Development of E-Comic Media on the Addition Operation of Iteger Numbers Phase B Applied in Science Learning

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Abstract: Learning media is one of the supports in growing and increasing students' interest in learning. However, based on the results of initial research through interviews conducted at SDN 14 Labuah, Tanjung Raya District, Agam Regency, it was found that the school did not have adequate learning media and did not utilize them well. Teachers only used existing textbooks and used the whiteboard as a medium for delivering lesson materials. This study aims to develop interactive e-comic learning media for mathematics subjects on the material of integer addition operatioans for third-grade elementary school students. The background of this study is the low interest and learning outcomes of students (only 40% achieved the KKM) at SDN 14 Labuah due to inadequate learning media. This study uses the 4D model Research and Development (R&D) method, which includes the Define, Design, Development, and Disseminate stages. However, this study focuses on the Development stage, namely validation and practicality tests. Data collection was carried out through observation, interviews, and questionnaires. The results showed that the e-comic media was declared highly feasible with validation scores of 85.71% from media experts, 88.64% from material experts, and 91.66% from language experts. Furthermore, this media was also deemed highly practical based on teacher (93.18%) and student (93.75%) responses. Thus, it was concluded that this e-comic media is feasible to use and highly effective as a mathematics learning medium in grade III of elementary school.

Keywords: Addition; E-comics; Learning interest; Learning media; Whole numbers

Introduction

Education has a big impact because education makes people have character and knowledge. Based on (Government Regulation Number 4 Article 1 Paragraph 1, 2022) in Filho et al. (2018) concerning National Education Standards, it explains that education is an effort to create a learning environment in a planned and conscious manner so that students are able to improve their own processes towards spirituality. Become, religious strength, intelligence, noble morals, self-control, personality, and the abilities needed by themselves, society, nation and state (Lesch, 2023).

Education is also an important thing that must be present in people's lives. In education we can gain knowledge and develop each individual's potential, including talents and interests, which need to be developed (Evans et al., 2018; Kamalov et al., 2023). In addition, education has a crucial role in forming the next generation of the nation who has character and noble morals. The goal is to create humans as quality assets. According to Iqbal et al. (2023) and Piwowar-Sulej (2021), the quality of human resources includes insight, expertise, and a person's capacity that can be utilized to produce professional services. Sukmana & Hakim (2023) and Tran (2024), agrees that the quality of human

resources is always related to the implementation of work professionally. Considering that education is crucial and needs to be mastered by every citizen, although it cannot be denied that there are various problems in the world of education, especially in Indonesia. According to Körkkö et al. (2024), problems in the world of education are caused by various factors, including: the approach used in learning; curriculum changes; teacher competence.

One of the main problems is the method applied to teaching and learning activities (Henriksen et al., 2021; Sakir & Kim, 2020). According to Maryanti & Sartono (2024), the learning method refers to the method or strategy applied by each teacher in the learning process for students. This method focuses on the interaction between teachers and students and the learning conditions that can create conducive learning conditions. The approach applied must be in line with the learning objectives and characteristics of students, and the existing activity conditions (Plooy et al., 2024; Nguyen et al., 2022). "Methods and media are two very important elements in the learning process." The learning process can occur because there are students, teachers and curriculum that are interconnected and mutually supportive. Students can obtain efficient learning if the facilities and infrastructure that support learning are available properly, and the learning model applied is interesting and the media provided during the learning process is in accordance with today's needs (Darling-Hammond et al., 2020; Coman et al., 2020).

Mastery of this concept is the foundation for understanding other arithmetic operations. However, many students have difficulty in connecting the concept of addition to everyday life. Along with the development of technology, the use of digital media in learning has become a necessity. One potential media is e-comics, namely comics in digital form that can present learning materials in an interesting and fun way (Purnama et al., 2024; Alwi et al., 2024). The use of e-comics that integrate elements of stories and illustrations of physical phenomena, such as pushing, pulling, and moving objects, can help students understand the concept of addition in a more real context (Kartika et al., 2023; Yulaichah et al., 2024). Based on the background above, research was conducted with the aim of developing interactive e-comic learning media for mathematics subjects on the material of integer addition operations for third-grade elementary school students.

Method

Research and development (R&D) conducted by researchers aims to create a product. In the context of education, research and development is a research method designed to create and refine a learning product which is then tested for its effectiveness. This study adopts the 4D (four-D) model developed by Thiagrajan, and Semmel which includes four main stages: defining, designing, developing, and disseminating. One of the advantages of the 4D model is its high level of accuracy, making it more suitable to be used as a reference for the product to be developed in the form of e-comic media on the material of additional operations of whole numbers for grade III students, which can also be used by grade IV elementary school students. Because grade III is in the same phase as grade IV in the current independent curriculum. In developing a product, each development model has its own stages and procedures in the process. This study applies the 4D model which involves four main stages, namely Define (definition), Design (design), Develop (development), and Disseminate (dissemination). The general 4D development stage can be seen in Figure 1.
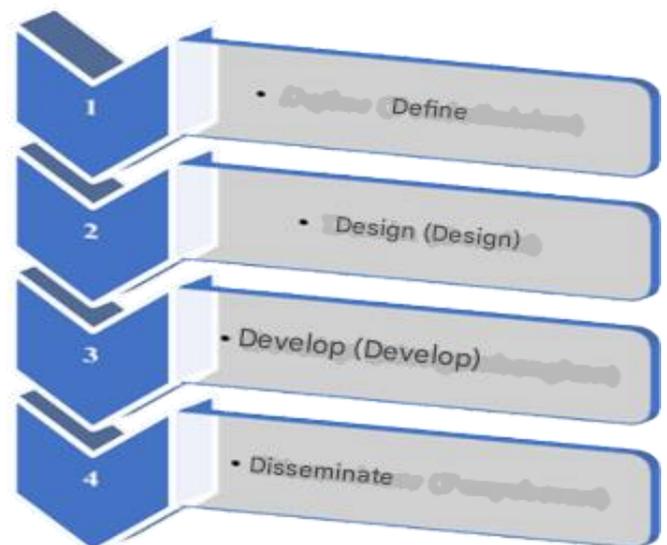

Figure 1. 4D model development stage

Then, in the development of e-comic media, the development stages are more specific and can be seen in Figure 2.

In this study, the researcher tested the instrument validation instrument itself by applying questionnaires and validation sheets for media experts, materials, language, teachers and also students which were used to measure the flexibility of the study, the level of effectiveness and usability of the product was calculated using the percentage formula (Lestari & Nurkamid, 2019). In this study, the subject of the comic media feasibility test validation included 3 validators, namely media experts, material experts and language experts. In this study, the researcher created five instrument grid tables for the assessment of media experts, materials, language, practicality and product validity levels. Media

expert verifiers were used to obtain data on the form of product quality from the authenticity of the display design and content, and the characteristics can be seen in Table 1.
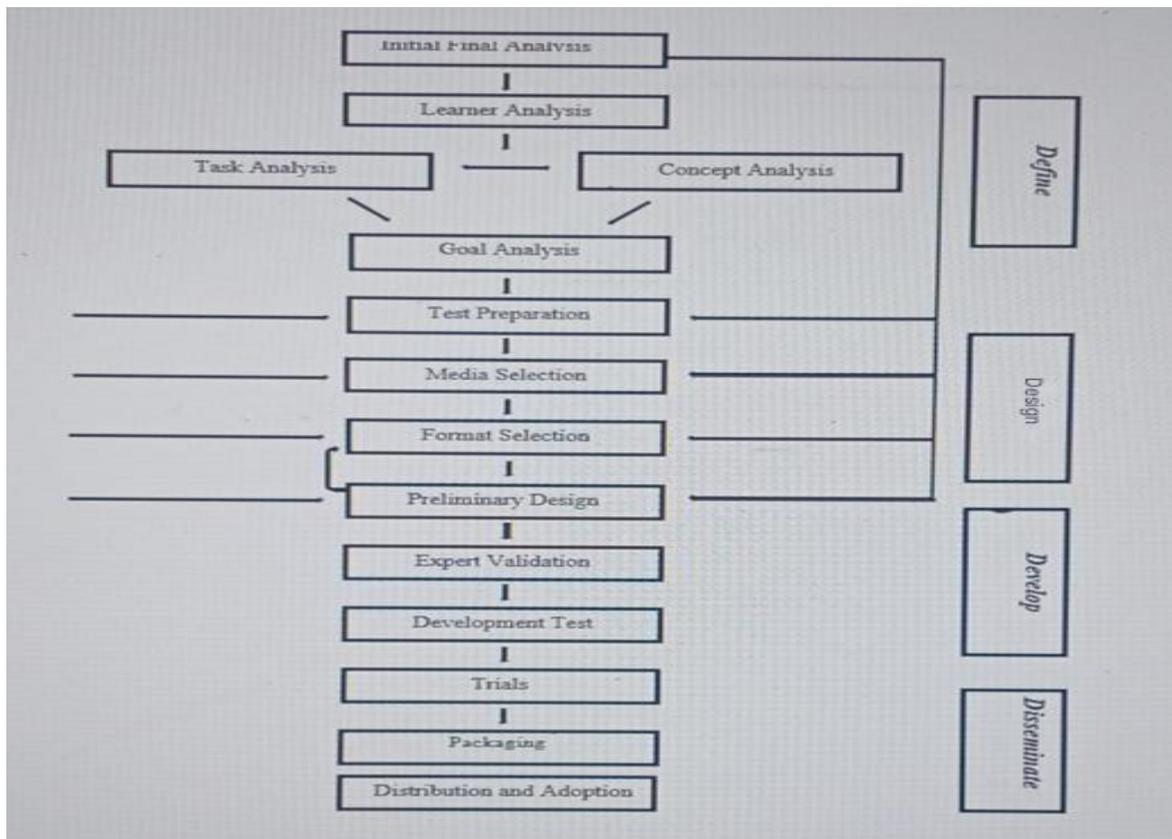

Figure 2. E-comic development stages/procedures

Table 1. Media assessment instrument grid

Indicator	Amount
Appearance and Content	
Color composition	1
Illustration	1
Letter	1
layout	1
Instructions for use	1
Characteristics	
Use	1
Attractiveness	1
Total number	7

Table 2. Material assessment instrument grid

Indicator	Amount
Content Suitability Aspect	
Media relevance to Basic Competence	1
Material intensity in accordance with cognitive development	1
Validity of the presented concept	1
Overall material	1
Usefulness of e-comic media	1
Language aspect	
Relevance to Indonesian EYD rules	1
Effectiveness and accuracy of language	1
Presentation aspect	

Indicator	Amount
Clarity of objectives and indicators in the media	1
Integrity of information	1
Logical and systematic delivery of material	1
Media delivery increases student interest	
Total number	11

Material experts are used to obtain data on product quality in terms of content suitability, linguistic aspects and presentation aspects (Table 2).

Language expert tools are used to obtain data in the form of language clarity quality, communicativeness, suitability to the level of student development, coherence and integration of thought flow (Table 3).

Table 3. Language assessment instrument grid

Indicator	Amount
Straightforward	
Accuracy of sentence structure	1
Effectiveness of sentences	1
Standard language	1
Communicative	
Readability of meaning	1
Accuracy of language use	1
Suitability to the level of development of students	
Suitable for intellectual development	1

Indicator	Amount
According to emotional development	1
Coherence and integration of thought flow	
Regularity and integrity accompany the act of training	1
Order and integrity between	1
Total number	9

Practicality tools are used to obtain data in the form of clarity and neatness, clean and attractive, suitable for students, practical and flexible and of good quality. And can be seen in Table 4.

Table 4. Practical and flexible and of good quality

Indicator	Amount
Clear and Neat	
E-comic media is not abstract in its presentation	1
Preparation of e-comic media	1
Clean and Attractive	
E-comic media is clean and not berantakan	1
E-comic media has the ability to increase interest in learning	1
Suitable for students	
E-comic media is relevant to the characteristics of students	1
E-comic media according to what is taught	1
Practical, Flexible and Durable	
E-comic media is easy to use	1
E-comic media is easy to carry	1
E-comic media can be used repeatedly	1
Good quality	
E-comic media has high quality	1
Oriented to the needs of students	
E-comic media is easy to store and carry	1

The evaluation results applied to calculate the effectiveness and practicality of the product to be innovated according to the percentage standards are shown in Table 5 of the product validity levels.

Table 5. Product validity level

Likert Scale	Score Range (%)	Mark	Category
4	76–100	A	Very Good
3	51–75	B	Good
2	26–50	C	Not good
1	25–00	D	Very Poor

In accordance with the assessment criteria, the e-comic media for mathematics lessons on the material of addition operations of whole numbers can be said to be valid if it meets the presentation criteria of all aspects ≥ 51%, so that it can be tested on students, and the results of the developed product can be said to be practical if ≥ 51% is obtained.

Result and Discussion

Development Results

This study aims to develop e-comic media on the material of addition operations of whole numbers for grade III elementary school students phase B. The development was carried out using the 4D model from Thiagarajan, which consists of the Define, Design, Develop, and Disseminate stages. This article discusses two initial stages, namely Define and Design.

Define Stage (Definition)

This stage aims to explore initial information to determine the need for media development: Initial-Final Analysis: Interviews were conducted with the principal and grade III teachers of SDN 14 Labuah. The results showed that although projectors and speakers were available, digital learning media specifically for mathematics had not been used due to the limited availability of appropriate teaching materials; Student Analysis: Students are at the concrete operational stage and show interest in illustrated and technology-based media. They prefer learning that is presented visually and interactively; Task and Concept Analysis: The focus of development is the material on adding whole numbers up to 1000, in accordance with the Learning Outcomes (CP) in the Independent Curriculum. The Learning Objectives (ATP) developed include the ability to complete mathematical sentences, understand number patterns, and develop addition patterns. Learning Objectives: The objectives are formulated so that students are able to understand the steps for completing addition operations, filling in unknown values, and solving contextual problems using whole numbers. The results of the Define stage reinforce the urgency of developing media that supports students' learning needs visually, attractively, and contextually.

Design Stage

At this stage, the initial design of the e-comic media is carried out. The steps include: Test Preparation: The test is designed according to the characteristics of the students and the competency indicators being targeted; Media and Format Selection: The Canva platform is used as a design tool. The media format is chosen as landscape for a wider and more attractive display. The e-comic components include: cover, foreword, table of contents, instructions for use, CP, TP & ATP, character introduction, story opening, to interactive learning sections such as "Let's Observe", "Let's Ask", "Let's Watch", "Let's Practice", and "Let's Correct". The e-comic media is designed so that students not only read, but also actively participate through stories, illustrations, practice questions, and reflections. The content is inserted with videos via links, as well as illustrations of

daily activities that are contextual to the lives of students.

Develop Stage

This stage focuses on developing valid, practical, and effective e-comic products.

Validity Test

The validity test was conducted by three experts, namely media, material, and language experts. Each validator provided an assessment using a Likert scale.

Media Expert

The final validation results showed a score of 85.71% with a very valid category. Revisions made included adjusting the background color, replacing the visual numbers, and improving the layout.

Table 6. Revisions made included adjusting the background color, replacing the visual numbers, and improving the layout

Indicator	Amount
Appearance and Content	
Color composition	3
Illustration	3
Letter	4
layout	3
Instructions for use	4
Characteristics	
Use	4
Attractiveness	3
T Number of Values	25
Percentage (%)	85.71
Criteria	Very good

Material Expert

The final validation results were 88.64% (very valid). Revisions included changing the color of the writing and adjusting the learning objectives with KKO.

Table 7. Revisions included changing the color of the writing and adjusting the learning objectives with KKO

Indicator	Amount
Content Suitability Aspect	
Media relevance to Basic Competence	3
Material intensity in accordance with cognitive development	4
Validity of the presented concept	3
Overall material	3
Usefulness of e-comic media	3
Language aspect	
Relevance to Indonesian EYD rules	4
Effectiveness and accuracy of language	3
Presentation aspect	
Clarity of objectives and indicators in the media	4
Integrity of information	4

Indicator	Amount
Logical and systematic delivery of material	4
Media delivery increases student interest	4
Number of Values	39
Percentage (%)	88.64
Criteria	Very good

Language Expert

The language validation score was 91.66% with a very valid category. Revision suggestions included the use of effective sentences and the relevance of examples.

Table 8. Revision suggestions included the use of effective sentences and the relevance

Indicators	Amount
Straight forward	
Accuracy of sentence structure	3
Effectiveness of sentences	3
Standard language	4
Communicative	
Readability of meaning	4
Accuracy of language use	3
Suitability to the level of development of students	
Suitable for intellectual development	4
According to emotional development	4
Coherence and integration of thought flow	
Regularity and integrity accompany the act of training oneself	4
Order and integrity between paragraphs	4
Number of Values	33
Percentage (%)	91.66
Criteria	Very good

Summary of Validation Results

Table 9. Summary of validation results

Aspect	Percentage (%)	Category
Media	85.71	Very Valid
Material	88.64	Very Valid
Language	91.66	Very Valid

Practicality Test

The practicality test was conducted through observation and questionnaires to teachers and students.

Small Group

Tested on 5 students. Obstacles found were: use of foreign terms; font size that was too small. Revisions were made based on the results of the small group trial before the large group trial.

Large Group

Table 10. Validation by class teachers as practitioners

Indicators	Amount
Clear and Neat	
E-comic media is not abstract in its presentation	4
Preparation of e-comic media presentation is neat	4
Clean and Attractive	
E-comic media is clean and not messy	4

Indicators	Amount
E-comic media has the ability to increase interest in learning	4
E-comic media is clean and not messy	4
E-comic media is relevant to the characteristics of students	4
E-comic media according to what is taught	4
Practical, Flexible and Durable	
E-comic media is easy to use	3
E-comic media is easy to carry	4
E-comic media has high quality	4
Oriented to the needs of students	

Indicators	Amount
E-comic media is easy to store and carry	3
Number of Values	41
Percentage (%)	93.18
Criteria	Very good

Tested on all third grade students of SDN 14 Labuah. Student response to e-comic media reached 93.75% (very good). Validation by class teachers as practitioners resulted in a score of 93.18% with a very practical category, although there were notes such as network and device limitations in certain areas.

Table 11. Recapitulation of student response values to e-comic media on the operation of adding whole numbers

Student's Name Nickname	Value Acquisition				Percentage (%)	Percentage Level	Total Value
	4	3	2	1			
Abiyyu	10	4			92.85	A	5525 52
Auzar	10	4			92.85	A	52
Dzikra	10	4			92.85	A	52
Fira	10	4			92.85	A	52
Ilham	10	4			92.85	A	52
Khaira	9	5			91.07	A	51
Meisha	10	4			92.85	A	52
Nabila	10	4			92.85	A	52
Nahda	10	4			92.85	A	52
Rafi	10	4			92.85	A	52
Rava	11	3			94.64	A	53
Reyhan	12	2			96.42	A	54
Rifki	11	3			94.64	A	53
Tazkia	10	4			92.85	A	52
Aisyah	10	4			92.85	A	52
Alfian	12	2			96.42	A	54
Chelsea	11	3			94.64	A	53
Nadhira	11	3			94.64	A	53
Nadiatul	11	3			94.64	A	53
Nayla	12	2			96.42	A	54
Amount							1050
Percentage (%)							93.75

Effectiveness Test

The effectiveness of the media is tested with a learning outcome test compiled based on learning indicators: Number of students: 20; Students who completed: 17; Students who have not completed: 3; Average score: 82%; KKTP: ≥ 70. These results indicate that e-comic media is effective in improving student learning outcomes.

Product Revision

Based on the validation results, revisions were made mainly on the media aspect (appearance, visual content, and usage guide). The revisions improved readability and suitability of the content to the level of students' cognitive development.

Disseminate Stage
Product Packaging

The media is packaged in PDF format and Hyzine link, so that it can be distributed online and offline to elementary schools in Tanjung Raya District.

Discussion of Research Results

This e-comic media was developed by following the effective 4D model procedure for developing learning media (Arini et al., 2024; Serevina et al., 2021). The validation results show that the media is conceptually feasible (by experts) and procedurally (by practitioners). Quantitative data (questionnaires) and qualitative data (observations, interviews, comments) show that this media: Attracts students' attention and increases enthusiasm; Helps teachers explain abstract concepts; Can be used flexibly, both online and offline. The opinions of teachers and students are in line with the theory of comics as a learning medium put forward by

Dewi et al. (2023). Comics make learning more fun and effective (Lubis, 2018). Comics help understanding through visualization, casual language, and the appeal of color (Khotimah et al., 2021), E-comics increase interest in learning and are easy to use (Bella et al., 2024).

Technological advances in this modern era of globalization can be transferred to the world of education as a medium to facilitate the learning process (Haleem et al., 2022; Mhlanga, 2024). Educators must be able to provide and use more innovative, creative and interactive learning media based on digital technology. "All applications of technology require a strong theoretical foundation based on in-depth systematic research" (Chakraborty et al., 2022). The results of a preliminary study showed that the majority of students and educators tend to use electronic learning media rather than print media. One form of electronic teaching media is teaching media in the form of e-comics which are displayed on an in-focus screen when children are doing the teaching and learning process in class (Palioura & Dimoulas, 2022). Students can also carry out learning at home by using Android phones. However, based on the results of initial research through the interview process that has been carried out at SDN 14 Labuah, Tanjung Raya District, Agam Regency, it is known that the school does not have adequate learning media and does not utilize it, teachers in teaching only use existing textbooks and use the blackboard as a medium in delivering lesson materials (Almekhlafy, 2020; Alokluk, 2018).

So, that students are less interested and enthusiastic in learning mathematics, and there are still many learning processes that are still inefficient and lack of attraction for students in learning mathematics, even tending to bore students (Laurens et al., 2017; Boadu & Boateng, 2024). This can be seen from the learning outcomes of students, namely an average of only 40% of students achieve the minimum completeness criteria (KKM) during the mathematics learning process in the odd semester of the 2023/2024 academic year. Low learning outcomes, which are still below the Minimum Completion Criteria (KKM) at SDN 14 Labuah, Tanjung Raya District, are related to basic abilities in performing arithmetic operations of adding whole numbers. This is due to two factors, namely the first factor that comes from within the students (internal) and the second factor that comes from influences outside the students (external).

The factor from among the students is the lack of attention of students to the topic of arithmetic operations of adding whole numbers delivered by the teacher, because students have not mastered the basic principles of arithmetic operations of adding whole numbers (Nanda & Rani, 2025; López-Martín et al., 2022). External factors from the students themselves, among others, the

less conducive learning environment in the classroom itself (Konstantinidis, 2024). Mathematics learning in elementary school is often considered abstract by students because of the lack of connection to the real world. One of the basic topics that is very important for students to understand is the additional operation of whole numbers (Sidik et al., 2021; Nunes et al., 2016).

Conclusion

This research successfully developed e-comic learning media for the material of integer addition arithmetic operations in grade III of elementary school using the 4D model. This e-comic media: Very valid based on expert assessments (media experts 85.71%, material experts 88.64%, and language experts 91.66%); Very practical based on teacher (93.18%) and student (93.75%) responses; Effective in improving student learning outcomes, with an average student score of 82% and classical completeness reaching 85%. The advantage of this media is its ability to increase student interest and understanding through a combination of visuals, narratives, and interesting story contexts. It is recommended that teachers adopt e-comics as an alternative media, media developers adapt this format for other materials, and future researchers can carry out further development with richer multimedia integration.

Author Contributions
Conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing—original, draft preparation, writing—review and editing, visualization, N.S., R.H., D., and F.Y. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest
The authors declare no conflict of interest.

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