These recommendations had not been implemented at the time of this analysis. The recommendation about questionnaire instructions concerns the evaluation instrument rather than the application interface.

2.6 Implementation Phase

The classroom trial was conducted on October 16, 2025. The researcher also served as the classroom teacher. Students first completed a pretest through Google Forms. The media was developed after the pretest and used that day, followed by the posttest. Students accessed the application using their own smartphones, while an interactive television displayed the media for whole-class instruction. The teacher explained the Computer Systems material alongside application use. Students also completed an application evaluation questionnaire. The exact instructional duration was not documented. The posttest measured immediate performance following the combined use of the media and teacher explanation.

2.7 Evaluation Phase

Evaluation addressed expert assessments of the product, students' responses to the application, and changes in learning scores. Expert assessment took place after the classroom trial and provided recommendations for further development. The student questionnaire captured perceptions of presentation, content, ease of use, and feedback. Learning outcomes were examined using complete pretest and posttest records from the same 24 students. The comparison did not isolate the application's contribution or assess long-term retention.

2.8 Instruments and Data Collection

Data were collected using Google Forms. The material expert questionnaire contained 11 items addressing content suitability, accuracy, organization, language, and instructional relevance. The media expert questionnaire contained 11 items concerning visual design, navigation, interactivity, feedback, and technical performance. The student questionnaire contained 10 items. The percentage calculations used a maximum rating of 5 per item. Exact verbal labels for every response option were not available in the exported responses.

Table 3. Instruments and scoring

Instrument	Items	Responses	Maximum score
Material questionnaire	11	1 expert	55 total
Media questionnaire	11	2 experts	110 combined
Student questionnaire	10	24 students	1,200 total
Pretest	10	24 students	100 per student
Posttest	10	24 students	100 per student

Each test contained 10 multiple-choice questions. The recorded totals were consistent with 10 points for a correct response and 0 for an incorrect or unanswered response. Pretest and posttest questions differed, and their equivalence had not been

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established. For retrospective item analysis, scoring keys were reconstructed from responses awarded 100 points and checked against all exported totals; this procedure reproduced every recorded score. It did not independently verify the original Google Forms answer-key settings or establish the content validity of the questions.

Internal consistency was examined retrospectively using the classroom response data. The student questionnaire yielded Cronbach's alpha = .919 for 24 complete responses. Binary item scores based on the reconstructed keys yielded alpha = .556 for the pretest and .186 for the posttest. These estimates describe internal consistency in the implementation sample. High alpha alone does not establish construct validity or unidimensionality (Tavakol & Dennick, 2011). The expert questionnaires were reported descriptively; the small number of experts did not support a meaningful alpha estimate.

The retrospective reliability analyses were conducted only on available student responses and must not be interpreted as prospective instrument validation. Item difficulty and the observed upper-end clustering warrant caution in reading score gains. Expert assessment percentages indicate the experts' descriptive ratings of the assessed product version; they do not constitute a content-validity coefficient.

2.9 Data Analysis

Expert assessments and student responses were summarized using obtained scores, means, and percentages of the maximum possible score. Percentages were interpreted descriptively, without categorical validity or practicality labels. Material and media items were grouped by content for descriptive reporting; these groupings were not treated as separately validated subscales. Learning scores were summarized using the mean, standard deviation, median, minimum, and maximum. Shapiro–Wilk tests examined pretest scores, posttest scores, and within-student score differences.

Paired scores were compared using the Wilcoxon signed-rank test (Wilcoxon, 1945). A two-sided test was computed at a significance level of .05 using a normal approximation with tied-rank adjustment and no continuity correction. One zero difference was excluded from the ranking procedure, leaving 23 non-zero differences. The approximate effect-size statistic was calculated as $r = |Z|/\sqrt{n}$, where n denotes non-zero differences. Analyses were recomputed during manuscript revision using SciPy version 1.17.0. The Shapiro–Wilk test for score differences did not reject normality; thus, non-normality of differences was not the rationale for this rank-based comparison. Results were interpreted cautiously because test equivalence and measurement quality were limited.

2.10 Ethical Considerations

Verbal permission to conduct the study was obtained from the school. Students were informed that their responses and test results would be used for research and that they could decline participation. Parental consent was also obtained. Students' names were used to match pretest and posttest records. The student questionnaire collected names and was therefore not anonymous.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Expert assessment

Table 4. Expert assessment results

Assessment	Obtained	Maximum	Percentage

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Material expert	52	55	94.55%
Media expert 1	45	55	81.82%
Media expert 2	47	55	85.45%
Combined media assessment	92	110	83.64%

The material expert assigned 4 points to three items: logical organization, relevance to technological developments, and absence of spelling or grammatical errors. The remaining eight items received 5 points. The content-based groupings below provide descriptive detail rather than independent evidence of construct validity.

Table 5. Descriptive grouping of material assessment items

Aspect	Items	Score / maximum	Percentage
Content and learning support	1–5, 9–11	38 / 40	95.00%
Language	6–8	14 / 15	93.33%

Table 6. Descriptive grouping of combined media assessment items

Aspect	Items	Score / maximum	Percentage
Visual presentation	1–4	32 / 40	80.00%
Navigation	5–6	19 / 20	95.00%
Interactivity and feedback	7–8	16 / 20	80.00%
Technical performance	9–11	25 / 30	83.33%

Navigation received the highest media percentage. Visual presentation and interactivity and feedback received comparatively lower scores. These findings describe the assessed version of the product; expert recommendations had not yet been implemented.

3.1.2 Student responses

Table 7. Student questionnaire results with 24 responses

Item	Statement	Mean
1	The application's appearance is attractive and easy to understand.	3.71
2	The combination of colors and text is comfortable to view.	3.79
3	Illustrations and animations help explain the material.	3.92
4	The material is easy to understand.	3.83
5	The material is presented in a clear and logical sequence.	4.00
6	Quiz questions correspond to the learning material.	3.92
7	The application is easy to use without teacher guidance.	3.58

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8	The application increases my enthusiasm for learning Computer Systems.	3.96
9	Quiz feedback is easy to understand.	3.83
10	The application helps me understand computer system components.	4.00
All	Mean across 240 item responses	3.85

The aggregate score was 925 out of 1,200 (77.08%). Material sequence and perceived support for understanding computer components received the highest means (both 4.00), while ease of use without teacher guidance received the lowest (3.58). These are student perceptions, not direct measures of conceptual understanding or intrinsic motivation.

3.1.3 Learning outcomes

Table 8. Paired learning scores with 24 participants

Test	Mean	SD	Median	Minimum	Maximum
Pretest	52.92	19.44	55.00	30	100
Posttest	89.58	9.99	90.00	70	100

Mean scores increased by 36.67 points. Twenty-three students obtained higher posttest scores and one obtained the same score on both assessments. The Wilcoxon comparison yielded $W = 0$ and $Z = -4.208$, $p < .001$. The approximate effect-size statistic was $r = .88$ using 23 non-zero differences. This statistic describes the paired score pattern and does not estimate the causal effect of the application.

Table 9. Shapiro–Wilk results

Distribution	W	p
Pretest	0.913	0.040
Posttest	0.847	0.002
Posttest minus pretest	0.934	0.123

Nine students (37.50%) achieved the maximum posttest score, compared with one student (4.17%) on the pretest. Two posttest items were answered correctly by all 24 students. The concentration at the upper limit suggests a possible ceiling effect. Because the tests used different items, item-level response changes were not interpreted as direct evidence of conceptual correction.

3.1.4 Visual documentation

Figures 1–3 show the documented application interfaces. The figure legends identify the visible controls and game elements.

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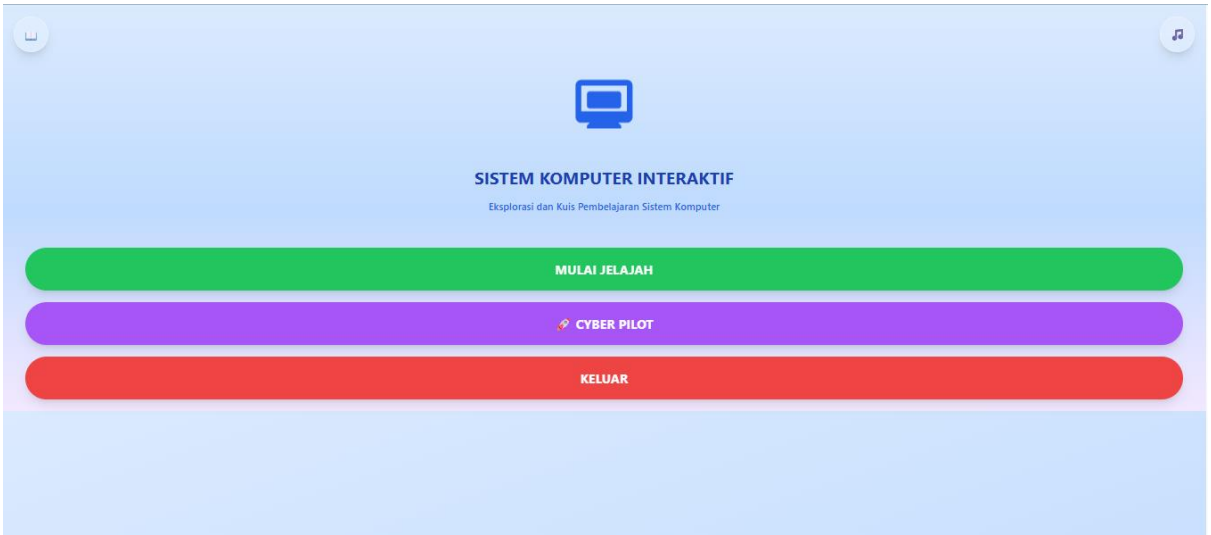


Fig. 1. Main menu of the application.

Visible controls: the green button opens Start Exploring; the purple button opens Cyber Pilot; the red button exits the application.

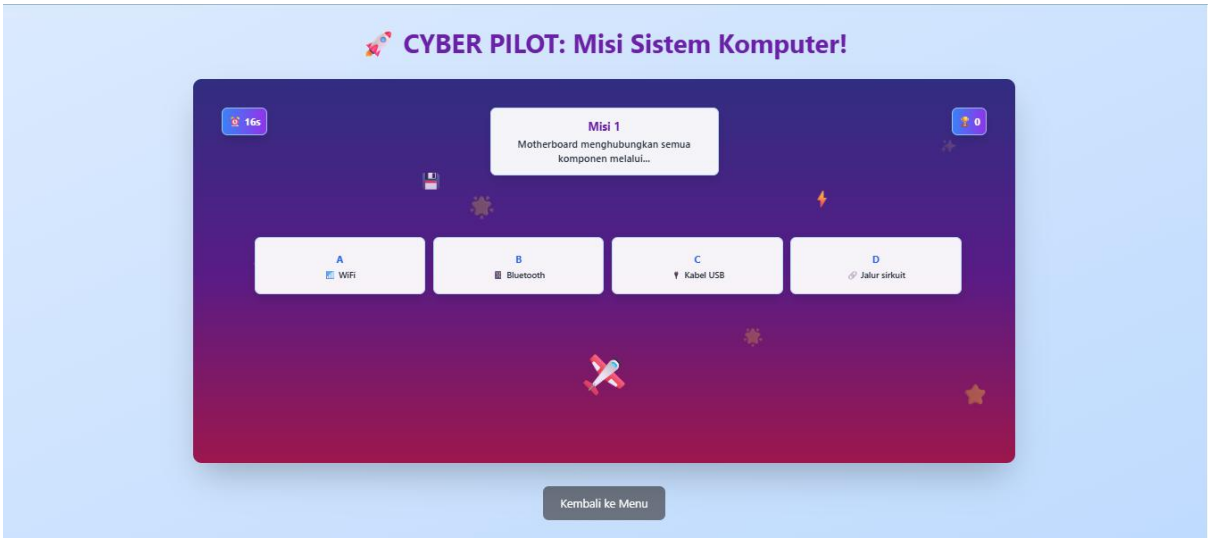


Fig. 2. Cyber Pilot mission interface.

Visible elements: countdown timer at the upper left, mission question at the upper center, score indicator at the upper right, and four answer options across the center. Response indicators are visible beside the options.

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Fig. 3. Computer Systems comprehension quiz.

Visible elements: the question and answer options occupy the central panel; the question counter appears at its lower left; navigation buttons are below the panel.

3.2 Discussion

The findings provide different forms of evidence concerning the application. Expert assessments identified strengths and areas for refinement, while student responses described their experience of using it. Navigation received comparatively favorable expert ratings, but students rated ease of use without teacher guidance lower than the other questionnaire items. An interface judged clear by experts may therefore still require instructional support in classroom use. Higher posttest scores were observed following application use and teacher explanation, but the design does not identify their separate contributions.

The material expert's recommendation to provide explanations after each question can be interpreted through Hattie and Timperley's (2007) feedback framework. Information about correctness can help students monitor performance, whereas explanations may help them understand errors and identify what requires further study. Because the recommended explanations had not yet been implemented, their potential benefits are a rationale for further development rather than a demonstrated mechanism behind the observed score change. Assessment by one material expert also provides limited evidence and should not be treated as sufficient proof of content validity. Kuklick et al. (2023) likewise found that the type and elaboration of computer-based feedback can influence cognitive and motivational responses; their evidence supports refining feedback quality rather than assuming any immediate feedback is equally useful.

Student ratings suggest that the application may be useful as a resource for teacher-supported instruction rather than as a fully independent learning tool. Nevertheless, the questionnaire measured perceptions, and its high internal consistency does not establish the validity of every interpretation drawn from the responses (Tavakol & Dennick, 2011). Responses were identifiable, and the researcher taught the class; favorable evaluations may therefore partly reflect social desirability or reluctance to criticize the application. Research on gamified learning management systems also emphasizes alignment between gamification features and instructional functions (Limantara et al., 2023). In the present application, account tracking and course-management functions were not demonstrated, which limits the appropriateness of interpreting it as a complete LMS. Sailer and Sailer (2021) studied gamification of in-class activities in flipped classroom lectures, a setting

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that further illustrates why implementation conditions should be specified when discussing student responses.

The increase in recorded scores is directionally consistent with the higher posttest performance reported by Andriani et al. (2025) for gamified network topology media. However, differences in subject matter, assessment instruments, and implementation mean that raw gains cannot establish which product is more effective. Chen et al. (2018), in contrast, evaluated gamified activities embedded in an LMS using experimental and control groups in graduate-level statistics. That design provides a comparison absent from the present classroom trial. These differences limit direct generalization between studies. For comparison, Díaz-Ramírez (2020) used a semester-long engineering intervention, whereas the present dataset reflects an immediate one-class evaluation. Legaki et al. (2020) investigated challenge-based gamification in statistics; transferring those findings to Computer Systems requires caution.

The documented contribution is the combination of content exploration and game-based practice within a Canva-based Computer Systems application. The exploration pathway connects component illustrations, a data-flow diagram, and a comprehension quiz, while Cyber Pilot presents questions through a space-themed interface with time and score indicators. The format differs from the Canva-based e-comic reported by Sujatniko et al. (2025), and the topic and platform differ from the Articulate Storyline media reported by Andriani et al. (2025). These differences describe design and context rather than superiority. The study offers a classroom example that teachers may adapt, while further investigation is needed to establish which features support learning. Unlike a full learning management system, the documented Canva-based product does not establish user-account management, persistent progress records, or teacher analytics. The LMS label in the article title is retained to preserve continuity with the reviewed manuscript, while the implemented product is described as an interactive learning application.

The literature suggests several reasons not to equate positive responses with demonstrated instructional effectiveness. Sailer and Homner (2020) and Bai et al. (2020) report aggregate benefits across different forms of gamification, but such synthesis cannot isolate the impact of this application. Reviews by Balalle (2024), Chan and Lo (2024), and Huang et al. (2024) address different educational contexts and outcomes, limiting direct comparison. Likewise, Mohammed et al. (2024) examined motivation in an elementary-school field experiment; the current questionnaire did not validate a separate motivation construct. A statistically significant within-class score difference therefore remains distinct from an effect attributable to this Canva application. Meta-analyses by Li et al. (2023) and Kurnaz and Koçtürk (2025) also synthesize gamification outcomes across educational settings; however, their findings do not establish whether this particular application independently caused the observed score difference.

Several limitations guide interpretation. The study involved one conveniently selected class, 24 complete paired records, and no comparison group. Instruction combined application use and teacher explanation. The pretest and posttest contained different questions of unestablished equivalence, and retrospective reliability estimates indicated limited consistency, particularly for the posttest. Posttest items 9 and 10 addressed the application's display or expected learning benefit, which limits the interpretation of the total as a measure solely of Computer Systems knowledge. The high frequency of maximum posttest scores suggests a possible ceiling effect. Same-day assessment provided no retention evidence, and a novelty effect cannot be ruled out. Questionnaire responses were not anonymous. Expert assessment involved one material expert and two media experts, occurred after classroom use, and had not resulted in

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implemented revisions. The exact instructional duration was not documented. Future studies should refine and pilot the instruments, establish comparable assessments, implement and document revisions, and use comparison groups and delayed assessments. The source screenshots were available only as raster images; enlargement improves display dimensions but cannot recover missing native image detail. Item-level review of test responses and reconstruction of scoring keys do not replace an independent expert content-validation procedure.

Measurement quality is an especially important limitation. The retrospective Cronbach's alpha values of .556 for the pretest and .186 for the posttest indicate weak internal consistency in this sample; the 10-item forms also used different questions without evidence of equivalence. Although the student-response questionnaire yielded alpha = .919, this does not independently establish validity (Tavakol & Dennick, 2011). With no contemporaneous item-validation record or additional data collection, new validity coefficients, expert agreement indices, or claims of instrument standardization cannot responsibly be supplied. Future replications should conduct prospective item review and pilot testing, use equivalent test forms, and document item analysis before implementation.

4. CONCLUSION

This study developed and evaluated a Canva-based interactive application for Grade X Computer Systems learning. Expert assessments and student responses identified favorable ratings for content and navigation, alongside areas requiring further refinement and teacher support. Higher posttest scores were observed after instruction combining application use and teacher explanation; however, the design and measurement limitations prevent firm conclusions about effectiveness. The application provides a classroom example of integrating content exploration with game-based practice. Further development should implement the expert recommendations, improve the assessment instruments, and examine outcomes using comparable tests, a comparison group, and delayed assessment.

5. AUTHORS' NOTE

The authors declare no conflict of interest regarding the publication of this study.

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