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Development of Digital Education Comics on Style Around Us to Improve IPAS Learning Outcomes

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A B S T R A C T

This study aims to describe the development design, test the feasibility and effectiveness of Digital Education Comics to improve the learning outcomes of fourth-grade students at SDN Sadeng 03 Elementary School in Semarang City. The type of research used is Research & Development (R&D) with the Borg and Gall development model. The development design of the Digital Education Comic includes components such as the cover, preface, table of contents, learning outcomes, learning objectives, character introduction, reading instructions, content material, bibliography, and developer profile. The feasibility of the Digital Education Comic was assessed by subject matter experts (93.75%), media experts (90.63%), teacher responses (93.75%), and student responses (100%) with the criterion of highly feasible. The effectiveness of the Digital Education Comic is demonstrated by an increase in pretest and posttest results of 23.50%, the results of the paired sample t-test with a sig. value (2-tailed) < 0.001, indicating a significant difference, and the N-Gain test results of 0.663 with a moderate criterion. The conclusion of this study indicates that the Digital Education Comic has been successfully developed, is feasible, and effective in improving the learning outcomes of fourth-grade students at SDN Sadeng 03 Elementary School in Semarang on the topic of forces around us.

1. Introduction

Education serves as a strategic foundation in shaping individuals who are not only intelligent but also possess strong character and adaptability to the evolving times. According to Sayyidi et al. (2020), in the era of disruption, global challenges, and technological advancements, education must go beyond merely transferring knowledge; the learning system must be able to cultivate character, religious values, and the independence of learners. This is reinforced by Government Regulation No. 4 of 2022 on National Education Standards, which emphasizes the importance of integrating the values of Pancasila, religion, morality, as well as character and 21st-century skills at all levels of education. Each level of education plays a strategic

role and has a significant impact on the development of students, particularly at the elementary school level.

Students at the elementary education level require an educational approach that is appropriate for their stage of development. The learning process involves not only the delivery of material, but also active interaction between students, educators, and learning resources available in the school environment, thus necessitating an understanding of student characteristics in order for the learning process to be optimized. Research by Swihadayani (2022) shows that a learning approach that takes into account the cognitive and social development characteristics of students can significantly improve motivation and learning outcomes.

This reinforces the view that learning strategies designed to be contextual and varied are essential in the early stages of primary education. According to Sudianto et al. (2023), students at the elementary school level are in the concrete operational stage within Piaget's cognitive development theory framework. At this stage, children begin to demonstrate logical thinking abilities regarding real or concrete objects. This thinking process still requires support in the form of visual aids and direct experiences to ensure optimal understanding.

The cognitive development of students can be seen from their ability to categorize, identify, and sequence based on certain characteristics. In addition, students at this stage also begin to demonstrate their ability to actively speak and understand basic cause-and-effect concepts. According to Sari et al. (2025), children of elementary school age are in the process of developing thinking skills that are not yet fully mature, so learning needs to be designed in a concrete and contextual manner to suit their limited thinking abilities, which are still focused on real-world matters.

Upper-grade students (grades IV–VI) in elementary school generally demonstrate more complex thinking abilities. Children begin to think logically, systematically, and critically in a broader context. Additionally, they also demonstrate a high level of curiosity, enthusiasm for learning, a realistic attitude, and interest in specific subjects or fields. Fauziah et al. (2025) noted that during the concrete operational stage, children begin to understand the principle of conservation of mass and volume and can solve simple problems through a logical approach based on direct experience.

Science and Social Studies (IPAS) learning is an integration of two scientific fields, namely Natural Sciences (IPA) and Social Sciences (IPS), which aims to deepen students' understanding of concepts while honing their skills in accordance with the established learning outcomes. The IPAS learning process at the elementary school level requires methods that are in line with children's cognitive development. Referring to the concrete operational stage experienced by elementary school-aged students, learning media that can visualize abstract concepts into more concrete and easily understood forms are needed (Suningsih et al., 2021). Therefore, learning media that are attractive, interactive, and contextual play an important role in fostering learning interest and encouraging students' critical thinking skills regarding material that is considered complex. The results of Praja et al. (2025)

research indicate that the use of technology-based and interactive media can increase students' motivation and understanding of IPAS material because it allows students to relate the concepts they learn to real phenomena in their surroundings.

Various efforts have been made to optimize the quality of the learning process, one of which is through the use of learning media. Learning media plays an important role in supporting the continuity of learning activities. Madina et al. (2023) state that the use of learning media provides a number of benefits, including facilitating the achievement of learning objectives more efficiently and increasing effectiveness in the process of delivering material. Educational media not only function as visual or audio aids but also play a role in creating more standardized, engaging, and interactive learning experiences. According to Nurfadhillah et al. (2021), the use of media can accelerate learning time, improve the quality of learning outcomes, allow access to materials anytime as needed, and attract students' interest in the material being studied. Educational media also influences the role of teachers, who increasingly innovate as active and creative learning facilitators.

Based on the results of preliminary research conducted through observation and document analysis in class IV of SDN Sadeng 03 Semarang City with 16 students, several problems were found in the implementation of learning. The identified problems were the suboptimal use of technology-based learning media with a narrative or storytelling approach by teachers, which resulted in low student learning outcomes. Data from the diagnostic assessment showed that 12 students (75%) scored below the Learning Objective Achievement Criteria (LOAC), while only 4 students (25%) achieved scores above the established LOAC of 70.

Students still have difficulty understanding the material presented by teachers, especially in IPAS lessons on forces around us. Interviews with teachers revealed that most students still have misconceptions regarding the basic concepts of force and its effects on objects. Based on a needs assessment survey, 87.5% of students indicated a need for visually appealing and interactive learning materials. Additionally, 93.75% of students expressed a preference for reading materials rich in images. Students at the elementary school level, aged 6-12 years, are in the concrete operational stage of cognitive development. Children's logical thinking abilities are still limited and highly dependent on tangible and visual elements. Based on these characteristics, the researcher views the development of learning media in the form of comics as a relevant and appropriate alternative that aligns with the needs and learning patterns of students in this age range.

Comics are a medium used to convey ideas through a combination of images, text, and other visual elements. Currently, comics are one of the most popular media among children and teenagers due to their attractive appearance and easy-to-understand presentation. According to Anjani et al. (2023), comics can be an effective learning medium because they can adapt their content and presentation to the characteristics of learners, thereby increasing reading interest and understanding of the material. Comics are not only for entertainment but also a potential educational tool in improving learners' academic performance in the current digital era. The characteristics of educational comics are unique and appealing because

they combine visuals and narratives appropriate for children's ages. Their creation is flexible, allowing content to be adapted to the characteristics of learners and incorporating contextual issues that encourage learners to think critically through educational storylines. Research conducted by Pangesti et al. (2024) shows that the use of Digital Education Comic media has a significant impact on improving students' critical thinking skills. This is evident from the significant difference between pretest and posttest results, which serve as an indicator of the success of using this media. Thus, Digital Education Comics can be an effective alternative learning medium.

Based on the background described above, the development of Digital Education Comics by researchers presents an innovation in IPAS learning for fourth graders on the subject of forces around us. The development of Digital Education Comics is expected to increase student motivation, cognitive abilities, and learning outcomes. This study aims to describe the development design, test the feasibility, and measure the effectiveness of the Digital Education Comic in improving the learning outcomes of fourth-grade students in SDN Sadeng 03, Semarang City.

2. Methodology

This study uses a Research and Development (R&D) research design. According to Sugiyono (2023), research and development is a method aimed at researching, designing, producing, and testing the validity of the developed product. In this study, the researcher adopted the Borg & Gall development model, which has been adapted by Sugiyono (2023), with 10 implementation stages, including: (1) potential and problems; (2) data collection; (3) product design; (4) design validation; (5) design revision; (6) initial testing; (7) product revision; (8) usability testing; (9) product revision; and (10) mass production. The flow of the Borg & Gall model development stages can be seen in Figure 1.

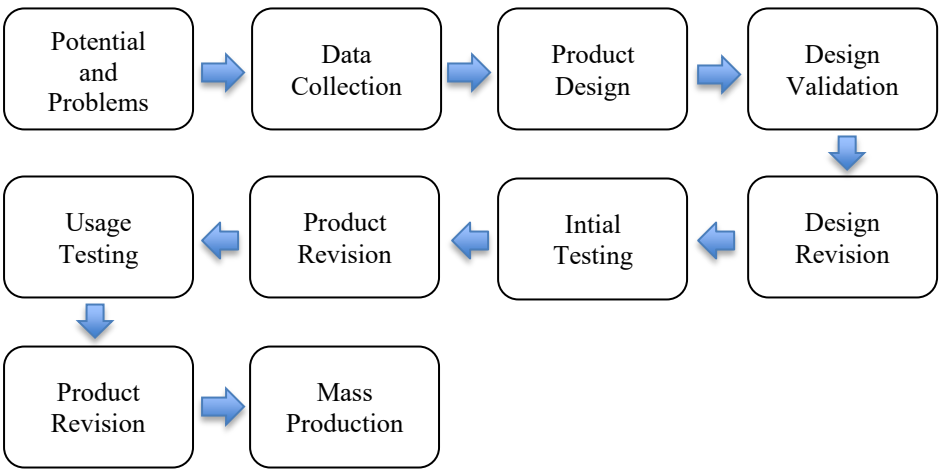

Figure 1. Borg and Gall Development Design (Sugiyono 2023)

This study was conducted at SDN Sadeng 03 Semarang City in the even semester of the 2024/2025 academic year, involving 16 students. Six students were used as subjects in the initial small group trial phase, while the other 10 students became subjects in the large group trial phase. The data collection techniques used included non-test methods, such as observation, interviews, questionnaires, and documentation, as well as test methods through the implementation of pre-tests and post-tests. Initial data analysis was conducted using a normality test, while final data analysis utilized a paired sample t-test and N-Gain calculations to measure improvements in learning outcomes.

3. Results and Discussion

This study produced a product in the form of a Digital Education Comic for teaching IPAS material on forces around us in grade IV at SDN Sadeng 03 Elementary School in Semarang City. The results of the study include: (1) the design of the Digital Education Comic on Forces Around Us; (2) the feasibility of the Digital Education Comic on Forces Around Us; and (3) the effectiveness of the Digital Education Comic on Forces Around Us.

Design Development of Digital Education Comics on Style Around Us

Potential and Problems

The initial stage carried out by researchers is to identify potential and problems. At this stage, researchers conduct pre-research activities such as observation, interviews, questionnaires, and documentation. Based on the results of pre-research conducted in class IV of SDN Sadeng 03, several problems were found. Teachers have not been optimal in using technology-based learning media that are narrative in nature, and the learning media used are not interactive enough, making them less engaging and less effective in facilitating students' understanding of the material. The low level of student activity in learning is attributed to the use of uninteresting methods, and low motivation and interest among students are also major contributing factors (Khairani et al., 2024). In IPAS learning, students face difficulties in understanding the basic concepts of force and types of force. Additionally, students have misconceptions about the effects of force on objects. This results in low learning outcomes for IPAS material on forces around us.

SDN Sadeng 03 has the potential to support the implementation of optimal learning activities. SDN Sadeng 03 has a range of learning facilities that are quite complete and adequate. Each classroom is equipped with a projector or LCD device, enabling teachers to deliver material in a visual and interactive manner. Additionally, the availability of an internet network supports teachers in presenting materials and implementing digital-based learning. With these potentials, SDN Sadeng 03 has a great opportunity to implement innovative, creative, and technology-aligned learning models. The optimal utilization of available facilities can support the creation of more engaging, interactive, and meaningful learning experiences for students. Based on the analysis of existing potential and challenges, the researcher

identified students' needs to improve learning outcomes. From this analysis, the researcher then developed an educational technology-based learning tool, namely the Digital Education Comic on the topic of Forces Around Us.

Data Collection

After the potential and problems have been identified, the next stage is data collection, which serves as the basis or foundation for designing products that are specifically tailored to the needs that have been identified (Sugiyono, 2023). The data collection process is carried out by distributing response questionnaires to teachers and students to find out their needs in learning activities. The survey results indicate that teacher and student textbooks are considered ineffective because they require repetition of material to be understood properly. Additionally, time constraints in learning encourage teachers to seek innovative media that use language appropriate to the cognitive development of students. The proposed learning media concept received positive feedback and support from both teachers and students. In line with the times, students also need learning media that not only contains text but is also equipped with colorful images to increase appeal and strengthen understanding of the material.

Based on this data, it can be concluded that it is necessary to develop learning media that is interesting, in line with technological advances, and includes visual elements such as images and colors, while still paying attention to the content that must be conveyed. In addition, the learning media developed must be relevant to current educational needs and still refer to the applicable curriculum standards so that it can be used optimally in learning activities.

Product Design

The third stage is product design. The products developed through research and development are expected to contribute to improving the quality of education delivery. (Zahroh et al., 2022). This Education Comic Digital Material on Styles Around Us is also accompanied by videos so that students can learn through visual and audio-visual experiences. This Digital Education Comic is structured based on the Learning Outcomes (LO) and Learning Objectives (LO) that have been established. The development of the Digital Education Comic incorporates a concept that includes dialogue between characters, animated illustrations, appealing color combinations, and videos tailored to the developmental level of the students to make the material easier to understand.

This digital educational comic was created using the Canva application, incorporating elements designed to form a coherent storyline about the styles around us. In addition to displaying dialogue between characters, this medium also includes videos to support the learning material. The size of the Digital Education Comic created is 21 x 29.7 cm, which is ideal for display on mobile devices such as smartphones and laptops. The final product is in the form of a digital book, so the design created needs to be extracted using an additional application called Heyzine. The process of creating this media includes inserting videos into the

previously designed pages. The completed Digital Education Comic will then be shared via a link that requires an internet connection to access it. The Digital Education Comic Style Around Us consists of the following displays: (1) Cover display; (2) Preface display; (3) Table of contents display; (4) Learning outcomes display; (5) First and second learning objective view; (6) Character introduction view; (7) Digital Education Comic reading instructions view; (8) Content view; (9) Bibliography view; (10) Developer profile view. The Digital Education Comic views can be seen in Figures 2, 3, 4, and 5.

Figure 2. Cover Display and Character Introduction

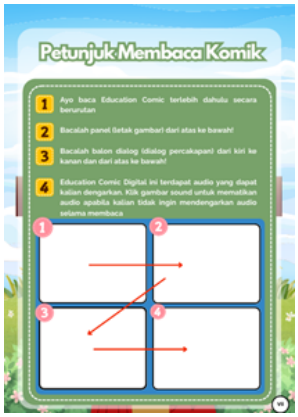

Figure 3. Reading Instructions Display

Figure 4. Display of Learning Outcomes and Learning Objectives

Figure 5. Content Display

Steps for designing the Education Comic Digital Gaya di Sekitar Kita: 1) Prepare the concept and prototype; 2) Design the product content in accordance with the learning materials in Canva; 3) Extract the Canva design into Heyzine.

Design Validation

The fourth stage is design validation, which is carried out after the product design is complete. The developed design is assessed by experts to evaluate the product's feasibility before it is applied in small group trials (Fuadi et al., 2025). This assessment aims to determine whether the product is ready for use or still needs improvement. The instrument used is a structured questionnaire designed to measure various aspects. The assessment is carried out by two parties, namely media experts and material experts. Media experts assess visual aspects, appearance, technical feasibility in terms of presentation, and ease of use. Meanwhile, material experts assess the suitability of the content with the learning objectives, the accuracy of the information, and the overall feasibility of the material. Feedback from the validators, whether in the form of evaluations, critiques, or suggestions, serves as a reference for revising and refining the product to make it more optimal before it is implemented in the learning process. Based on the validation results from both experts, the product, an Education Comic Digital with the topic Styles Around Us, was deemed valid and falls into the category of highly suitable for use as a learning medium.

Design Revision

The fifth stage was design revision. Researchers revised the learning media design according to the directions, criticism, and suggestions from subject matter and media experts. Suggestions from media experts included changing the font type and bolding the text. Suggestions from subject matter experts included inserting worksheets in the form of QR codes into the storyline. The results of the revision of the Digital Education Comic can be seen in Figures 6, 7, 8, and 9.

Figure 6. Font Display Before Revision

Figure 7. Font Display After Revision

Figure 8. Presentation of Material Before Revision

Figure 9. Presentation of Material After Revision

Initial Testing

The sixth stage of this research was the initial trial. At this stage, the researchers continued the development process by conducting an initial trial of the Education Comic Digital Material Gaya di Sekitar Kita. The initial trial was conducted on a small group of six fourth-grade students at SDN Sadeng 03 in Semarang to obtain feedback and suggestions for improvement before the product was used on a larger scale. In the initial trial, the six students were selected and grouped based on their academic ability, which was classified into three categories: less proficient, proficient, and highly proficient. Before the initial trial, the researcher first administered a pretest to the students to identify their initial abilities. After the trial, the researcher administered a post-test to the students to assess their learning outcomes. The researcher also distributed response questionnaires to teachers and students to gather information regarding their responses, perceptions, and evaluations of the quality and suitability of the developed learning media. The data obtained from these questionnaires served as the basis for determining whether revisions were necessary before proceeding to the large-scale usage trial phase.

Product Revision

The seventh stage is product revision, which is carried out as a follow-up to the assessment of the feasibility and effectiveness of the developed product. Developers conduct an in-depth analysis of the results of initial trials conducted on a small group to identify any remaining shortcomings or weaknesses, whether in terms of design, content, or other technical aspects, so that the product can be refined before being used more widely. The revision is based on questionnaires filled out by teachers and students in the small group. Feedback and responses are important considerations in refining the product. The revised aspects include visual appearance, content structure, interactivity, and the suitability of the material to the needs and characteristics of the students. The analysis of the responses provided by teachers and students shows that the developed product has met the established criteria, so no further revisions are needed. This indicates that the product has met the established criteria and is therefore highly suitable for proceeding to the testing phase with a larger group.

Usage Testing

The eighth stage was a trial run, conducted to test the effectiveness of the product on a large group. The developed product was implemented on a large group, namely 10 fourth-grade students at SDN Sadeng 03 in Semarang City. Before the product was applied in the learning process, the researcher first gave a pretest to the students to identify their initial abilities. After the learning activities using the product were conducted, the students were given a post-test to determine the improvement in learning outcomes. In addition to the tests, data collection was also conducted through the distribution of questionnaires to teachers and students to obtain information regarding their responses, evaluations, and perceptions of the suitability and effectiveness of the Digital Education Comic with the "Styles Around Us" material that had been developed.

Product Revision

The ninth stage in the development process is the final product revision stage. This stage is the final step taken by researchers before the product is mass produced. The revision process is carried out by referring to data from trials on large groups, which is obtained through questionnaires completed by teachers and students after using the product in learning activities. This revision process is a final refinement based on the feedback provided, so that the quality of the product can be maximized. Based on the results of the questionnaire analysis, it was found that there were no deficiencies or aspects that needed improvement in the developed product. This indicates that the product has met the standards of suitability and effectiveness, so no further revisions are required at this stage.

Mass Production

The final stage is mass production. After going through the nine stages, the product is declared ready for widespread production. The Education Comic Digital Material

Style Around Us that has been developed is ready to be distributed to a wider audience, both for learning purposes in schools and as a learning resource that can be accessed at any time. Mass production includes distribution in digital format, accessible online via links, to provide easy access for teachers, students, and other parties in need of engaging and interactive educational materials.

Feasibility of Digital Comic Education Material on Style Around Us

The suitability of using the Education Comic Digital developed for IPAS learning on the topic of forces around us was assessed through a feasibility test by subject matter and media experts. Media validation was conducted to assess the quality of the developed media, evaluating aspects such as content and purpose suitability, structural aspects, and technical or visual appearance aspects. Meanwhile, content validation focused on evaluating the suitability of the educational media content, particularly regarding the topic of Forces Around Us. This evaluation was conducted by considering the alignment of the content and questions with the Learning Outcomes (LO) and Learning Objectives (LO). The results of the feasibility analysis by the media experts and subject matter experts are presented in Table 1.

Table 1. Results of Validation by Material Experts and Media Experts

Validator	Percentage (%)	Criteria
Material Expert	93,75%	Highly Feasible
Media Expert	90,63%	Highly Feasible

Based on Table 1, the development of the Digital Education Comic Gaya di Sekitar Kita is considered highly feasible, with a rating of 93.75% from subject matter experts and 90.63% from media experts. Supporting research was conducted by Solihah et al. (2022), the expert validation results showed a feasibility level of 96% from subject matter experts and 92% from media experts, which qualifies it as highly feasible. Based on this, it can be said that the Digital Education Comic Style Around Us can be categorized as good and feasible for testing, with the note that revisions are made. The results of the development of the Digital Education Comic Style Around Us are supported by the results of the analysis of questionnaire responses from teachers and students, as presented in Table 2.

Table 2. Teacher and Student Response Questionnaire Results

Response	Percentage (%)	Criteria
Teacher	93,75%	Highly Feasible
Students	100%	Highly Feasible

Based on the data presented in Table 2, the questionnaire results show that teachers' responses to the product trial reached 93.75% and were categorized as very feasible. Meanwhile, student responses reached 100%, which was also categorized as very feasible. Based on the analysis of the suitability of the media and materials in Table 1, as well as the response data from teachers and students in Table 2, it can be concluded that the Education Comic Digital Style Around Us is highly suitable for use as a learning medium for IPAS, particularly on the topic of forces around us.

Supporting research conducted by Hasanah et al. (2023) shows that the media trial results received a 100% response from teachers and an 87.2% response from students. Therefore, the digital comic media is categorized as highly suitable for use in science education for fifth-grade elementary school students because the content in the digital comic media aligns with the core competencies and the digital comic media is effective in helping students understand the learning material.

The Effectiveness of Digital Comic Education Materials on Styles Around Us

This study focuses on the development of Education Comic Digital material on Styles Around Us. The resulting product is a learning medium that needs to be tested to measure its effectiveness in improving student learning outcomes. The material is validated by subject matter experts, while the medium is validated by media experts. After the validation process, a pilot test was conducted by collecting data through pre-tests and post-tests administered during the learning process. The collected data was then analyzed using normality tests, t-tests, and N-Gain Score calculations to determine the level of effectiveness of the media in supporting improvements in student learning outcomes. The results of the pre-test and post-test analyses are presented in Table 3.

Table 3. Pre-test and Post-test Results of Usage Testing

Aspect	Pretest Score	Posttest Score
Average	60	83,50
Maximum Score	85	100
Minimum Score	45	60

Based on the data in Table 3, there was an increase in the average learning outcome of students by 23.50, where the average pretest score of 60 increased to 83.50 on the posttest.

Normality Test

Normality testing is a statistical procedure used to determine whether the data being analyzed is normally distributed or not. Normality testing aims to identify whether the independent variable, dependent variable, or both have a normal data distribution pattern. Normality testing is performed to ensure that the data used meets the basic assumption of normal distribution as a prerequisite in certain statistical analyses (Ghozali, 2018). The results of the normality test in this study were obtained through the Shapiro-Wilk test, which was processed using the SPSS application. The results of the normality test are presented in Table 4.

Table 4. Normality Test Results

Treatment	Significance Value (Sig.)	Description
Pretest	0.425	Normal
Posttest	0.086	Normal

The determination of criteria in the normality test is based on the significance value (Sig.). Data is considered normally distributed if the Sig. value is > 0.05, whereas

if the Sig. value is < 0.05, the data is considered to not meet the normality assumption. Based on Table 4, the results of the normality test show that the Sig. value in the Shapiro-Wilk test for the pretest data is 0.425 and for the posttest data is 0.086. Since both Sig. values are > 0.05, it can be concluded that the pretest and posttest data have a normal distribution.

Paired T-test

The Paired t-test (One-Sample t-Test) is a statistical analysis method used to test whether there is a significant difference between the mean of a sample and a specific value from a population that is known or assumed beforehand (Triola, 2018). The results of the Paired t-test analysis are presented in Table 5.

Table 5. Results of Paired T-test Pretest and Posttest

Treatment	N	Mean	T	Sig. (2 tailed)
Pretest	10	60	-23.500	< 0,001
Posttest	10	83,5		

Based on the data in Table 5, the results of the Paired t-test show a significant difference between the mean pretest and posttest scores. The calculated t-value was -23.500, with a mean pretest score of 60 and a mean posttest score of 83.50, from a total sample of 10 students. The results of the Paired t-test indicate a significance level (Sig. 2-tailed) < 0.05, specifically < 0.001. Therefore, H_0 is rejected and H_a is accepted. This indicates that there is a significant difference between learning outcomes before and after the use of the Education Comic Digital Material on Forces Around Us as a learning medium. This finding proves that the developed media is effective in improving students' learning outcomes in achieving the IPAS learning outcomes on the topic of forces around us.

N-Gain Test

The final stage in the data analysis process in this study was the N-Gain test. This test was used to measure the effectiveness of learning media in improving student learning outcomes. The assessment focused on the improvement in the average learning outcomes of students on the topic of Forces Around Us after using Education Comic Digital. The analysis was conducted by comparing pretest and posttest results. N-Gain data processing was performed using the SPSS application. The results of the N-Gain test analysis are presented in Table 6.

Table 6. N-Gain Test Results

Treatment	Average	N-Gain	Criteria
Pretest	60	.6630	Moderate
Posttest	83,5		

Based on the data in Table 6, the use of Education Comic Digital by fourth-grade students at SDN Sadeng 03 Semarang City in the material Gaya di Sekitar Kita (Styles Around Us) showed an increase in average learning outcomes with an N-Gain value of 0.6630, which falls into the moderate category. This result indicates

a significant improvement in learning outcomes after the implementation of the media in a large group during the pilot phase. Thus, the developed learning media has proven to be effective in supporting the learning process. The visualization of the average improvement in student learning outcomes after the use of the Digital Education Comic is shown in Figure 10.

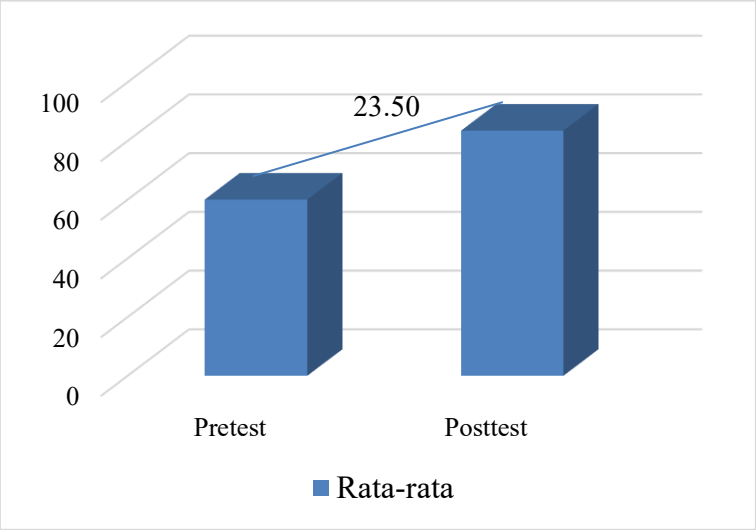

Figure 10. Average Pretest and Posttest Results of Grade IV Students at SDN Sadeng 03, Semarang City

Based on Figure 10, there was an increase in the average pretest and posttest scores in the usage trial (large group) of 23.50, which is classified as moderate. Several factors that influenced this moderate increase include: (1) the readiness of students to learn. Technical readiness in using digital devices such as Chromebooks to access Education Comic Digital had a significant influence. Participants who are not yet accustomed to independent learning may not be able to utilize the Education Comic Digital efficiently, so guidance is necessary. This aligns with the research by Elisyah et al. (2025) that guidance activities in the use of digital learning media play an important role in improving students' readiness and interest in learning. (2) Variations in learning styles.

The Digital Education Comic is suitable for students with visual and audio-visual learning styles, so students with auditory or kinesthetic learning styles are not fully accommodated. This aligns with Trisnanda's (2025) research, which found that adapting teaching methods to students' learning styles (visual, auditory, kinesthetic) significantly increases learning interest. Students feel more valued because their learning needs are accommodated, leading to greater student activity, enthusiasm, and engagement in learning. (3) Adaptation in using Digital Education Comics. This is influenced by the lack of familiarity with reading using electronic devices. Many students are more accustomed to printed textbooks, so they struggle to follow the visual-verbal flow, are confused by the navigation of the Digital Education Comic, and are not yet accustomed to multimodal reading (text and images). This hinders understanding of the material and limits the effectiveness of learning. Research conducted by Salsabila et al. (2024) found that there are factors

influencing the average improvement results in the moderate category. Internal factors include various conditions directly related to the students themselves, such as learning psychology, reading and comprehension skills, intelligence level, and attention to detail in completing tasks. These conditions play a significant role in determining how effectively students can utilize the provided media. Meanwhile, external factors encompass elements outside the learner's control that also impact the learning process, such as classroom learning atmosphere, spatial comfort, lighting, noise levels, and other learning environment supports. A conducive learning environment enhances the effectiveness of learning media, while less supportive conditions can act as barriers.

4. Conclusion

Based on the results and discussion described above, it can be concluded that the Digital Education Comic was successfully developed with important components, namely the cover, preface, table of contents, learning outcomes, learning objectives, character introduction, reading instructions, content, bibliography, and developer profile. The validation results by media experts and subject matter experts indicate that the developed product received a rating in the highly suitable category, reinforced by teachers' responses through a questionnaire with similar evaluation results. The effectiveness of the product was also tested through improvements in pretest and posttest scores, supported by t-test results and N-Gain scores falling within the moderate category. Thus, the Digital Education Comic is deemed successfully developed, suitable, and effective for use in improving the learning outcomes of fourth-grade students at SDN Sadeng 03 in Semarang City in the IPAS subject, particularly the Forces Around Us material. Data analysis results indicate that the use of this media significantly enhances students' learning outcomes.

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