

Development of a Padlet-Based Interactive Digital Comic to Enhance Learning Outcomes and Appeal of Science for Elementary School Students

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ABSTRACT

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In elementary science education, traditional didactic approaches frequently lead to low learning outcomes and disengaged students. By creating and examining the effectiveness of an interactive digital comic based on Padlet to improve student learning outcomes and subject appeal, this study filled this knowledge gap. With a perfect Scale Content Validity Index (S-CVI/Ave) of 1.00, the product achieved a Highly Valid classification across content, media, and instructional design after undergoing rigorous expert validation using the Dick and Carey model. Its high acceptance (OMS = 0.46) was further validated by a small group feasibility evaluation. Twenty-four fourth-graders participated in a one-group pretest-posttest design to evaluate the comic's efficacy. The mean learning score increased dramatically from 56.16 on the pretest to 97.92 on the posttest, according to the results. This improvement was statistically significant ($t = 10.24$; $p < .001$), indicating that the comic promoted almost flawless subject mastery. In summary, it has been established that the interactive digital comic is a very legitimate, practical, and successful teaching tool for improving science education and boosting student interest in elementary school.

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Introduction

The traditional didactic methods often employed in elementary science education frequently fail to engage students, leading to diminished interest and perceived difficulty in the subject matter [1]. This disengagement often results in suboptimal learning outcomes and a lack of foundational scientific literacy, crucial for future academic pursuits and civic engagement [2]. This concern is further exacerbated by the abstract and complex nature of many scientific topics, which can negatively affect students' attitudes and motivation in elementary education [3].

Comics have emerged as a powerful form of interactive learning media that combine visual and textual elements to enhance students' engagement, comprehension, and motivation [4–5] emphasize that comics, as multimodal resources, effectively develop learners' communicative competence and willingness to interact by integrating text, images, and symbols in meaningful ways. Similarly, Lamminpää et al. [6] found that creating and reading science comics allows students to express their understanding of scientific concepts more vividly, promoting positive attitudes toward learning. Lestari and Firman [7] demonstrated that comic-based instruction can effectively reduce negative behaviors like bullying while fostering empathy and reflection, showing the medium's strength in character education. Integrating comics within interactive multimedia systems [8], further enhances accessibility and learner participation through digital platforms padlet making them ideal for 21st-century classrooms [9]. Digital comics are an innovative learning medium that combines visual and verbal elements to enhance students' motivation and understanding in learning. Research shows that reading literacy comics helps students comprehend material more easily and improves reading skills through interactive displays [10]. The integration of text and images also deepens the learning process, as both complement each other in building conceptual understanding [11]. Moreover, visual media such as picture books the foundation of digital comics, can foster imagination, creativity, and positive reader identities among children [12]. Overall, comics function not only as engaging narrative tools but also as interactive learning media that foster cognitive, emotional, and social development in education.

In order to address this, incorporating cutting-edge digital learning resources, like interactive digital comics, offers a viable way to promote increased student involvement and comprehension in science instruction [13–15]. Moreover, employing engaging media like comics, which inherently appeal to children, can significantly enhance their understanding and retention of scientific concepts. However, despite these advancements, the full potential of interactive media in elementary science remains largely untapped, contributing to suboptimal learning outcomes [16]. This gap underscores the necessity for targeted interventions that leverage engaging formats to bridge the cognitive and motivational barriers often encountered

by elementary students in science lessons, particularly in under-resourced educational settings [17].

Research from several international studies shows that comics effectively enhance student engagement and learning outcomes by integrating visual and narrative elements. Digital comics boost motivation and comprehension through interactive text-image combinations [18], promote critical thinking and value formation [19], and foster creativity and reflective learning through visual storytelling [20]. Overall, comics serve as an engaging pedagogical tool that supports deeper understanding and active learning. In line with earlier research on Digital Interactive Math Comics (DIMaC), this study emphasizes the promise of interactive e-comics for enhancing student engagement and learning performance. DIMaC's favorable reception—especially its user-friendly design and suitability for digital-native learners—underscores the value of incorporating visual and interactive features in creating culturally responsive educational media [21]. Echoing the findings of the Super Divya study—which demonstrated that comic-based modules are practical, well-received, and effective in boosting educators' knowledge—this research similarly shows that interactive digital comics can increase student engagement and comprehension. The results highlight the promise of digital comics as innovative and scalable educational tools designed for 21st-century learning [22]. Further supporting these findings, a recent study involving Canva-based animated comic video learning media demonstrated strong validity and practicality, underscoring its effectiveness in boosting student motivation and participation. This evidence suggests that well-designed digital comic formats can foster engaging and meaningful learning experiences that enhance students' conceptual understanding [23].

Recognizing this, the present study builds upon the understanding that technology, particularly interactive digital tools, can significantly transform learning experiences by making complex subjects more accessible and stimulating [24–25]. The strategic application of interactive digital comics, facilitated by platforms like Padlet, offers a compelling solution to address the challenges of student disengagement [26]. This study posits that by integrating interactive elements and collaborative features within this format, students' active participation and enthusiasm for science can be significantly elevated [27]. Additionally, this method is in line with current educational trends that emphasize student-centered learning and the use of technology to create dynamic and captivating learning environments while developing critical 21st-century skills known as digital literacy [28–32].

Therefore, this research focuses on developing Padlet-based interactive digital comics as an innovative learning medium designed to enhance students' understanding and

engagement in science lessons, while promoting more effective and enjoyable learning experiences for elementary school students.

Material and Methods

A. Research Design

The product development process in this research followed the Dick, Carey and Carey instructional design model which consists of ten systematic steps: identifying instructional goals, conducting instructional analysis, analyzing learners and contexts, writing performance objectives, developing assessment instruments, developing instructional strategies, developing and selecting instructional materials, designing and conducting formative evaluation, revising instruction, and designing and conducting summative evaluation [39]. This model was selected because it provides a structured framework that emphasizes clear alignment between learning objectives, instructional materials, and evaluation, ensuring measurable learning outcomes. Product development is carried out until the product obtains expert feasibility and effectiveness in the classroom. So that the product development process is carried out through formative evaluation, the final revision is carried out in Step 9. Summative Evaluation aims to test the use of products on diverse student characteristics with a wide range of subjects, so it requires an evaluation design that is separate from this activity.

Table 1. Summary of Product Development Process Using the Dick, Carey, and Carey Model

No.	Steps	Main Activities	Tools/Instruments
1	Identifying Instructional Goals	Determined instructional goals based on curriculum and student needs. Focused on the science topic "Change in the State of Matter".	Curriculum analysis, classroom observation checklist
2	Conducting Instructional Analysis	Broke down the topic into sub-skills and key concepts to identify prerequisite knowledge and conceptual connections.	Concept maps, content analysis forms
3	Analysing Learners and Contexts	Collected data on student characteristics, learning styles, and available school technology.	Student learning profile form, environmental observation sheet
4	Writing Performance Objectives	Formulated measurable learning objectives aligned with Bloom's taxonomy to ensure clear outcomes.	Objective formulation matrix
5	Developing Assessment Instruments	Designed assessment tools to evaluate knowledge, motivation, and product validity.	Pretest-posttest, expert validation sheets, student questionnaires (Likert scale)
6	Developing Instructional Strategies	Designed a learning sequence using story-based, visual, and interactive elements integrated into the digital comic.	Lesson flowchart, storyboard, narrative design plan

No.	Steps	Main Activities	Tools/Instruments
7	Developing and Selecting Instructional Materials	Created visuals using Gemini AI, refined manually for consistency and age appropriateness, and integrated with Padlet.	Gemini AI tools, image editor, Padlet platform
8	Designing and Conducting Formative Evaluation	- Conducted expert validation and limited student trials to assess accuracy, media quality, and instructional design. - Implemented a comic with 24 fourth-grade students for 1 month. Conducted pretest, posttest, and student survey.	Expert validation sheets (5-point Likert scale), student trial observation. Pretest–posttest, N-Gain analysis, motivation questionnaire, paired t-test
9	Revising Instruction	Revised content, visuals, and interactivity based on expert and student feedback.	Revision log, feedback summary form.

B. Participants

Data were collected from August to September 2025. The participants involved in the development of this digital Comic consist of three expert validators (a content expert, a media expert, and an instructional design expert), as well as 24 fourth-grade elementary students from SDN V Pulosari, Ngunut. The data collection instruments used in this study were questionnaires and tests (pretest and posttest). The questionnaires were employed to obtain validation data from experts and to measure the practicality and user responses from students toward the developed interactive digital comic. Meanwhile, the pretest and posttest were administered to determine the effectiveness of the Padlet-based interactive digital comic in improving students' learning outcomes.

C. Research Instrument

Table 2 presents the instrument grid for expert validation, which covers three key aspects: content, media, and instructional design. Each aspect includes indicators and item statements used to evaluate the quality, accuracy, and feasibility of the Padlet-based interactive digital comic. The content aspect ensures scientific accuracy and alignment with learning objectives, the media aspect assesses visual design and interactivity, and the instructional design aspect examines pedagogical structure and integration. Together, these validations ensure the product's overall validity, usability, and educational effectiveness.

Table 2. Instrument Grid of Validation

Data Type	Aspect of Validation	Indicator / Item Statement
Content Validation	Alignment with Learning Objectives	The comic content aligns with learning objectives.
	Cognitive Appropriateness	The comic material suits the students' cognitive development level.
	Scientific Accuracy	The concepts presented in the comic are scientifically accurate.

Data Type	Aspect of Validation	Indicator / Item Statement
Media Expert Validation	Language Clarity	The language used is clear, communicative, and appropriate for students.
	Contextual Understanding	The comic helps students understand the material contextually.
	Activity Relevance	Included activities or games are relevant to the content.
	Material Organization	Material arrangement on Padlet is systematic and logical.
	Character-Building Value	The comic and game contain educational value for character building.
	Assessment Alignment	Learning outcome test items are suitable for measuring objective achievement.
	Visual Appeal and Appropriateness	The comic visuals are appealing and appropriate for student characteristics.
	Graphic and Layout Quality	Illustrations, color, and layout support content comprehension.
	Accessibility and Navigation	Navigation and Padlet access are easy to understand and use.
	Interactivity and Feedback	The interactive game is easy to play and provides clear feedback.
Instructional Design Validation	Cross-Device Compatibility	The comic and game perform well across various devices (laptop, HP, tablet).
	Integration Quality	Integration between comic, Padlet, and game feels seamless and non-confusing.
	Motivation and Engagement	Interactive media is capable of increasing student interest and motivation.
	Interactivity Flow	Comics and games have a clear interactive flow supporting objective achievement.
	Clarity and Alignment of Objectives	Objectives are clear, specific, and align with curriculum outcomes.
	Suitability of Material	Material suits student characteristics and cognitive development.
	Learning Strategy and Engagement	Learning strategy aligns with objectives and promotes active student involvement.
	Structure of Learning Activities	Learning activities are systematic and logical (introduction, core, conclusion).
	Appropriateness of Teaching Methods	Teaching methods are appropriate and varied (cooperative, discussion, etc.).
	Assessment Relevance	Assessment covers cognitive, affective, and psychomotor aspects, matching indicators.
Instructional Design Validation	Integration of Learning Media	The lesson plan effectively integrates media (comic, Padlet, game).
	Coherence of Learning Components	Learning components have coherence and continuity across sections.
	Contextual and Meaningful Learning	Design supports meaningful and contextual learning.
	Responsiveness to Student Diversity	Design is responsive to students' needs from diverse backgrounds.

Table 3 presents the instrument grid for the students' response questionnaire, which was designed to evaluate students' perceptions of the Padlet-based interactive digital comic. The questionnaire aims to assess various aspects, including interest, visual clarity, accessibility, interactivity, and learning effectiveness. Each statement item focuses on measuring how engaging, understandable, and helpful the comic is in supporting students' motivation, comprehension, and memory retention. The data were collected using a 5-point Likert scale,

and the results were analysed based on mean scores and percentage of agreement to determine students' overall responses toward the developed learning media.

Table 3. Instrument Grid for Students' Response Questionnaire

Aspect / Indicator	Statement Item
Interest and Attractiveness	The interactive comic is interesting for me to read.
Visual and Text Clarity	The colors, images, and text in the comic are easy for me to see and read.
Emotional Engagement	I feel happy when using this comic.
Accessibility	I can easily open the comic on Padlet.
Usability and Functionality	I can understand how to use the interactive comic and games.
Ease of Interaction	I don't feel confused when doing the interactive games.
Learning Support	The interactive comic helps me understand the subject matter.
Learning Motivation	The interactive games make me more enthusiastic about learning.
Memory Retention	After reading this comic, it is easier for me to remember the lesson content.

The learning outcomes in this study were measured using pretest and posttest instruments administered to the students before and after engaging with the Padlet-based interactive digital comic. The pretest was designed to assess students' prior knowledge and understanding of the science topic, while the posttest evaluated the extent of their learning improvement after the intervention. The learning outcome test was developed as a multiple-choice assessment instrument to measure students' understanding of the topic "Changes in the State of Matter." The instrument construction was based on the learning objectives and indicators specified in the curriculum. The test consisted of 25 multiple-choice items designed to assess higher-order thinking skills (HOTS). The content coverage included concepts related to phase transitions (melting, freezing, evaporation, condensation, and sublimation). The items were mapped according to Bloom's Taxonomy, focusing on cognitive levels C2 (Understanding), C3 (Applying), and C4 (Analyzing). Content validity was ensured through expert judgment, and the instrument was reviewed to confirm alignment between the test items, content indicators, and targeted cognitive levels. All items were validated by experts to ensure alignment with the curriculum and instructional goals. By comparing the two sets of scores, the researcher could determine the effectiveness of the digital comic in enhancing students' comprehension and retention of the material. A significant increase in posttest results indicated that the interactive digital comic successfully supported learning objectives and contributed to meaningful knowledge gains among students.

D. Data Analysis

The data analysis in this study employed a combination of quantitative techniques to evaluate the validity, effectiveness, and practicality of the Padlet-based interactive digital comic. The results from the three expert validators covering content, media, and instructional design aspects were analyzed using the Content Validity Index (CVI) to determine the accuracy

and feasibility of the developed product. Each expert rated the items on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The expert validation used a 5-point Likert scale. For CVI calculation, ratings of 4 (Agree) and 5 (Strongly Agree) were categorized as 'relevant' (score 1), while ratings of 1 to 3 were categorized as 'not relevant' (score 0). The Content Validity Index (CVI) for each item (I-CVI) was calculated by dividing the number of experts who gave a 'relevant' rating by the total number of experts. The Item Content Validity Index (I-CVI) was calculated for each item by dividing the number of experts who rated the item as relevant by the total number of experts. The Scale Content Validity Index (S-CVI/Ave) was then obtained by averaging the I-CVI values across all items within each validation aspect (content, media, and instructional design).

$$\text{Formula CVI} = \frac{\text{Number of Valid Items}}{\text{Total Items Assessed}} \quad (1)$$

The CVI's value is calculated using Eq. (1). According to the interpretation criteria for CVI values are shown in Table 4.

Table 4. Criteria for CVI Interpretation

CVI Value Range	Interpretation	Category
$CVI \geq .79$	Acceptable / Highly Valid	Product is valid and acceptable
$.70 \leq CVI < .79$	Needs Revision	Requires minor improvements
$CVI < .70$	Invalid	The product must be revised extensively

Based on these criteria, the validation results showed that the developed digital comic achieved an S-CVI/Ave above 0.79, indicating a *Highly Valid* category in terms of content accuracy, media quality, and instructional design coherence. The interpretation of CVI values followed established criteria, where a CVI value of ≥ 0.79 indicates acceptable or high validity, values between 0.70 and 0.78 indicate the need for minor revision, and values below 0.70 indicate insufficient validity requiring major revision.

To assess learning effectiveness, pretest and posttest data were analysed using descriptive statistics (mean and standard deviation) and a paired sample t-test to determine the significance of improvement in students' learning outcomes. The normalized gain score (N-Gain) was calculated using the formula proposed by [34].

$$N\text{-Gain} = \frac{(\text{Posttest score} - \text{Pretest score})}{(100 - \text{Pretest score})} \quad (2)$$

The N-Gain score is calculated using Eq. (2). The interpretation of N-Gain values is presented in Table 5.

Table 5. Criteria for N-Gain Interpretation

N-Gain Value (g)	Interpretation	Category
$g > .70$	High	Effective
$.30 \leq g \leq .70$	Moderate	Fairly Effective
$g < .30$	Low	Ineffective

Meanwhile, data from the students' response questionnaire were analysed using mean scores and percentage of agreement to assess practicality, usability, and engagement. The results revealed a consistently high mean score and agreement percentage ($\geq 80\%$), indicating that the interactive digital comic was engaging, user-friendly, and effective in improving students' motivation and conceptual understanding [34]. Student responses were analyzed based on the percentage of agreement. An agreement level of $\geq 81\%$ was categorized as Very Practical, 61–80% as Practical, 41–60% as Fairly Practical, and $\leq 40\%$ as Impractical. These categories were used to determine the feasibility of the digital comic for classroom implementation.

Student responses were collected using a questionnaire with a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire assessed aspects of usability, attractiveness, clarity, and learning support of the digital comic. The mean score for each aspect was calculated by averaging student responses across all items. To determine practicality, the mean scores were converted into percentages using the following formula.

$$\left(\frac{\text{obtained score}}{\text{maximum possible score}} \right) \times 100\%. \quad (3)$$

Results

A. Learning Material using Padlet

The analysis of learning needs revealed that students experienced difficulties understanding abstract science concepts through text-based materials [35], while teachers expressed the need for engaging visual media to enhance motivation and comprehension. This aligns with the initial phase of the Dick and Carey Instructional Design Model, which emphasizes defining clear instructional goals based on authentic learning challenges. Moreover, the move to use a digital comic format is supported by recent empirical findings showing that digital comics and multimedia learning media significantly increase students' motivation and conceptual understanding in science and other disciplines [36–37].

The preliminary analysis revealed that the students already demonstrated adequate digital literacy skills for engaging with platforms such as Padlet, and teachers at SDN V Pulosari, Ngunut, expressed readiness to integrate technology-enhanced instruction into classroom activities. These findings indicated that adopting a multimedia design—incorporating comics and interactive game elements was highly appropriate for the learners' characteristics. Consequently, the product was developed to combine narrative storytelling, vivid visuals, and interactive tasks aimed at fostering active participation and context-rich learning experiences. This approach aligns with the first phase of the *Systematic Design of Instruction* (Dick and Carey) model, which emphasizes defining instructional goals based on learner needs and learning

contexts [9]. Moreover, prior studies have shown that when students already possess sufficient digital literacy, and teachers are willing to implement technology-supported learning [38], the use of multimedia tools such as interactive comics and digital games significantly enhances engagement and contextual learning outcomes. Learner analysis showed that most students prefer visual and interactive materials like digital comics. Most have access to smartphones, though some face occasional internet issues. The school offers helpful resources such as Wi-Fi and projectors, making it possible to use Padlet-based learning tools. These insights shaped the creation of interactive digital comics that focus on visual engagement and can be used offline.

Based on the learning goals, performance objectives were aligned with curriculum standards, emphasizing understanding of physical science concepts, critical thinking, and character development. Assessment instruments consisted of pretest and posttest evaluations to measure learning outcomes, as well as questionnaires for expert validation and student responses. The instruments were developed using a 5-point Likert scale to assess validity, feasibility, and practicality.

Following the Dick and Carey model, the digital comic was designed and implemented entirely using Gemini AI's multimedia and creative generation capabilities. The design leveraged Gemini's ability to generate interactivity, color-rich visuals, and custom educational content that strictly aligns with the principles of effective multimedia learning. Each learning scene integrated AI-generated educational dialogue, diverse visual styles, and gamification elements, all customized by Gemini to reinforce specific learning objectives and maximize user motivation.

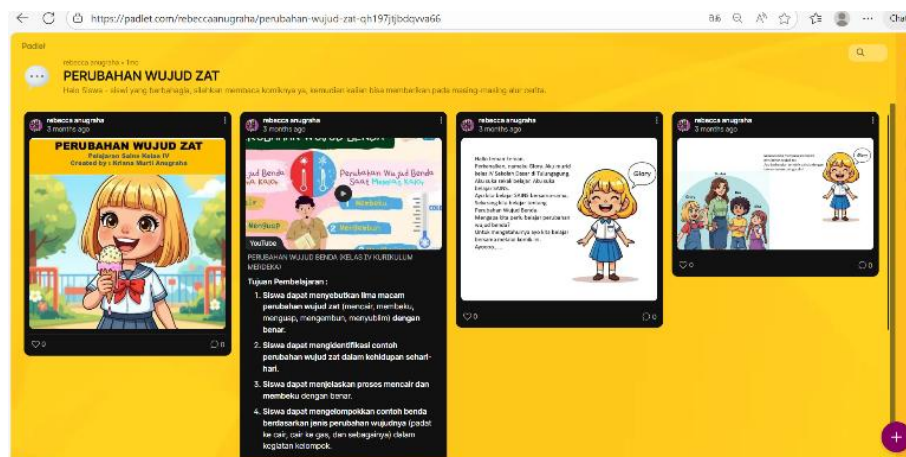


Fig. 1. Interactive Comic in the Padlet Platform

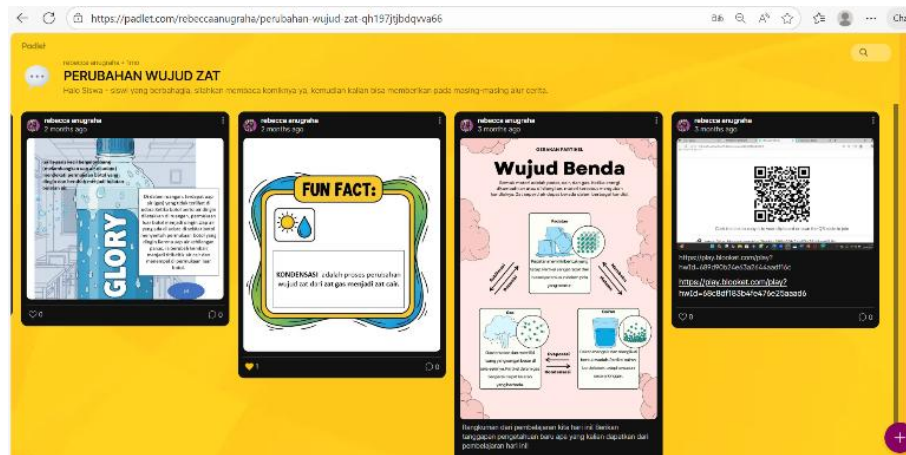


Fig. 2. Interactive Comic with Games Education Booklet

B. Expert Validation Results

Based on the data presented in the following table, it can be concluded that the Interactive Digital Comic Media meets high standards for quality and suitability across all evaluated aspects. The validation process involved three key expert areas: Content, Media, and Instructional Design, each confirming a Highly Valid result. The high level of agreement and positive evaluation across these distinct domains is reflected in the strong overall Average Score and Scale Content Validity Index (S-CVI/Ave) of 4.63, providing robust evidence for the media's readiness and effectiveness for its intended use following Table 6.

Table 6. Average Validity Result from Expert Validators

No.	Index	Result	Information
1	Content Expert Validation	4.56	Highly Valid
2	Interactive Digital Comic Media Expert Validation	5.00	Highly Valid
3	Instructional Design Expert Validation	4.40	Highly Valid
Average Score and Scale Content Validity Index (S-CVI/Ave)		4.63	Highly Valid

Source: research's data

Table 6 indicates that all three aspects achieved a Scale CVI (S-CVI/Ave) of 1.00, placing them in the "Highly Valid" category. The content aspect obtained a mean score of 4.56, the media aspect achieved a perfect score of 5.00, and the instructional design aspect reached 4.40. These results show that the developed interactive comic is valid in terms of scientific accuracy, technical feasibility, and instructional appropriateness.

The content validity of the Padlet-based interactive digital comic was assessed by a content expert to ensure scientific accuracy and alignment with the curriculum. The validation results, presented in Table 6, show that all nine items achieved an Item Content Validity Index (I-CVI) of 1.00, as every item was rated as 'Agree' (4) or 'Strongly Agree' (5). The overall Scale Content Validity Index (S-CVI/Ave) for the content aspect is 1.00, with an average mean score of 4.56 out of 5. Based on the established threshold ($CVI \geq 0,79$), the content of the digital comic is categorized as Highly Valid and highly appropriate for use in elementary science learning. This

indicates that the material is scientifically sound, cognitively suitable for the target students, and effectively integrates contextual concepts and character-building values.

The second expert is a Media Expert. The feasibility of the Padlet-based interactive digital comic from the media aspect was assessed by a media expert to ensure its technical quality, user-friendliness, and visual appeal, and the results are presented in Table 6.

Table 6 indicates exceptional consistency and quality across all indicators. Every item, ranging from visual appeal to technical performance and seamless platform integration, was rated as “Strongly Agree” (5). Consequently, the Scale Content Validity Index (S-CVI/Ave) for the media aspect achieved the maximum score of 1.00, corresponding to a mean score of 5.00. This indicates that the media component—including the Padlet platform's usability, the interactive game design, and cross-device compatibility is Highly Valid and requires no revision. The high validity score confirms that the tool is technically sound and visually engaging for the target elementary student users.

The third expert focused on the instructional design aspect, assessed by an expert to ensure the pedagogical aspect and effectiveness of the learning strategy. The evaluation covered 10 key items, including objective formulation, teaching strategies, integration of the Padlet-based media, and the overall coherence of the learning experience. As shown in Table 1, the expert rated every item as either 'Agree' (4) or 'Strongly Agree' (5), resulting in a perfect Item Content Validity Index (I-CVI) of 1.00 for all items. Consequently, the overall Scale Content Validity Index (S-CVI/Ave) achieved 1.00, with a high mean score of 4.40. This result confirms that the digital comic and its accompanying lesson plan are Highly Valid from a design perspective, assuring that the learning activities and strategies are systematic, promote active student involvement, and are appropriate for the target students' developmental stage.

The validation results show that the Padlet-based interactive digital comic scored highly in all areas: content, media, and instructional design. Each aspect received a perfect Scale Content Validity Index (S-CVI/Ave) of 1.00, classifying them as Highly Valid. The content received a mean score of 4.56, which means the material is scientifically accurate, matches the curriculum, and is suitable for elementary students. The content also includes relevant science concepts and character-building values, making it both educational and developmentally appropriate.

The media aspect also received a perfect mean score of 5.00, showing it is technically sound, visually appealing, and easy to use. The instructional design scored 4.40, indicating it is well-aligned with teaching goals, has a clear lesson structure, and supports active, student-centered learning.

C. Small Group Evaluation

The results of the experts' assessment show that the development product has met the feasibility of the expert so it can be continued to test the user (students) to find out the

effectiveness of the development product as a science teaching material. The activities consisted of a Small Group Evaluation and a field trial. There were 5 students as participants in the Small Group Evaluation, and the student's feedback presented in Table 7.

Table 7. Small Group Evaluation

No.	Index	Result	Information
1	Students' Responses toward the Use of Padlet Interactive Digital Comics	4.6	Highly Valid
2	Students' Evaluation of Content Quality and Learning Effectiveness of the Interactive Digital Comic	4.89	Highly Valid
Average		4.745	Highly Valid

Source: research's data

Table 7 indicates that the interactive comic was exceptionally well-received, confirming its high feasibility and positive impact. The overall assessment resulted in an Outstanding Mean Score (OMS) of 4.60 (out of a maximum 5.00), placing the comic firmly in the "Very Positive" category. This high score is supported by the near-unanimous approval from the participants, reflected in an Overall Percentage of Agreement (Strongly Agree or Agree) of 97.78%. Critically, no participants chose "Disagree" or "Strongly Disagree" for any statement.

Table 7 indicates that the interactive comic's outstanding effectiveness and acceptance, reflected by a 100% Overall Percentage of Agreement and a near-perfect Overall Mean Score (OMS) of 4.84 (out of 5.00), which squarely places the resource in the "Excellent" development category. The comic demonstrated absolute strength across multiple dimensions, with five statements—covering language clarity (Q4), engagement (Q6), organization (Q7), positive values (Q8), and assessment suitability (Q9) receiving a perfect Mean Score of 5.00 from all five participants. The remaining statements, which addressed visuals, content accuracy, and enhanced understanding, also performed exceptionally well (MS = 4.80). The only slight deviation was a single "Neutral" response concerning content relevance (MS = 4.60), but since no participant disagreed, the results confirm that the interactive comic is highly successful and feasible, demonstrating excellence in both pedagogical and functional aspects.

The purpose of conducting a Small Group Evaluation is to test the use of development products in a small number of students before the product is tested on students in class. This needs to be done to identify learning problems that students may have and determine if students can use digital comics without interaction with a teacher [39].

D. Field Implementation and Effectiveness Testing

The field trial involved 24 fourth-grade students using the one-group pretest–posttest design. Pretest and posttest data were analyzed using paired sample t-tests and N-Gain analysis [34] Following Table 8.

Table 8. The Score of Pretest and Posttest

Test	Total Participants (N)	Mean (X)	Standard Deviation (SD)	Standard Deviation of Difference	Significance (2-tailed)/ - value	N-gain Score
Pretest	24	56.16	19.86			.953 (95.3%)
Post-test	24	97.92	3.32	20.35	< 0.001	High Improvement

Sources: Research Data

Table 8 presents a clear improvement in students' performance after the intervention. The mean score increased significantly, rising from 56.16 in the Pretest to 97.92 in the Posttest, showing that students achieved an almost perfect understanding of the material. Additionally, the Standard Deviation (SD) decreased sharply from 19.86 to 3.32, indicating that students' scores became much more consistent. This reduction in variability means that most students scored very close to one another, specifically within the high range of 92 to 100, demonstrating that the intervention not only improved overall performance but also ensured a more uniform mastery of the subject among all learners. The results of the Paired Sample T-Test provide strong statistical evidence supporting the effectiveness of the interactive comic intervention. The Mean Difference (D) of 41.76 confirms that students collectively showed a substantial average score increase 41.76 of points following the treatment. Furthermore, the calculated t-value of 10.24 is exceptionally high, and the associated value is less than .001 ($p < .001$), a finding that is well below the standard α level of 0.05. This highly significant result indicates that the observed improvement in learning outcomes between the Pretest and Posttest is statistically robust and highly unlikely to have occurred by chance. The present findings are consistent with prior research that highlights the importance of interactive and visually enriched media in enhancing student engagement and academic achievement [5]. The N-Gain Index = .953 (95.3%), meaning that students' performance increased by 95.3% of the maximum possible improvement after the learning intervention. This indicates that the learning activity or instructional media was highly effective in improving students' understanding or achievement.

The validation results presented below confirm the high quality and effectiveness of the educational comic media across both its technical design and pedagogical utility. With an overall average percentage of agreement at 97.78 and a mean score of 4.60, the medium is consistently rated as Very Good. This strong consensus validates that the comic not only excels in its Design and Usability (scoring 4.56) but is also highly effective in promoting Learning Engagement and Effectiveness (scoring a near-perfect 4.64), indicating it is a visually appealing and powerful tool for improving student motivation, understanding, and memory retention [38]. The students' responses toward the use of an interactive digital comic following Table 9.

Table 9. Students' Responses toward the Use of Interactive Digital Comic

No.	Aspect Evaluated	Percentage of Agreement (%)	Mean Score (MS)	Category
1	Design and Usability — The comic's visuals, layout, and accessibility (items 1–5)	96.00%	4.56	Very Good
2	Learning Engagement and Effectiveness — The comic's impact on understanding, motivation, and memory (items 6–9)	99.50%	4.64	Very Good
Overall Average		97.78%	4.60	Very Good

Source: research's data

The interactive comic was assessed as possessing a Very Good level of feasibility and high user acceptance among the field group (N = 24), substantiated by an Overall Mean Score (OMS) of 4.60 and a near-unanimous 97.78% Overall Percentage of Agreement. No participants registered any level of disagreement on any item, highlighting the product's strong foundation. Its key strengths lie in Engagement and Access (MS = 4.80), achieving 100% agreement for being interesting (Q1) and easily accessible on Padlet (Q4). High scores (MS = 4.60) also confirmed aesthetic quality (Q2), positive emotions (Q3), and unconfused usability (Q6), along with strong Learning Impact through increased enthusiasm (Q8) and better memory (Q9). The only minor points for review (MS = 4.40) were the two items receiving a single Neutral response concerning understanding the games (Q5) and subject matter comprehension (Q7); however, these still maintained 80% an agreement rate. In sum, the comic is overwhelmingly accepted and fulfills all tested feasibility criteria. This confirms the media's practicality and motivational value in real classroom contexts [40].

Conclusion

The Padlet-based interactive digital comic was confirmed as Highly Valid by content, media, and instructional design experts, all achieving a perfect Scale Content Validity Index (S-CVI/Ave) of 1.00, indicating flawless technical, visual, and pedagogical quality before field implementation. The subsequent Small Group Feasibility Evaluation (N = 5) confirmed this high quality with an Outstanding Overall Mean Score of 4.60 to 4.84 and a near-unanimous 97.78% to 100% agreement, proving the comic is highly accepted, engaging, and usable. Most critically, the comic demonstrated significant effectiveness in the field trial (N = 24), evidenced by a dramatic increase in the Mean learning score from 56.16 (Pretest) to 97.92 (Posttest), and a highly significant Paired Sample T-Test result ($t = 10.24$, $p < .001$). This comprehensive evidence confirms that the digital comic is a highly valid, feasible, and effective educational tool that successfully fosters near-perfect mastery of the subject matter.

Conflict of Interest

The authors declare no conflict of interest.

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