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Development of Interactive Digital Comic Media: "My Region and Its Natural Resources" with a Differentiated Approach

Lintang Kirana Leokiss Wijaya[1*], Barokah Isdaryanti[1]

[1]Elementary School Teacher Education, Universitas Negeri Semarang, Semarang, Indonesia

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Corresponding Author:
Lintang Kirana Leokiss Wijaya*
lintangkiranalw@gmail.com*

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Abstract: This study addresses the scarcity of technology-based learning media for natural and social sciences learning tailored to the diverse learning needs of fourth-grade students in Semarang, particularly in regards to regional natural resource potential. The primary objective is to design, evaluate the feasibility, and assess the effectiveness of Interactive Digital Comic media with a differentiated approach. This development research uses the Research and Development (R&D) method with the ADDIE model, comprising Analysis, Design, Development, Implementation, and Evaluation phases. The feasibility assessment by material experts and media experts yielded a percentage of 92.85% and 87.50%, respectively, rating the media as "Very Feasible" based on criteria such as content accuracy, instructional design, and multimedia integration. The effectiveness of the media was evaluated using a quasi-experimental design with a paired sample t-test and N-Gain test. The results showed a significant difference in average student learning outcomes (sig. (2-tailed) = 0.000 < 0.005) and an N-Gain value of 0.82, indicating a significant average increase and high criteria. This study demonstrates the potential of Interactive Digital Comic media to enhance student learning outcomes and engagement in natural and social sciences learning, providing an engaging and interactive learning experience and catering to diverse learning needs.

Keywords: Interactive Digital Comics; Learning Media; Learning Outcomes

Introduction

Permendikbudristek (2022) reiterates its dedication to enhancing the learning process. The underlying principles adopt a comprehensive and sustainable methodology, tailored to accomodate the diverse learning requirements of students from varied backgrounds. The ultimate goal of learning extends beyond mere academic achievement, seeking to foster character development and integrate local environmental and cultural aspect.

The leveraging of technological and scientific advanvements has emerged as vital factor in the advancement of the learning process (Yuniarti & Radia, 2020). Contemporary education necessitates the integration of information and communication technology into the curriculum (Rusli et al., 2022).

Consequently, innovative technology development is required to enhance the effectiveness of the current learning process, with one such innovation being the development of learning media, a crucial component of the learning process that fosters meaningful learning and encourages students to cultivate 21st-century skills (Daryanes et al., 2023).

To augment the efficacy of modern learning, educators must employ innovative and creative pedagogical approaches that foster active student participation (Bachri et al., 2023). The majority of learning processes in Indonesia necessitate student

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engagement, yet numerous students remain inactive due to inadequate motivation and interest (Rusli et al., 2022). The strategic incorporation of modern information and communication technology in learning media has been identified as a crucial element in achieving successful learning outcomes (Abdilah & Wulandari, 2024).

Media can facilitate the effective conveyance of learning materials and enhance students' enthusiasm for learning (Yuniarti & Radia, 2020). Learning media serves as an intermediary tool that facilitates the delivery and reception of information, with the ultimate goal of enhancing learning outcomes, boosting student motivation, and enabling them to engage in comprehensive and meaningful learning experiences (Maulidya & Astuti, 2025). The use of learning media has become an essential component of the learning process (Kartika et al., 2023).

Learning media constitutes a pedagogical tool that educators can employ to augment the learning process (Oktaviana & Ramadhani, 2023). Learning media functions as a medium for conveying instructional materials, thereby facilitating students' comprehension of the presented content (Yuniarti & Radia, 2020). The integration of learning media into instructional practices not only enhances students' understanding of the material but also fosters their enthusiasm for the learning process (Nur et al., 2020).

Effective learning necessitates consideration of children's desires and needs to optimize learning outcomes (Jessica Alfa & Asrizal, 2024). The learning process must be adapted to the students' developmental stages, particularly in elementary education (Yuniarti & Radia, 2020). According to Piaget (Nur et al., 2020), children between the ages of 6 and 12 are in the concrete operational stage, which suggests that they require tangible and realistic examples to facilitate learning.

A needs assessment conducted at SDN Kalibanteng Kidul 01 Semarang revealed several key issues, including the suboptimal utilization of technology in the instructional process, lack of natural and social science learning media, and heterogeneous learning needs of students. These challenges must be addressed to ensure that instruction is more effective and inclusive for all learners. An analysis of the learning style preferences of students in fourth-grade at SDN Kalibanteng Kidul 01 Semarang showed that 48% of students prefer a visual learning style, 42% prefer an auditory learning style, and 10% prefer a kinesthetic learning style. These findings indicate the need for a differentiated approach to cater to the diverse learning needs of students.

This research aims to develop an Interactive Digital Comic medium for Grade IV Science instruction, incorporating a differentiated approach as a solution to address the identified challenges. Interactive learning media have the potential to enhance the learning process, rendering the conveyed message more explicit and facilitating the attainment of educational objectives in an effective and efficient manner. The utilization of interactive learning media necessitates students to engage in interactions throughout the learning process, extending beyond mere observation of presentations or objects.

Interactive learning media have the potential to enhance the learning process, rendering the conveyed message more explicit and facilitating the attainment of educational objectives in an effective and efficient manner (Afifah et al., 2022). Moreover, interactive learning media can foster active participation among elementary school students in the learning process (Utomo, 2023). The utilization of interactive learning media necessitates students to engage in interactions throughout the learning process, extending beyond mere observation of presentations or objects (Harsiwi & Arini, 2020).

Comics are defined as a literary genre that integrates images and text to convey meaning (Aulia & Wuryandani, 2019). The utilization of comic media has been shown to be effective in enhancing students' comprehension of subject matter and fostering their interest in learning (Yuniarti & Radia, 2020). Furthermore, comic media has the potential to promote student engagement in the learning process, as the combination of visual and textual elements creates an immersive and engaging learning experience (Yuniarti & Radia, 2020). Comics typically depict events involving one or more characters within a limited timeframe, thereby facilitating the development of students' imagination and creativity (Syahmi et al., 2022).

Visual media has the capacity to capture students' attention, thereby enhancing engagement (Aulia & Wuryandani, 2019). Digital comics constitute a narrative form featuring specific characters presented in a visual format, with electronic devices employed for their dissemination (Syahmi et al., 2022). Digital comics serve as an effective medium for visual communication learning, wherein this learning context pertains to the communication process between students and educational resources (Nazhiroh et al., 2021).

Interactive digital comic media represents an evolution of digital comic media, incorporating interactive elements that facilitate active student participation in the learning process. This medium enables students to engage in a range of activities beyond mere reading and image viewing, including completing quizzes, watching videos, and playing games relevant to the learning material. Interactive comics refer to a series of deliberately sequenced images

or symbols created entirely with computer assistance, distinguishing them from conventionally produced comics that are scanned and digitally colored. These interactive comics are published in digital formats, offering an alternative to traditional printed versions (Farahiba & Kayati, 2021; Habiddin et al., 2022; Utamingsih et al., 2023).

This research involves the development of Interactive Digital Comic learning media, incorporating a differentiated approach and facilitated by the Canva application. This innovation is designed to address the challenge of integrating technology into learning, tailored to accommodate the diverse learning needs of students. The primary objective of this media development is to optimize technological utilization and cater to the heterogeneous learning needs of students, particularly in natural and social sciences learning, with a focus on the topic of Regional Natural Resource Potential in Semarang City and its environs. This development is expected to contribute significantly to enhancing the quality of natural and social sciences learning instruction at the elementary school level.

This study is supported by several preceding research endeavors, including a study undertaken by Megantari et al. (2021) entitled "*Belajar Sumber Daya Alam Melalui Media Komik Digital*", which showed that the utilization of digital comic media in instructional settings can effectively enhance students' comprehension of curricular materials. Bachri et al (2023) research "*Impact of phenomenon-based learning model assisted by Virtual Book-based Digital Comics on Elementary-School Students' Agile Innovation and Independence In Science Learning*", revealed that virtual book-based digital comics constitute a highly effective learning medium. Radeswandri (2021) study, "*Developing instrument to measure the use of online comic as Educational Media*", highlighted the potential of integrating digital technology, such as online comics, as an effective alternative educational medium in the current educational landscape.

Utomo (2023) research, "*Inovasi Media Pembelajaran Interaktif Untuk Meningkatkan Efektivitas Pembelajaran Era Digital Di Sekolah Dasar*", demonstrated the significant potential of innovative interactive learning media in enhancing the learning process at the elementary school level. Nadzhiroh et al. (2021) study, "*Pengembangan Multimedia Interaktif E-Komik dalam Meningkatkan Hasil Belajar Bahasa Jawa*", revealed a significant correlation between the use of interactive e-comic multimedia and improved learning outcomes.

Prior research has demonstrated the efficacy of digital comic media and interactive media in enhancing student learning outcomes. Consequently, the development of Interactive Digital Comic media for elementary school students warrants further investigation to cater to the diverse learning needs of students.

This study builds on previous research that has demonstrated the efficacy of digital comic media and interactive media in enhancing student learning outcomes. However, there is a need for further investigation into the development of Interactive Digital Comic media for elementary school students, particularly in the context of natural and social sciences learning. This research will investigate three research questions: the design; the feasibility; and the effectiveness of Interactive Digital Comic media 'My Region and Its Natural Wealth', incorporating a differentiated approach.

The novelty of this research lies in the development of Interactive Digital Comic media that incorporates a differentiated approach, tailored to accommodate the diverse learning needs of students. This research is important because it addresses the need for innovative and effective learning media in the Indonesian context, particularly in natural and social sciences learning. The findings of this study are expected to contribute significantly to enhancing the quality of natural and social sciences learning instruction at the elementary school level.

Method

This developmental research employs the Research and Development (R&D) methodology, utilizing the ADDIE model, which comprises five stages, as articulated by Robert Maribe Branch (Sugiyono, 2022). The ADDIE model was chosen for its systematic approach to instructional design, allowing for a comprehensive and structured development process. These stages include: *Analysis*, wherein students' learning needs are analyzed and the requisite media are determined to address these needs; *Design*, involving the design of the media from a multifaceted perspective, encompassing design, material, and learning; *Development*, entailing the testing of the media's feasibility, with a focus on validation by subject material experts and media experts; *Implementation*, wherein the media's effectiveness is assessed by measuring student learning outcomes prior to and following the media's application in small and large groups; and *Evaluation*, involving the evaluation of the developed media, based on the outcomes obtained in the preceding stages.

The research subjects comprise the Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach, competent experts in their fields, teachers, and fourth-grade students of SDN Kalibanteng Kidul 01 Semarang. The experts consist of two lecturers as material experts and

media experts to provide reviews of the developed media, teachers as practitioners, a small group of 6 students, and a large group of 23 students. The subjects of this study were selected using the purposive sampling technique. Purposive sampling is a technique for selecting sample data sources with certain considerations (Sugiyono, 2022).

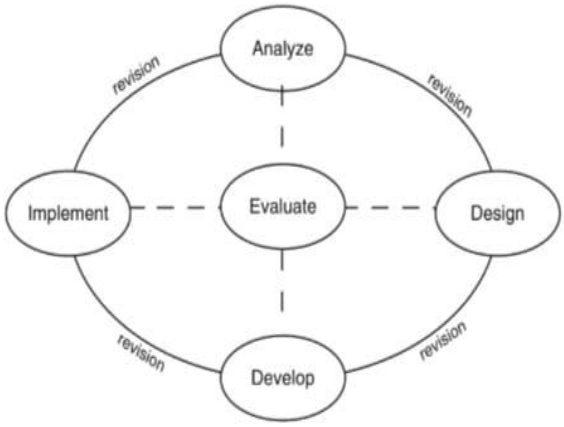

Figure 1. The ADDIE Concept

The feasibility of the Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach, was assessed by subject material experts and media experts. The selection of these experts was based on specific criteria, including their expertise in the subject matter and their experience in media development. The material experts were chosen for their in-depth knowledge of the subject matter, while the media experts were selected for their expertise in designing and developing interactive digital media. This feasibility test used a Likert scale with response options: strongly agree, agree, disagree, and strongly disagree. The media was evaluated by calculating the mean score and establishing the feasibility test criteria using the following formula.

$$NP = \frac{R}{SM} \times 100\% \quad (1)$$

Description:
NP = percentage value
R = raw score obtained
SM = maximum score

Table 1. Feasibility Test Criteria.

Percentage (%)	Criteria
86 – 100	Very Feasible
76 – 85	Feasible
60 – 75	Sufficiently Feasible
55 – 59	Less Feasible
<54	Not Feasible

The effectiveness of the media was assessed by comparing the results of the pretest and posttest. The pretest was administered before students' participation in natural and social sciences learning, focusing on regional natural resource potential in Semarang City and its surroundings, utilizing the Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach.

The data collection techniques involved administering the pretest and posttest to students, with the pretest consisting of 15 multiple-choice questions and the posttest consisting of 15 multiple-choice questions.

Initial data analysis was carried out with a normality test. The normality test of learning outcomes is carried out to determine wether the data is normally distributed or not. The normality test was calculated using the *Shapiro Wilk* test formula assisted by SPSS Statistic 24. Data is said to be normal if sig > 0.050.

The final data analysis involved the application of paired sample T-Test and N-Gain test. The paired sample T-Test was utilized to investigate the difference in mean scores between the pretest and posttest, with the aim of assessing the effectiveness of the Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach. The researcher employed parametric statistical techniques, specifically the paired sample t-test, using SPSS 24. Jika $t_{value} > t_{table}$, H_a accepted, but if $t_{value} < t_{table}$, H_a rejected.

The success criteria for this study were defined as a significant increase in student learning outcomes, as measured by the N-Gain test, and a high level of student satisfaction with the Interactive Digital Comic media. In this study, the N-Gain test results were classified according to the criteria for improving learning outcomes with the N-Gain test formula as follows:

$$N\ gain = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score} \quad (2)$$

Table 2. N-Gain Test Criteria.

Interval	Criteria
N-Gain < 0.3	Low
0.3 ≤ N-Gain < 0.7	Medium
N-Gain ≥ 0.7	High

(Lestari & Yudhanegara, 2024)

Development Needs

The Development of Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach began with identifying problems using observation and interview techniques with grade four teachers at SDN Kalibanteng Kidul 01 Semarang which are then analyzed so that several

problems are found, namely the lack of maximum utilization of technology in the learning process, the absence of natural and social sciences learning media, on the material of the potential natural wealth of the region of residence, coupled with the diversity of student learning needs is also a challenge that needs to be overcome so that learning can run more effectively for all students. From the findings above, the data is used as a reference to create Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach

Data Collection

This research uses two types of data, qualitative and quantitative data. Qualitative data was obtained through observations and interviews. Quantitative data was obtained through material expert and media expert validation questionnaires, as well as student learning outcomes data tested for normality, mean difference and mean improvement using SPSS 24.

Initial Product Development

The stages of designing Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach media assisted by the Canva application natural and social sciences learning about potential of natural resources in Semarang and its surroundings with a differentiated approach: determine the material, learning outcomes, and learning objectives to be achieved; create a prototype; create an Interactive Digital Comic design using the Canva application starting from the character/character, cover, general information, usage guide, content, animation, background, backsound according to the material of potential natural wealth in. Semarang according to the needs of diverse students.

Result and Discussion

Initial Data Analysis

The normality test is used to determine whethe the pretest and posttest data of students in fourth-grade of SDN Kalibanteng Kidul 01 Semarang are normally distributed or not. The normality test in this study used the Shapiro-Wilk formula in SPSS 24.

Table 3. Nomality Test Results in Small Group

	Kolmogorov – Smirnov[a]			Saphiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
Pretest	0.198	6	0.200*	0.965	6	0.792
Posttest	0.196	6	0.200*	0.846	6	0.203

*. This is a lower bound of the true significance
a. Lilliefors Significance Correction

Normality Test

Table 3 shows the results of the normality test of pretest and posttest scores of small group with the Shapiro-Wilk formula on SPSS 24 showing that the normality test of pretest scores has a sig = 0.792 dan the normality test of posttest scores has a sig = 0.203. From the table it shows that the normality test of the pretest value is 0.792 > 0.050 so the data is normal. The normality test result of the posttest value is 0.203 > 0.050 so the data is normal. Based on these data, it can be concluded that the pretest and posttest values are normally distributed, so the next calculation uses parametric statistics.

Table 4. Nomality Test Results in Large Group

	Kolmogorov – Smirnov[a]			Saphiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	0.172	23	0.075	0.923	23	0.077
Posttest	0.202	23	0.015	0.916	23	0.054

a. Lilliefors Significance Correction

Table 4 shows the results of the normality test of pretest and posttest scores of large group with the Shapiro-Wilk formula on SPSS 24 showing that the normality test of pretest scores has a sig = 0.077 dan the normality test of posttest scores has a sig = 0.054. From the table it shows that the normality test of the pretest value is 0.077 > 0.050 so the data is normal. The normality test result of the posttest value is 0.203 > 0.050 so the data is normal. Based on these data, it can be concluded that the pretest and posttest values are normally distributed, so the next calculation uses parametric statistics.

Table 5. T-Test Result on Small Group

Paired Samples Test									
Paired Diferences									
		Mean	Std. Deviation	Std. Error Mean	95% Comfidence Interval of Difference		T	df	Sig (2-tailed)
					Lower	Upper			
Pair 1	Pretest – Posttest	-46.667	8.383	3.422	-55.464	-37.870	-13.637	5	0.000

Final Data Analysis

The mean difference test is conducted to determine the average difference in pretest and posttest scores which will be used to test the effectiveness of the media. Researchers used parametric statistical techniques through the paired sample t-test formula in the SPSS 24.

Table 5 shows the results of the pretest and posttest average difference test in the small group shewed a sig (2-tailed) value of 0.000. The t-test results show sig (2-tailed) 0.000 < 0.005, so it can be concluded that there is a significant difference between the pretest and posttest results.

Table 6. T-Test Result on Large Group

Paired Samples Test									
Paired Diferences									
		Mean	Std. Deviation	Std. Error Mean	95% Comfidence Interval of Difference		T	df	Sig (2-tailed)
					Lower	Upper			
Pair 1	Pretest – Posttest	-50.609	9.302	1.940	-55.631	-46.586	-26.093	22	0.000

Table 6 shows the results of the pretest and posttest average difference test in the large group showed a sig (2-tailed) value of 0.000. The t-test results show sig (2-tailed) 0.000 0.005, so it can be concluded that there is a significant difference between the pretest and posttest results

Table 7. N-Gain Results in Small Group

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain	6	0.67	1.00	0.8290	0.14635
Valid N (listwise)	6				

Table 8. N-Gain Resuls in Large Group

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain	23	0.62	1.00	0.8255	0.10791
Valid N (listwise)	23				

N-Gain Test

Table 7 shows the results of the calculation of the average increase test (N-Gain) in the product trial in small groups showed an average increase in the N-Gain test of 0.829 with pretest score 43 to 90 on the posttest score and average difference of 47 and including high criteria.

Table 8 shows the results of the salsulation of the average increase test (N-Gain) in the product trial in large group showed an average in the N-Gain test of 0,825, with a pretest score of 38 to 89 on the posttest score and average difference of 51.

Product Validation

The material assessment conducted by material experts covered three aspects (Megantari et al., 2020), namely: material or content; language or communication; presentation. The indicators of the material/content aspect were: completeness and clarity in presenting identity; clear presentation of learning objectives; clear presentation of material. The material/content aspect scored 12 with a percentage of 100% and a "Very Feasible" criterion, the language/communication aspect scored 6 with a percentage of 75% and a "Fairly Feasible" criterion, and the presentation aspect scored 8 with a percentage of 100% and a "Very Feasible" criterion. The overall result of the material expert validation scored 26 with a percentage of 92.85% and a "Very Feasible" criterion.

The assessment by media experts was conducted to determine the feasibility of the Interactive Digital Comic media. The media assessment conducted by media experts covered four aspects (Megantari et al., 2020), namely: sound and text; visual; characterization; overall

appearance. The sound and text aspect scored 7 with a percentage of 87.5% and a "Very Feasible" criterion, the visual aspect scored 10 with a percentage of 83.3% and a "Feasible" criterion, the characterization aspect scored 7 with a percentage of 87.5% and a "Very Feasible" criterion, and the overall appearance aspect scored 4 with a percentage of 100% and a "Very Feasible" criterion. The overall result of the media expert validation scored 28 with a percentage of 87.5% and a "Very Feasible" criterion.

The assesment consiting of material expert and media expert on Interactive Digital Comic media 'My Region and Its Natural Wealth' with a differentiated approach received an assessment in the "Very Feasible" category. The results of the feasibility assesment on Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach by materian expert and media expert can be seen in Table 9.

Table 9. Feasibility Test Result

Validator	Precentage (%)	Criteria
Material	92.85%	Very Feasible
Media	87.5%	Very Feasible
Average	90%	Very Feasible

The Interactive Digital Comic media 'My Region and Its Natural Wealth' with a differentiated approach has been deemed feasible for use in the 4th grade of SD Negeri Kalibanteng Kidul 01 Semarang based on the validation results from media and material experts.

Product

(A) (B)

Figure 2. Interactive Digital Comic Media Display: (A) Front Cover; (B) Back Cover

(C) (D)

Figure 3. Interactive Digital Comic Media Display: (C) Guidelines; (D) Characters

The Interactive Digital Comic is comprised of multiple sections, including Section 1 and Section 2. Section 1 of the Interactive Digital Comic focuses on the geographical landscape and the occupations of the local population, as illustrated in Figure 3.

(E) (F)

Figure 4. Interactive Digital Comic Media Display: (E), (F) Section 1 of the interactive Digital Comic

Section 2 of the Interactive Digital Comic explores the potential for natural wealth in Semarang and its environs, as illustrated in Figure 4

(G) (H)

Figure 5. Interactive Digital Comic Media Display: (G), (H) Section 2 of the interactive Digital Comic

(I) (J)

Figure 6. Interactive Digital Comic Media Display: (I) Author's Biodata; (J) Supervisor's Biodata

Conclusion

Based on the research and development results of the Interactive Digital Comic media 'My Region and Its Natural Wealth' incorporating a differentiated approach, this study obtained a "Very Feasible" criteria with a percentage of 90% based on the feasibility assessment by material and media experts. The paired t-test results showed a significant difference (sig. 2-tailed = 0.000 < 0.05), and the N-Gain value was 0.82, indicating a high increase in learning outcomes. This study's

findings highlight the potential of Interactive Digital Comic media in enhancing science and social studies learning at the elementary school level, particularly at SDN Kalibanteng Kidul 01 Semarang. The results of this study can be applied in classroom learning to improve student engagement and learning outcomes. However, this study has limitations, such as the small sample size and the limited scope of the research context. Future studies can build upon this research to explore the effectiveness of Interactive Digital Comic media in different educational settings.

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L. K. L. W. contributed to designing the research idea, developing the product, conducting data analysis, and writing the article. B. I. as supervisor - guided the research process until writing the article as well as reviewing and editing. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest in this research.

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