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Local Wisdom-Based Digital Comics for Enhancing Critical Thinking on the Water Cycle in Fifth Grade Elementary School Students

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Abstract

This study was driven by the necessity among teachers and students for engaging learning media capable of enhancing students' critical thinking skills. Specifically, the research aims to describe the process of developing digital comic media grounded in local wisdom related to the water cycle topic, evaluate the feasibility of this digital comic media, measure improvements in students' critical thinking skills through the media, and assess the practicality of using such media in educational settings. The study employs the Research and Development (R&D) methodology utilising the ADDIE framework, which includes five sequential stages: Analysis, Design, Development, Implementation, and Evaluation. The findings indicate that the process of developing digital comics involved initial needs analysis, followed by the design and production phases utilising Coreldraw X7 and Canva applications, including storylines, characters, instructional content, and comic covers. The media was validated by experts, receiving an average validation score of 89% (highly feasible) from media experts, 78% (feasible) from content experts, and 93% (highly feasible) from language experts. Further, the evaluation of students' critical thinking improvement through an N-Gain test resulted in an average score of 0.78, categorised as high, corresponding to an effectiveness percentage of 78.26%. Practicality assessment revealed highly positive feedback, with fifth-grade teacher responses rated at 95% and student responses at 83%, categorising the developed digital comic media as highly practical and valid for enhancing critical thinking skills in classroom learning contexts.

Keywords: *Local Wisdom-Based, Digital Comics Media, Learning Media, Critical Thinking, Water Cycle*

1. Introduction

Improving critical thinking skills at the elementary school level is an important issue in the world of education, especially along with the ongoing curriculum changes in Indonesia. The Merdeka Curriculum is present as a form of educational reform that emphasises the development of competencies, independent learning, poverty, and learning that is contextualised by the context of students' lives. However, various assessment results, both

nationally and internationally, still show that Indonesian students' high-level thinking skills have not developed optimally.

Based on the results of the Program for International Student Assessment (PISA) in 2018, Indonesia was ranked 72nd out of 78 countries in science literacy. These results show that many students still have difficulty analysing, reasoning, and solving problems using scientific information. (Arjaya et al., 2024; Hake, 1998; Kwangmuang et al., 2021; Pisa, 2019). This situation is of particular concern in the subjects of Natural Sciences (IPA) and Social Sciences (IPS) to help students understand scientific and social issues through an interdisciplinary approach. But the facts in the field, the implementation in the classroom, are still not optimal in supporting the development of students' critical thinking skills. (Amini & Sinaga, 2021; Hakim et al., 2022; Kwangmuang et al., 2021; Lugina, 2018).

A study found that engaging young learners in critical scientific thinking can be done digitally. (Ahied et al., 2020; Kwangmuang et al., 2021; Nguyen et al., 2018; Zaibon et al., 2019). In line with other studies, namely, teachers who involve students in developing digital comics based on local wisdom in studying the air cycle, a fundamental topic in the science and social studies curriculum for fifth graders, have a positive impact, the experience of changing students' perspectives. (Bloom & Quebec Fuentes, 2019). Research on comics in science education states that narrative visuals help bridge the abstractness of scientific content with students' prior knowledge, but little research connects this potential with local wisdom-based content that is tailored to specific regional contexts in Indonesia. (Arjaya et al., 2024; Harefa, 2024; Nguyen et al., 2018). This proves that integrating cultural relevance into educational materials can significantly improve learning outcomes, including motivation, engagement, and deeper understanding of concepts. (Eisenberg et al., 2021; Khoiriyah & Suprapto, 2021; Ladson-Billings, 2014; Spatioti et al., 2022).

Research examining the relationship between the use of digital comic media, the integration of local environmental wisdom values, and the development of critical thinking skills in the context of learning Natural Sciences (IPA) and Social Sciences (IPS) is still relatively limited and has not been explored in depth. These three elements have great potential in creating meaningful, contextual learning experiences, and can encourage students to think reflectively and analytically. (Ahied et al., 2020; Ningrum & Murti, 2023; Saggaf et al., 2017). Therefore, a comprehensive study is needed to explore how innovative learning media such as digital comics can be utilised effectively in conveying local values while stimulating students' critical thinking skills, especially at the elementary education level.

This study has two main objectives. First, to design learning media in the form of digital comics that integrate ecological knowledge with local cultural narrative elements from the Setu Patok area, which are thematically related to the concept of the water cycle. Second, to evaluate the effectiveness of the media in improving students' critical thinking skills, through a comparative analysis of assessment results before and after the learning intervention. More broadly, this study aims to examine the potential of digital storytelling based on local wisdom as a transformative pedagogical approach to bridge the gap in scientific literacy and foster critical awareness from an early age.

2. Methods

This study adopts a Research and Development (R&D) methodology, with the specific aim of developing and validating a digital comic based on local wisdom to enhance critical thinking among fifth-grade elementary school students. The process was guided by the ADDIE development model (Analyse, Design, Develop, Implement, and Evaluate) and integrates empirical procedures for validation, practicality testing, and effectiveness analysis. (Kwangmuang et al., 2021; Mergler & Hoyer, 1977; Richey & Klein, 2013).

The data for this study were collected through multiple sources and instruments. (Spatioti et al., 2022). Primary data were obtained from questionnaires distributed to three groups: (1) subject matter experts, (2) language and media validators, and (3) fifth-grade students and teachers involved in classroom trials. (Abuhassna et al., 2024; Cuban, 2004; Hake, 1998; Kwangmuang et al., 2021; Shahid & Khanam, 2024). The expert validation involved six experts (two for each area of validation), while the practicality and effectiveness testing involved 30 students and 2 classroom teachers from two elementary schools in the Kandangan District. Data collection techniques included direct observation, structured interviews, and self-administered questionnaires using both digital and printed forms.

Before analysis, the collected data underwent preprocessing to ensure integrity and reliability. Incomplete or inconsistent responses were excluded from the dataset. Questionnaire items were reviewed for internal consistency and semantic clarity. Validity testing was carried out through expert judgment, while reliability testing employed Cronbach's Alpha analysis. (Radeswandri et al., 2021; Zaibon et al., 2019). All data were encoded and standardised to prepare for statistical analysis.

The analytical procedures consisted of descriptive statistics, validation scoring, paired sample t-tests, and N-Gain analysis. For expert validation, scores were calculated using the feasibility percentage formula:

$$\rho = \frac{\sum \chi}{\sum \chi\iota} \times 100\%$$

Keterangan:
p = Percentage of feasibility
$\sum x$ = Total score given by validators
$\sum xi$ = Maximum possible score

Where ρ represents the feasibility percentage, $\sum \chi$ is the total score provided by all validators, and $\sum \chi\iota$ It is the maximum possible score. The feasibility criteria based on the percentage score are presented in the Table:

Table 1. Validation Criteria

No	Score Range	Category
1	0 – 20%	Very Not Valid
2	21 – 40%	Not Valid
3	41 – 60%	Fairly Valid
4	61 – 80%	Valid
5	81 – 100%	Very Valid

Following expert validation, the product's practicality was tested by obtaining responses from classroom teachers and students. This feedback served as an essential component for refining the media based on direct user experience. (Keskitalo, 2022).

The data analysis in this study comprised normality testing, paired sample t-tests, and an effectiveness evaluation using the N-Gain test. (Hake, 1998). The N-Gain test was selected for its robustness in measuring the improvement in students' learning outcomes before and after the use of the product. The formula used to calculate the N-Gain is:

$$N\ Gain = \frac{Pos\ Tes - Pre\ Tes}{Skor\ Max - Pre\ Tes}$$

Questionnaire items were developed based on Bloom's taxonomy and validated against prior instruments. (Radeswandri et al., 2021; Zaibon et al., 2019). The validation included both content and construct validation by appointed experts. The interpretation of the N-Gain scores follows the categories outlined in Tables 2 and 3:

Table 2. N-Gain Skor Criteria

N-Gain Value	Category
> 0,7	High
0,3 – 0,7	Moderate
< 0,3	Low

Table 3. N-Gain Percentage Effectiveness Criteria

N-Gain (%)	Category
< 40	Not Effective
40 – 55	Less Effective
56 – 75	Moderately Effective
>76	Effective

The research was evaluated across three dimensions: validity, practicality, and effectiveness. Validity was determined based on the validators' score categories as outlined in Table 1 (Validation Criteria), where a product scoring above 81% was categorised as "Very Valid." Practicality was measured through Likert-scale-based responses from teachers and students regarding the usability and clarity of the media. Effectiveness was interpreted using the N-Gain Score Criteria (Table 2) and Percentage Effectiveness Criteria (Table 3). These evaluations confirmed whether the developed comic met educational standards and improved students' learning outcomes.

Instrument reliability was confirmed via a pilot study, and the internal consistency coefficient (Cronbach's Alpha) was 0.81, indicating high reliability. All instruments were developed by the research team and adapted from previously validated tools with cited permission.

This study was conducted by ethical research guidelines established by the Syekh Nurjati State Islamic Cyber University. Participants were informed about the purpose of the study and provided written consent. Anonymity and confidentiality of all respondents were strictly maintained, and all data were stored in encrypted databases. Ethical clearance for this research was approved by the university's institutional review board.

3. Results and Discussion

3.1. *Analyse*

The initial phase of the ADDIE model, Analysis, is pivotal in ensuring that the developed educational product aligns with the learners' needs. In this study, a needs assessment was conducted using a structured questionnaire targeting students' requirements for learning media, particularly in the context of Integrated Science and Social Studies.

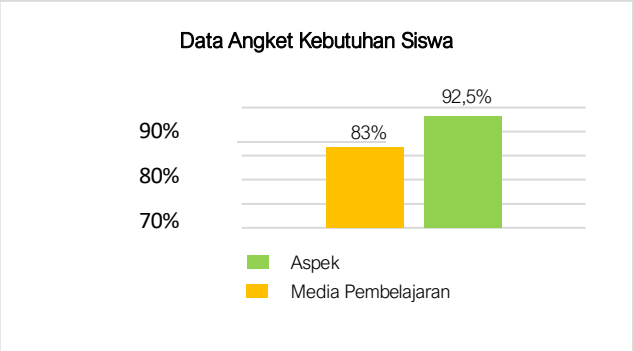


Figure 1. Needs Questionnaire

The analysis revealed that 83% of students expressed a significant need for engaging learning media, while 96.5% highlighted challenges in comprehending science and social studies content without supportive tools. These findings underscore the necessity for innovative instructional materials that can bridge the gap between abstract concepts and students' understanding.

The percentage findings indicate that the vast majority of students express a significant need for supportive media in the learning process of Science and Social Studies. This discovery is highly relevant as a foundational basis for product development, as it reflects the actual conditions encountered in the classroom. Students often face substantial challenges in understanding science and social studies material, which can be abstract and complex when conveyed solely through verbal explanation without the assistance of adequate instructional media. Consequently, the integration of educational media emerges as a rational solution to mitigate these pedagogical obstacles.

The high percentage of students identifying a need for learning media, 83%, suggests that the majority perceive instruction as being considerably more effective when facilitated by visual, auditory, or interactive tools. Engaging and interactive instructional media are believed to enhance student concentration, support the comprehension of complex concepts, and foster active learner participation. This aligns with the principles of constructivist learning theory, which asserts that students construct their knowledge through direct experiences, particularly when such experiences are scaffolded by appropriate media interventions.

Moreover, the figure of 96.5% about science and social studies specific learning challenges explicitly indicates the presence of subject-specific difficulties as perceived by the students. This may stem from the interdisciplinary nature of science and social studies, which combines both natural and social sciences. As a result, it often demands a comprehensive understanding and a pedagogical approach that is more integrative and innovative. In such a context, instructional media serve not merely as auxiliary tools but as facilitators that enable learners to synthesise abstract scientific concepts with concrete social phenomena encountered in daily life.

This needs analysis underscores the urgency and significance of the educational product that is to be developed. The design of the science and social studies instructional media should be deeply informed by student characteristics and the specific learning difficulties they encounter. As such, the intended media must transcend its basic function as a teaching aid by also enhancing student engagement, boosting motivation, and simplifying the acquisition of complex knowledge. Methodologically, this phase of needs analysis is a critical step in ensuring that the product development process is genuinely needs-based and responsive to the distinctive challenges of science and social studies instruction.

Furthermore, the findings recommend that throughout the product development process, special attention should be paid to the practicality and usability of the resulting media. The instructional product must be user-friendly and seamlessly integrable into everyday classroom activities. Accordingly, this needs analysis serves as an essential guide for the subsequent stages of design and development. The final product should demonstrably address the explicit educational needs identified during this analytical phase, ensuring that it is both pedagogically effective and contextually relevant.

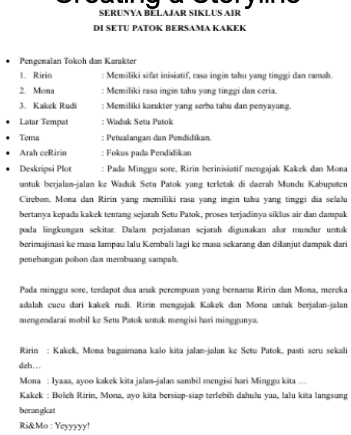
3.2.*Design*

In the Design phase, the development of digital comics was initiated using Coreldraw X7 and Canva. The process involved creating a storyboard to outline the narrative flow, designing characters that resonate with the target audience, and crafting a compelling cover to attract learners' interest.

Comic Design

Figure 2. Comic Design

Creating a Storyline



SERUNYA BELAJAR SIKLUS AIR
DI SETU PATOK BERSAMA KAKEK

- Pengenalan Tokoh dan Karakter
  1. Ririn : Memiliki sifat inisiatif, rasa ingin tahu yang tinggi dan ramah.
  2. Mona : Memiliki rasa ingin tahu yang tinggi dan ceria.
  3. Kakek Rudi : Memiliki karakter yang serba tahu dan penyayang.
- Latar Tempat : Waduk Setu Patok
- Tema : Petualangan dan Pendidikan.
- Arah ceRirin : Fokus pada Perdidikan
- Deskripsi Plot : Pada Minggu sore, Ririn berinisiatif mengajak Kakek dan Mona untuk berjalan-jalan ke Waduk Setu Patok yang terletak di daerah Mundu Kabupaten Cirebon. Mona dan Ririn yang memiliki rasa yang ingin tahu yang tinggi dia selalu bertanya kepada kakek tentang sejarah Setu Patok, proses terjadinya siklus air dan dampak pada lingkungan sekitar. Dalam perjalanan sejarah digunakan alur mundur untuk berimajinasi ke masa lampau lalu Kembali lagi ke masa sekarang dan dilanjut dampak dari penebangan pohon dan membuang sampah.

Pada minggu sore, terdapat dua anak perempuan yang bernama Ririn dan Mona, mereka adalah cucu dari kakek rudi. Ririn mengajak Kakek dan Mona untuk berjalan-jalan mengendarai mobil ke Setu Patok untuk mengisi hari minggunya.

Ririn : Kakek, Mona bagaimana kalo kita jalan-jalan ke Setu Patok, pasti seru sekali deh…
Mona : Iyaaa, ayoo kakek kita jalan-jalan sambil mengisi hari Minggu kita …
Kakek : Boleh Ririn, Mona, ayo kita bersiap-siap terlebih dahulu yaa, lalu kita langsung berangkat
Ri&Mo : Yeyyyyy!

Figure 3. Storyline

Creating Character Concepts and Characters

Figure 4. Character Concepts and Figures

Making a Cover

Figure 5. Cover

The content was meticulously aligned with the science and social studies curriculum, ensuring that the material not only engages but also educates. The integration of local wisdom into the storyline aimed to enhance cultural relevance and promote environmental awareness among students.

3.3. *Development*

3.3.1 Media Expert Validation

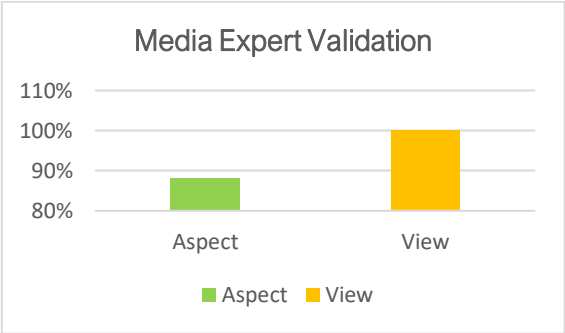


Figure 6. Media Expert Validation

The assessment of the visual and instructional design aspects of the media was carried out by media experts, resulting in a validity score of 89%. Based on these results, the learning media was assessed in the "very valid" qualification, indicating that the media is suitable for use in the context of learning, both in terms of visual aesthetics and the effectiveness of delivering instructional information.

3.3.2 Content Expert Validation

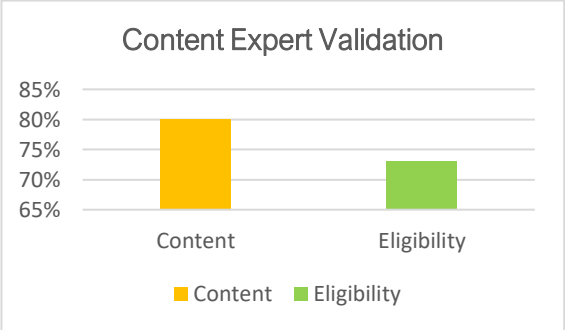


Figure 7. Content Expert Validation

Evaluation of the accuracy and relevance of the material was carried out by content experts, resulting in a validity score of 78%. This score indicates that the content presented in the learning media is in the "valid" category, so it is considered to have met the standards of material eligibility for use in an educational context. These results reflect that the substance of the material is by learning objectives and is relevant to the needs of students.

3.3.3 Language Expert Validation

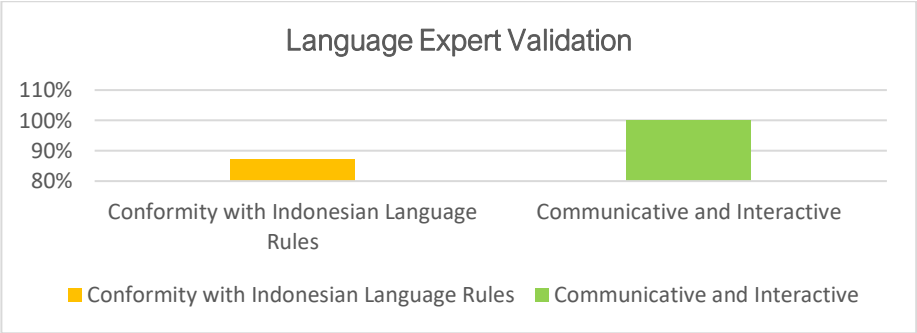


Figure 8. Language Expert Validation

The study of the linguistic aspects was carried out by language experts, who included an assessment of clarity, readability, and appropriateness of language use in the learning context. The results of the image above show a validity score of 93%, which indicates that the use of language in the learning media is at a very high level of appropriateness. This shows that linguistically, the media has met the linguistic standards that support optimal student understanding.

3.4.*Implementation*

The Implementation phase involved deploying the digital comic in a classroom setting and evaluating its impact on students' critical thinking skills. (Khoiriyah & Suprapto, 2021). A pretest-posttest design was utilized:

3.4.1 Pretest-Postest Result

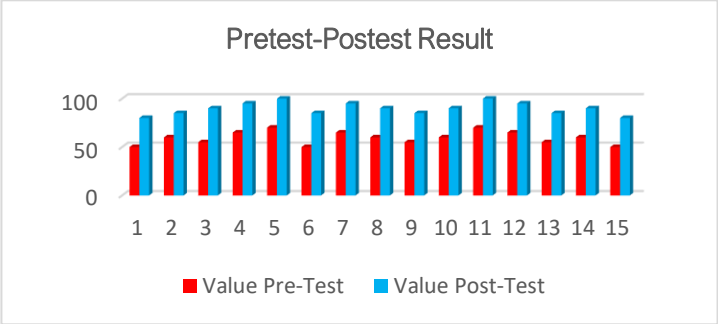


Figure 9. Pretest-Postest Result

The results of the data analysis showed that there was a significant increase in students' scores after they were involved in learning using digital comics. This finding indicates a substantial improvement in conceptual understanding and strengthening of students' critical thinking skills. This increase reflects the effectiveness of digital comic media as a learning aid that can stimulate students' cognitive involvement and support the achievement of learning objectives more optimally.

3.4.2 Normality Test

The pretest scores were normally distributed ($p > 0.05$), while the posttest scores were not ($p < 0.05$), necessitating the use of non-parametric tests for further analysis.

3.4.3 Wilcoxon Signed-Rank Test

The test revealed a significant difference between pretest and posttest scores ($p < 0.05$), confirming the effectiveness of the digital comic in improving students' critical thinking skills.

3.4.4 N-Gain Analysis

The normalized gain score was 0.78, categorizing the improvement as high. This metric reflects the substantial learning gains achieved through the intervention.

3.5.*Evaluation*

The final phase, Evaluation, focused on gathering feedback from both teachers and students to assess the practicality and acceptability of the digital comic:

3.5.1 Teacher Feedback

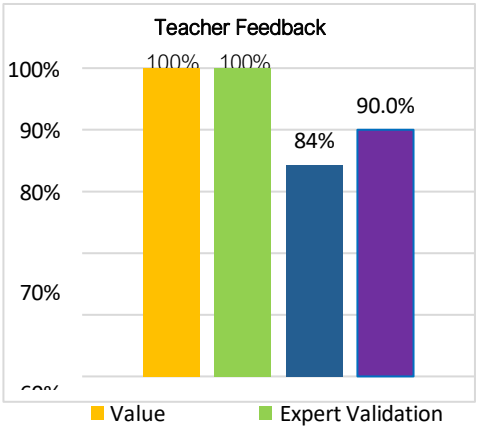


Figure 10. Teacher Feedback

Teachers involved in the implementation process reported a 95% satisfaction rate with the use of digital comics as a learning medium. This high level of satisfaction reflects a positive perception of the effectiveness of comics as a teaching aid that is not only visually appealing but also aligned with the learning outcomes set in the curriculum. In addition, this media is considered capable of facilitating a more contextual, interactive, and meaningful learning process for students.

3.5.2 Student Feedback

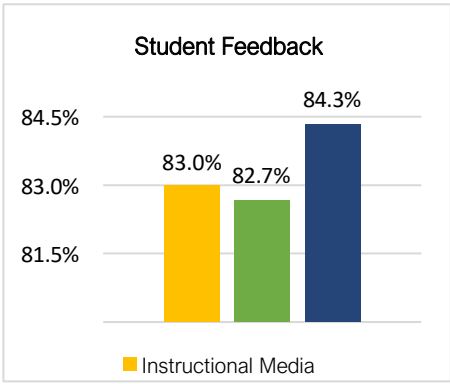


Figure 10. Student Feedback

Students expressed an 83.3% satisfaction rate, noting the comic's engaging content, clarity, and its role in facilitating better understanding of complex concepts.

In light of the results, instructional media serve as a tool for conveying messages or information that align with specific educational goals. In accordance with the demands of 21st-century education, educators are expected to provide learning experiences that are engaging, enjoyable, and stimulating. Furthermore, teachers must be capable of designing innovative learning processes and possess pedagogical competencies that are responsive to technological and pedagogical advancements. Within the instructional process, it is imperative that teachers demonstrate the ability to design and implement effective learning media that facilitate student understanding.

This notion is supported by the findings of Waisakanitri, who demonstrated the effectiveness of digital comics as instructional media in science education (Waisakanitri et al., 2023). Their study reported a *t*-test value of *t*_{calculated} = 3.69, exceeding the *t*_{table} value of 2.021 at a 5% level of significance. Based on this result, it can be concluded that the development of digital comic media is statistically effective and suitable for enhancing science learning outcomes in fifth-grade elementary education. This underscores the relevance of digital comics as a pedagogical innovation that supports content comprehension and learner engagement.

4. Conclusions

The development of a local wisdom-based digital comic was conducted using the ADDIE model, which comprises the stages of Analysis, Design, Development, Implementation, and Evaluation. The comic was designed with the aid of CorelDRAW X7 and Canva applications, incorporating essential elements such as storyline, characters, instructional content, and cover design. The validation process yielded a media expert score of 89%, categorised as highly feasible; a content expert score of 78%, categorised as feasible; and a language expert score of 93%, also categorised as highly feasible.

Furthermore, the effectiveness of the developed digital comic was assessed through an N-Gain analysis, which produced an average score of 0.78, indicating a high level of effectiveness, while the N-Gain percentage reached 78.26%, placing it within the effective category. In terms of practicality, the comic received positive responses from both users and educators, with fifth-grade homeroom teachers giving a score of 95% and students giving a score of 83%.

Based on these results, it can be concluded that the developed local wisdom-based digital comic meets the criteria of being highly valid and highly practical, thus representing an effective and feasible instructional medium for enhancing learning outcomes.

This study certainly has limitations, namely the development and testing of digital comics based on local wisdom were only carried out on fifth grade students in one elementary school. The results of this study cannot necessarily be generalized to other levels of education, different regions, or students with different backgrounds. In addition, the media was developed using the CorelDRAW X7 and Canva applications, which have limitations in interactivity features. If the media is developed with other software or technology such as interactive animation or web-based digital platforms, the results and user experience may be different. Digital comics may be more effective for students with visual learning styles, but less optimal for students who have kinesthetic or auditory preferences. and most importantly Not all schools or students have adequate access to digital devices, so the implementation of this media can experience technical constraints. Considering these limitations, there is still an opportunity for further improvement and development in the future.

5. CRediT Authorship Contribution Statement

Firyal Dwi Ezrina Suharta and Nur Atikoh: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Project administration, Resources, Software, Validation, Visualization, Writing–original draft, and Writing–review & editing. **Atikah Syamsi and Mohammad Syafiudin:** Conceptualization, Supervision, Validation, and Writing–review & editing.

6. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

7. Acknowledgements

Acknowledgments is where you acknowledge individuals who do not qualify for co-authorship but have contributed to your article intellectually, financially, or in some other manner. Acknowledging someone in your academic texts enhances your integrity as a writer by demonstrating that you are not claiming the ideas of other academics as your own intellectual property.

8. Data Availability

Data will be made available on request.

9. Ethical Approval

Ethical approval No patient-identifying parts in this paper were used or known to the authors. Therefore, no ethical approval was requested.

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