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Development of Comic Learning Media Based on Science Literacy in the Human Circulatory System Material

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ABSTRACT
This research aimed to develop a science literacy based comic as a learning medium on the topic of the human circulatory system that is valid, practical, and effective. The research employed the Research and Development (R&D) method using the 4D model, but was limited to the Develop stage due to time and budget constraints. Therefore, the testing was still conducted as a limited trial as part of the development process. This research was conducted from February to June 2025 with participants from class XI MIA at MAS Al Washliyah 22 Tembung, North Sumatra. Data collection involved teacher interviews, student needs questionnaires, expert validation sheets, response questionnaires, and a validated science literacy test of ten multiple choice questions. The comic media showed high validity with scores of 96% for media, 99% for content, and 95% for scientific literacy. It was rated very practical by students 93% and teachers 96%. Effectiveness was demonstrated by an increase in students' average scores from 44.06 to 85.63, with an N-Gain of 0.74 in the high category. Therefore, the science literacy based comic is considered suitable for use in the learning process.

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1. INTRODUCTION

21st century learning aims to equip students with the skills necessary to think responsively and compete in the current era of globalization (Mardhiyah et al., 2021). In line with this, the National Education Association (2012) states that to be globally competitive, students must master four essential skills communication, collaboration, critical thinking, and creativity, commonly referred to as the 4C skills (Wulansari & Sunarya, 2023). Furthermore, according to Herlinawati et al. (2024) 21st century learning does not only focus on improving academic achievement through the mastery of 4C skills, but also emphasizes students' ability to understand and apply scientific knowledge in everyday life. This ability is known as scientific literacy. Scientific literacy has become one of the essential competencies that students need in order to face the challenges of the 21st century (Osborne & Allchin, 2024).

Scientific literacy was first conceptualized by Paul DeHart Hurd in his 1958 article *Science Literacy: Its Meaning for American Schools*. Hurd stated that scientific literacy involves not only understanding scientific concepts but also knowledge of scientific methods and awareness of the role of science in society (Rudolph, 2024). Sjostrom (2024) described three main aspects of scientific literacy, including understanding basic scientific concepts, the nature of science, and the relationship between science, technology, society, and the environment. Okada (2013) explained that scientific literacy also includes the ability to apply scientific principles to solve problems in daily life. Individuals with scientific literacy can recognize valid scientific information and distinguish it from misinformation (Smyth et al., 2022). This ability is important for helping students face global challenges and keep up with technological progress (Kelp et al., 2023).

Nevertheless, various studies have shown that scientific literacy among Indonesian students remains low (Tillah & Subekti, 2025). The OECD (2023) reported that based on PISA 2022, the global average score for scientific literacy was 485, while Indonesia scored 383 and ranked 67th out of 81 countries. Although this ranking improved from 71st in 2018, the score dropped by 13 points and remained 102 points below the global average. Rahmadani (2022) found that 66 percent of tenth grade students at SMAN 1 Kuripan had low scientific literacy

in biology. A similar result was observed at SMA Negeri 2 Kotapinang in North Sumatra, where the average score was 50.76, with male students scoring 47.78 and female students 52.27 (Harahap & Harahap, 2022). Siregar (2025) also reported low literacy levels among eleventh grade students at SMA Negeri 1 Angkola Barat, with an average score of 46.59. These findings indicate that despite slight improvement in rank, students' scientific literacy in Indonesia remains far below international standards and requires serious educational attention (OECD, 2023).

In general, students' scientific literacy is limited to recognizing basic scientific knowledge without the ability to connect scientific topics or apply complex concepts to real life situations, even though education should prepare them to contribute to building an open, equitable, and dynamic society (Hasasiyah et al., 2020). In line with this, Zulanwari et al. (2023) emphasized that the low level of scientific literacy is also influenced by learning processes that are not oriented toward its development. This is supported by findings in the field, as revealed through interviews with teachers at a Madrasah Aliyah in Medan, who stated that students' low scientific literacy makes it difficult for them to understand the material and apply it. This is evident from students' limited ability to apply what they have learned in solving daily problem based tasks. Furthermore, the current use of teaching materials and learning media is limited to student worksheets, PowerPoint presentations, instructional videos, and cardboard posters, which primarily present concepts without addressing the key aspects of scientific literacy. As a result, these resources are insufficient in fostering students' scientific literacy skills.

Chiappetta et al. (1991) emphasized four fundamental components that should form the basis of science education, namely: science as a collection of knowledge, science as a method of inquiry, science as a mode of thinking, and the interrelationship between science, technology, society, and the environment. The aim of promoting scientific literacy is not to prepare students to become scientists, but to provide them with the scientific and technological understanding needed to make responsible decisions that affect their lives now and in the future (Ramli et al., 2022). A scientifically literate individual is capable of applying scientific principles learned through appropriate educational experiences to solve everyday life challenges (Rahmadani et al., 2018).

One way to enhance scientific literacy is through the use of relevant instructional media (Bramastia & Rahayu, 2023). One medium that is considered a potential solution is comics. Comics possess both visual and narrative appeal, which can simplify complex scientific concepts and make them easier to understand (Nurhakim et al., 2024). Rahma & Kusumawati (2020) emphasized that comics are not only visually engaging, but also contain elements such as panels, speech balloons, and storylines that can be effectively utilized to develop students' scientific literacy. Additionally, comics provide contexts that are relevant to everyday life, helping students construct scientific concepts more deeply (Handayani et al., 2021). This is in line with previous studies which found that the use of digital comics on biodiversity materials significantly improved the scientific literacy of tenth grade students (Pambudi, 2023). Further support comes from research showing that the use of webtoon based media in teaching the immune system successfully enhanced students' scientific literacy and learning skills through a reciprocal teaching approach (Pamasyah, 2019).

Based on previous studies, several researchers have developed comics as instructional media. Lestiani et al. (2021) developed comics on the topic of viruses for tenth grade students. Similarly, Oktaviana et al. (2022) developed comics for the human circulatory system topic in eleventh grade. Suwanda et al. (2023) created character education based comics for the excretory system material, also for eleventh grade. However, the development of comics specifically based on scientific literacy in biology learning remains limited to the topics of biodiversity for tenth grade (Pambudi, 2023) and the immune system for eleventh grade (Pamasyah, 2019). This indicates an opportunity to develop scientific literacy based comics for other biology topics, one of which is the human circulatory system.

The topic of the human circulatory system was selected based on findings related to the low level of scientific literacy in society, which has led to various misconceptions about this system (Sofyan & Miranto, 2017). Khairaty et al. (2018) found that 56.21% of students experienced misconceptions regarding the human circulatory system, 10.99% demonstrated conceptual understanding, and 32.79% did not understand the concepts at all. Similarly, Izza et al. (2021) noted students' difficulties in distinguishing between pulmonary and systemic circulation. Misconceptions include the belief that venous blood is blue (Rohmah & Raharjo, 2024). That hypertension is caused solely by salt intake (Ayu et al., 2022). Anemia is often thought to be merely a lack of blood, when in fact it can result from hemoglobin deficiency due to a lack of iron or vitamin B12 (Elidayani, 2021). Hemorrhagic stroke is also commonly believed to affect only the elderly, although it can occur in younger individuals due to uncontrolled hypertension or vascular abnormalities (Saifullah et al., 2024). Misconceptions about the circulatory system can hinder students' understanding and their ability to apply the concepts in real life contexts (Mukhlisa 2021).

Therefore, this research aims to develop a scientific literacy based comic on the human circulatory system that is valid, practical, and effective. The implication is that this comic can serve as an alternative, innovative, and engaging instructional medium, while also promoting the enhancement of students' scientific literacy. It is expected that students will be able to apply the concepts of the circulatory system in everyday life and become more competitive in the global era.

2. RESEARCH METHOD

This research adopted a Research and Development (R&D) methodology, following the 4D model developed by Thiagarajan et al. 1974, which includes four sequential phases Define, Design, Develop, and Disseminate. However, due to limitations in time and funding, the research was conducted only up to the Develop phase. Figure 1 provides a detailed depiction of the development process carried out in this research.

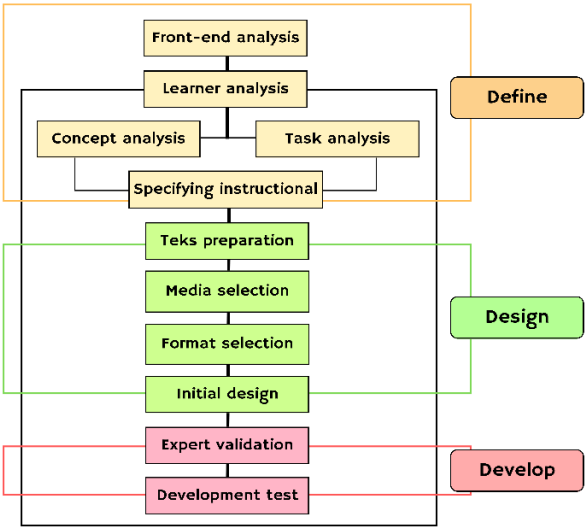


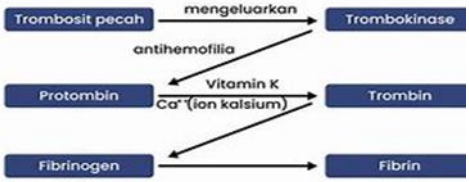
Figure 1. Stages of the 4D Model Design (Thiagarajan et al., 1974)

1. Define, this stage includes the following steps: (1) *Front-end analysis*, analyzing potentials and problems in learning through interviews with biology teachers. (2) *Learner analysis*, distributing questionnaires to assess students' learning needs. (3) *Concept analysis*, analyzing the subject matter to be used and aligning it with instructional needs. (4) *Task analysis*, analyzing learning tasks based on minimum competency standards. (5) *Specifying instructional objectives*, determining the learning objectives.
2. Design, this stage includes the following steps: (1) *Text preparation*, developing an outline of the instructional content in accordance with the learning objectives. (2) *Media selection*, Identifying appropriate instructional media that align with students' needs and address the existing learning problems. (3) *Format selection*, determining and establishing the appropriate format for presenting the instructional media. (4) *Initial design*, designing the overall structure and layout of the learning media.
3. Develop, this stage includes two main components. (1) *Expert appraisal*, which involves validating the product design by media experts, subject matter experts, and science literacy experts to assess its feasibility. (2) *Development testing*, which refers to the small scale trial of the product on a limited number of subjects to obtain feedback from both students and teachers. The feedback collected during this trial is used to revise and improve the product before conducting further testing to ensure its effectiveness on a larger scale.

This research was conducted from February to June 2025. The participants involved in the trial stage were students of Grade XI MIA at MAS Al-Washliyah 22 Tembung, North Sumatra. The practicality test was carried out on a small scale involving 12 students. This is in line with Sugiyono (2019), who stated that limited trials in development research may involve 6-12 participants to obtain in depth feedback on the developed product. Meanwhile, the effectiveness test involved 32 students to ensure that the data obtained were sufficient for statistical analysis. This aligns with Widoyoko (2012), who emphasized that a minimum of 30 participants is required for research results to be considered valid and generalizable. The selection of research subjects was carried out using purposive sampling, a technique in which samples are intentionally chosen based on specific considerations relevant to the objectives of the study. Participants were selected based on their alignment with the required characteristics of this research, including their readiness to learn, active engagement in the learning process, and the relevance of their background to the material being developed.

The instruments used in this study were developed in accordance with each stage of data collection. During the needs analysis stage, data were obtained through teacher interview sheets and student questionnaires to identify learning needs. To measure the validity of the product, validation sheets were utilized involving media experts, subject matter experts, and science literacy experts. The practicality test was conducted by distributing response questionnaires to both teachers and students to assess the practicality level of the media. Meanwhile, the effectiveness test was carried out through instructional implementation over two learning sessions, followed by measuring students' learning outcomes before and after using the biology comic based on scientific literacy. The assessment was conducted using written tests comprising pretest and posttest with a science literacy instrument adapted from Febriani (2021),, consisting of 10 multiple-choice questions that had previously been validated and achieved a validity score of 95.58%, categorized as "Very Valid".

Table 1. Sample Items from the Science Literacy Test Instrument

Science Literacy Question Indicators	Example Questions
Explaining scientific phenomena	The blood that carries O2 and the blood that carries CO2 in the body never mix or get interchanged in circulation. The blood that carries O2 in the image above is blue and the blood that carries CO2 is red. This happens because... a. Blood that carries O2 and CO2 flows through veins and arteries, veins have valves that prevent the blood from flowing backward. b. Blood that carries CO2 flows through the veins, veins have valves that prevent the blood from flowing backward c. Blood that carries O2 flows through the veins, veins have valves that prevent the blood from flowing backward. d. Blood that carries CO2 flows through the arteries, arteries have valves that prevent the blood from flowing backward e. Blood that carries O2 flows through both veins and arteries, veins have valves that prevent the blood from flowing backward.
Evaluating and designing scientific investigations	Dini has blood type B and donates her blood to Yudi, who is also classified as having the same blood type. However, after the transfusion process is completed, Yudi's blood begins to clot. This condition may occur because… a. The blood type testing was performed inaccurately, leading to an incorrect classification. b. Coagulation occurred despite matching blood types due to a difference in Rh factor. c. The transfused blood was contaminated with bacteria, causing clotting. d. The donor and recipient blood were incompatible due to differences in agglutinogens. e. The donor and recipient blood were incompatible due to differences in antigens.
Interpreting scientific data and evidence	 The diagram above illustrates the process of blood clotting. One of the essential components that supports blood clotting is vitamin K. The consequence that may occur if a person is deficient in vitamin K is... a. Blood will have difficulty clotting b. Blood will not clot c. Blood will clot normally d. Blood will not flow e. Blood will clot excessively

This research employed both qualitative and quantitative data analyses. Qualitative analysis was used to process data obtained from interviews, as well as feedback from content and media experts regarding the developed product. Meanwhile, quantitative analysis was applied to process data from validation questionnaires assessing product feasibility conducted by experts, as well as responses from teachers and students toward the produced output. Data from expert validations, teacher responses, and student responses were analyzed using a Likert scale ranging from 1 to 5, categorized as very good, good, sufficient, poor, and very poor (Sugiyono, 2019).

The analysis of validation results from media, content, and science literacy experts, as well as responses from teachers and students, will be conducted using Formula 1 to determine the feasibility level of the comic. The validity and practicality assessments are presented in percentage form, as shown in Table 2.

$$Percentage\ \% = \frac{Total\ score\ obtained}{Maximum\ possible\ score}\ X\ 100 \text{..... Formula 1}$$

Table 2. Scoring Criteria for Media Validity and Practicality

Percentage	Criteria
81% - 100%	Very Valid / Very Practical
61% - 80%	Valid / Practical
41% - 60%	Moderately Valid / Moderately Practical
21% - 40%	Less Valid / Less Practical
0% - 20%	Not Valid at All / Not Practical at All

Source: Mahadiraja & Syamsuarnis, (2020)

The effectiveness data were calculated using Formula 2. namely the N-Gain score equation. The increase in N-Gain scores from the pretest and posttest following the implementation of the science literacy based comic was then categorized based on the criteria presented in Table 3.

$$N - Gain = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score}$$ .....Formula 2

Tabel 3. N-Gain Score Criteria

N-Gain Score	Classification	Criteria
g > 0,7	High	Effective
0,3 ≤ g ≤ 0,7	Medium	Fairly Effective
g – 0,3	Low	Not Effective

Source: Sari & Adlini, (2024)

3. RESULT AND DISCUSSION

Based on the results of the conducted research, a science literacy based comic was developed as a learning medium for the human circulatory system material for Grade XI students. This medium was designed through systematic development stages using the 4D model, which is presented in detail in Table 4.

Table 4. Development Stages of the Comic Based Learning Media

Stage	Component	Activity Result
Define	*Front-end analysis*	The results of an interview with a Biology teacher at a Madrasah Aliyah in Medan City indicated that students' low level of scientific literacy hinders their understanding and application of the material, while the learning media currently used remain limited and do not adequately support the development of scientific literacy.
	Learner analysis	The results of the student needs questionnaire revealed that the existing learning media are insufficiently varied and tend to be monotonous, leading to decreased learning motivation. Students expressed a preference for media that are more visually appealing and concise.
	Concept analysis	The topic of the human circulatory system was selected because it often leads to misconceptions, such as the pathway of blood circulation, the color of venous blood, and the causes of diseases. These misconceptions hinder students' understanding and application of the concepts in everyday life.
	Task analysis	Students require learning that emphasizes concept application and contextual problem solving.
	Specifying instructional objective	The indicators of competency achievement and learning objectives were established based on Regulation of the Minister of Education and Culture No. 37 of 2018 and the 2013 Curriculum, referring to Core Competencies 3.9 and 4.9 (Permendikbud, 2018). The learning objectives for the human circulatory system material include: 1) Students are able to identify the structure and function of blood components, blood vessels, and the heart accurately through comic reading and discussion activities. 2) Students are able to explain the mechanism of human blood circulation (pulmonary and systemic circulation) accurately through comic reading and discussion activities. 3) Students are able to identify various disorders of the human circulatory system accurately through comic reading and discussion activities. 4) Students are able to determine blood types based on the ABO system and their relevance to blood transfusion accurately through comic reading and discussion activities. 5) Students are able to analyze the process of blood clotting accurately through comic reading and discussion activities. 6) Students are able to integrate preventive efforts and the application of technology in treating circulatory system disorders through comic reading and discussion activities. 7) Students are able to present study reports on the human circulatory system accurately through discussion activities.
Desain	*Teks preparation*	An outline of the human circulatory system material was developed, covering the structure and function of blood, blood vessels, the heart, circulation mechanisms, disorders, blood clotting, ABO blood groups, and medical treatment technologies.
	Media selection	Science literacy based comic media was selected as it suits the nature of the material and meets the students' needs.

Stage	Component	Activity Result
	Format selection	The comic media is structured into three main sections: introduction, content, and closing. The introduction includes the cover, foreword, table of contents, competencies, objectives, and character introduction. The content section presents a narrative accompanied by engaging illustrations based on science literacy. The closing section contains evaluation activities, a glossary, references, and the author's biography.
	Initial design	The initial design of the comic involved developing the storyline, script, layout, and complete content structure using Canva Premium in A5 paper format, while integrating learning objectives and science literacy.
Develop	*Expert appraisal*	The product was evaluated by media experts, subject matter experts, and science literacy specialists.
	Developmental tesing	The product trial involved feedback from teacher and subjects at a small scale, followed by revisions and further testing on a large scale to evaluate the effectiveness of the product.
Disseminate		This stage was not conducted due to time and budget limitations.

At the development stage, validation, practicality, and effectiveness tests were conducted. The validation test was carried out first, in accordance with the opinion of Jayanti & Pertiwi, (2023) who stated that validation should be conducted prior to implementation. The validation involved three experts to assess the feasibility of the media, the content, and the alignment of the comic with science literacy aspects. The assessment results are presented in Table 5.

Table 5. Validity Test Results

Expert	Statement Aspect	Number of Items	Score	Percentage	Validation Score (%)	Criteria
Media	Usefulness	4	19	96%	**97%**	Very Valid
	Readability	3	15			
	Comic Cover Design	3	14			
	Digital	3	14			
	Comic Illustration Design	7	34			
	Total Score		**96**			
	Maximum Score		**100**			
Content	Content Accuracy	5	25	99%		
	Scientific Concept Validity	3	15			
	Content Clarity	5	25			
	Bahasa	3	14			
	Total Score		**79**			
	Maximum Score		**80**			
Science Literacy	A body of knowledge	3	14	95%		
	Way of investigating	3	14			
	Way of thinking	3	14			
	Interaction of science, technology, and society	3	15			
	Total Score		**57**			
	Maximum Score		**60**			

Based on the data presented in Table 5, the results of the media expert validation showed a score of 96 out of a maximum of 100, equivalent to 96%. This score falls into the “Very Valid” category. The assessment covered several aspects, including usefulness, readability, and visual design elements such as the cover and illustrations. These results indicate that the media is highly feasible for use in terms of functionality, visual appeal, and ease of use. The high level of media validity demonstrates that the comic has met the standards of feasibility as an engaging and accessible learning medium. This aspect is crucial, as well designed and readable media can enhance student engagement and foster greater interest in learning. These findings are consistent with the research by Fatimah & Ningsyih, (2021) which states that the validity of comic based learning media is significantly influenced by the quality of readability and visuals, both of which play an important role in supporting students’ understanding of learning materials. Furthermore, according to Prasetyo, (2021) media with clear presentation and attractive design can improve students’ learning focus and accelerate information absorption. Therefore, high media validity not only confirms its visual and technical feasibility but also directly contributes to the effectiveness of meaningful learning.

In the material aspect, the assessment included content accuracy, conceptual correctness, clarity of presentation, and language usage. The validation results from the subject matter expert yielded a score of 79 out of 80, equivalent to 99%, which falls into the "Very Valid" category. This high level of validity indicates that the content presented in the comic aligns with scientific principles and the curriculum, and is delivered using clear, communicative, and student friendly language. High material validity directly contributes to the quality of the media by ensuring content accuracy and alignment with learning objectives. This is crucial to prevent misconceptions and to support deep conceptual understanding. As stated by Sugiharni (2018) material validity is a fundamental requirement to ensure the accuracy and precision of the concepts conveyed to students. Similarly, Zulfiah et al. (2020) emphasize that learning media with wel validated content are more effective in improving student learning outcomes. Therefore, the developed comic media is not only visually appropriate but also possesses strong substantive value in supporting biology learning at the senior high school level.

Furthermore, in the aspect of scientific literacy, the comic received a score of 57 out of 60, equivalent to 95%, and was categorized as "Very Valid". The assessment covered four dimensions of scientific literacy, science as a body of knowledge, science as a way of thinking, science as a way of investigating, and the interconnection between science, technology, and society. These results indicate that the comic successfully integrates scientific literacy in a comprehensive manner, encouraging students to perceive science not only as a collection of facts but also as a scientific process and an integral part of everyday life. The validation of scientific literacy significantly enhances the quality of the media, as it makes the learning content more contextual, applicable, and capable of fostering scientific ways of thinking. This finding is in line with Anggraini & Zulyusri (2023) who state that science literacy based comics should meet scientific standards and be understandable within real life contexts. In addition, Handayani et al. (2021) emphasize that effective science comics do not merely convey information but also promote critical thinking skills and an understanding of the relationship between science and society.

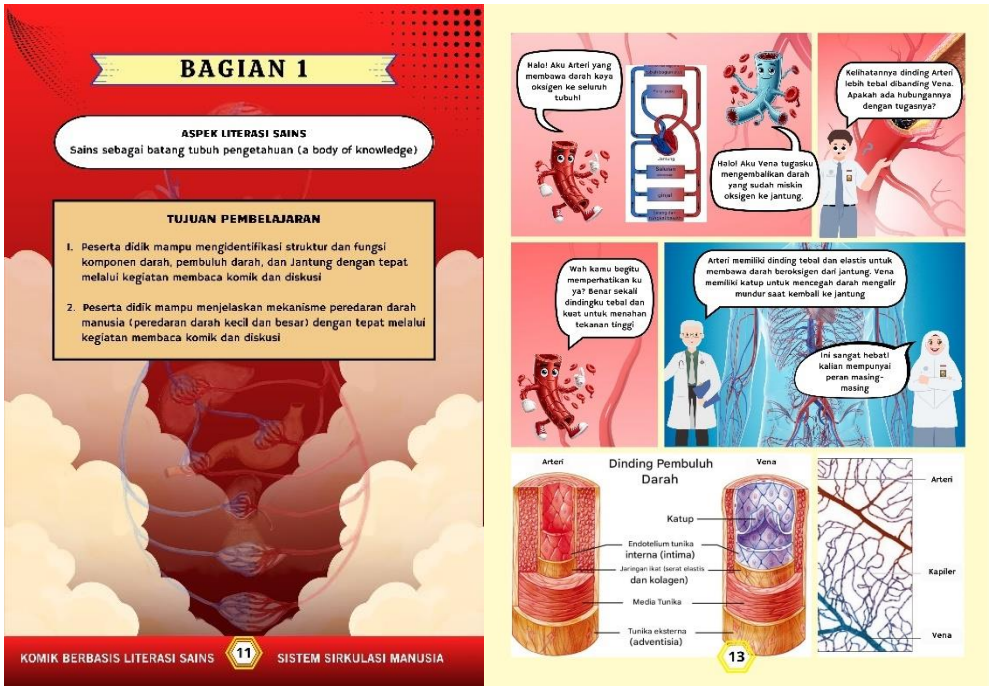
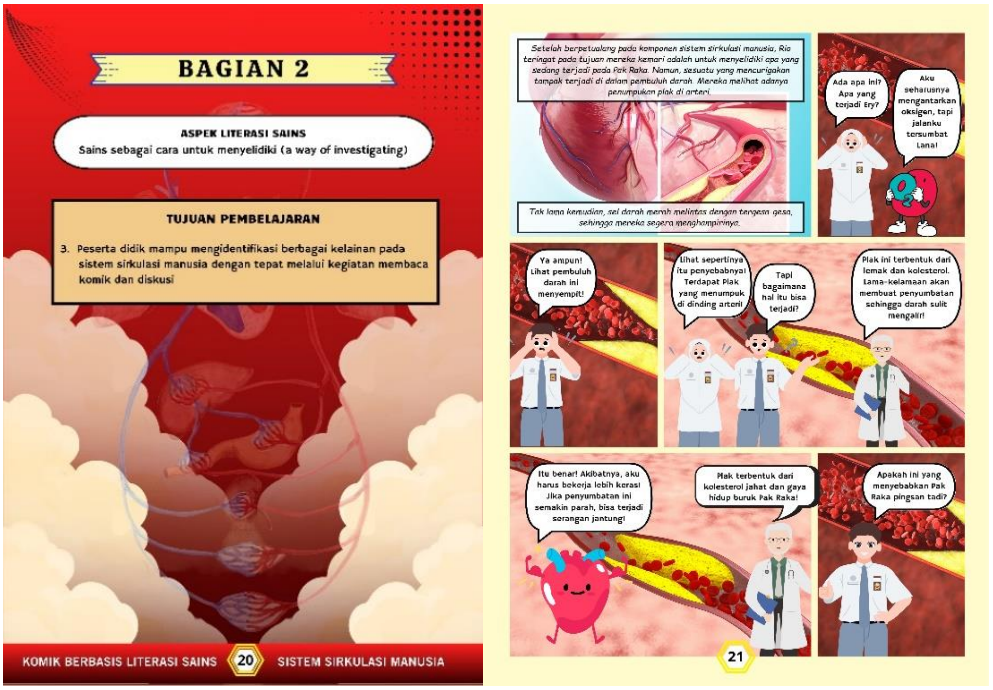
Based on the aspects of media, content, and science literacy, the comic learning media based on science literacy obtained an average validation percentage of 97% and was categorized as "Very Valid". This result indicates that the comic has fulfilled the eligibility criteria as an instructional medium. However, several suggestions for improvement were provided by the media expert, the content expert, and the science literacy expert. These suggestions are summarized in Table 6. as input for refining the media.

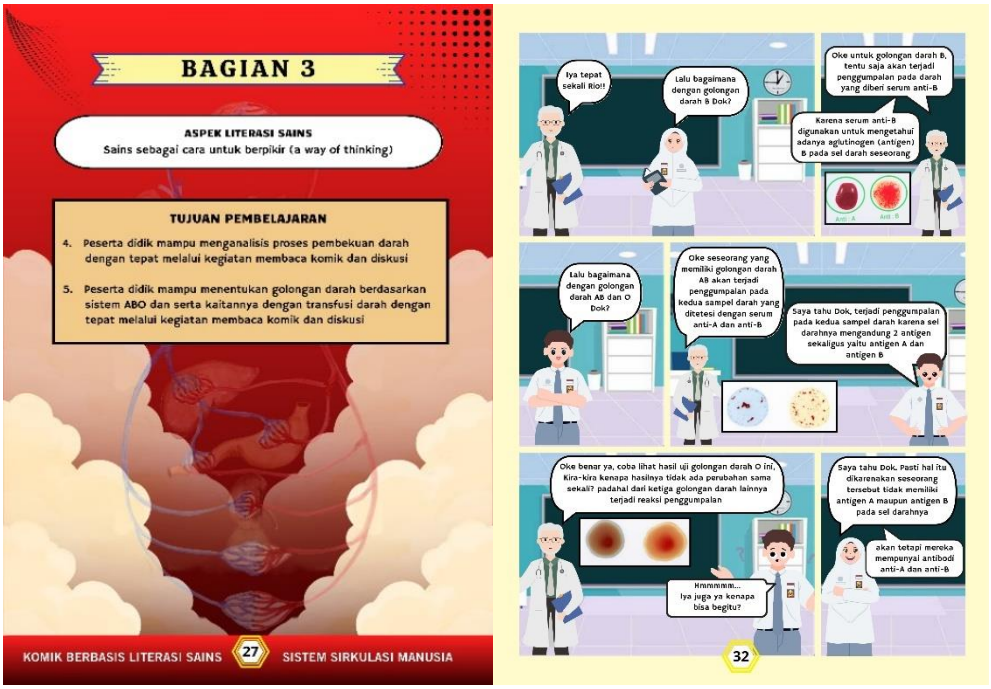
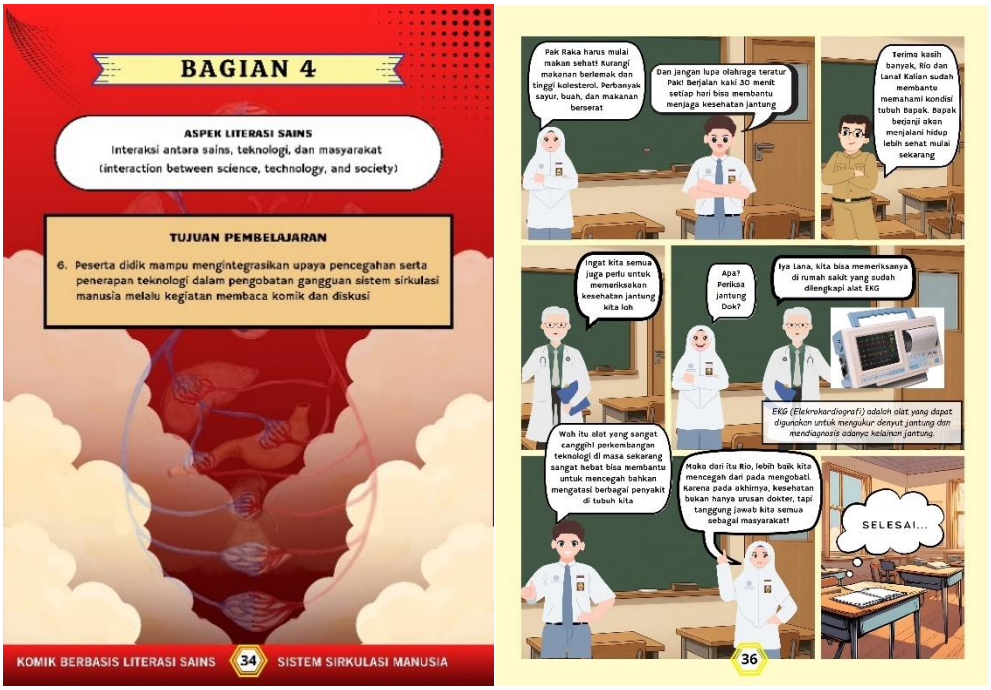
Table 6. Suggestions and Revisions from Experts

Experts	Suggestions	Revisions
Media	The comic does not include page numbers.	Add page numbers
	The phrase "Instructions for Use" in the comic is considered less appropriate and is suggested to be replaced with "Brief Description."	Replace the phrase "Instructions for Use" witl "Brief Description"
	The media does not yet provide a glossary.	Add a glossary in the closing section of the comic
	The background used in the comic for the blood type testing material is considered less suitable if placed inside the human body.	Change the background of the blood type testing comic to a laboratory setting
Content	There is a lack of conceptual accuracy in the explanation of the gas exchange mechanism.	Revise the concept of gas exchange to the concept of substance exchange
	It is recommended that the illustration of blood components include the percentage of leukocytes and thrombocytes.	Replace the illustration to display the overal percentage of blood components
	The selection of the illustration for the pulmonary vein section is considered inaccurate.	Add an image of the pulmonary vein to suppor understanding of the material
Science Literacy	The comic only implies elements of science literacy through dialogue. It is suggested that science literacy aspects be presented explicitly in the exercise section to clarify the development of student literacy.	Present science literacy aspects clearly in the exercise section to emphasize the parts tha develop student literacy

Based on the improvement suggestions provided by the media expert, content expert, and science literacy expert, revisions and refinements were made to the science literacy based comic learning media. The final result of this revision process is a comic that has been adjusted according to expert feedback and meets the established eligibility criteria. The final overview of the components in the science literacy based comic is presented in Table 7. which details the structure and content of the comic after the validation and revision process.

Table 7. Components of the Comic Based on Science Literacy

Science Literacy Aspect	Image
A body of knowledge	
	Presents facts, concepts, and principles related to the circulatory system including blood, blood vessels, the heart, and both pulmonary and systemic circulation in the form of a comic narrative that portrays science as a coherent and understandable body of knowledge.
Way of investigating	
	Contains an investigation of the case of Mr. Raka who fainted due to a blocked blood vessel caused by an unhealthy lifestyle. The comic includes methods of treatment and identification of various disorders in the circulatory system through observation, analysis, and drawing conclusions based on evidence.

Science Literacy Aspect	Image
Way of thinking	 Presents the determination of blood type based on the ABO system and its relevance to transfusion and blood clotting through a storyline that emphasizes reasoning, analysis, and decision making.
Interaction of science, technology, and society	 Contains the character's reflection in understanding the condition and solutions to the case, representing the application of scientific knowledge in real life and the importance of a healthy lifestyle based on scientific understanding.

After being validated by experts, the scientific literacy based comic learning media was subjected to a limited scale trial to determine its practicality and to collect input from teachers and students concerning the clarity of the content, the visual aspects, and the suitability of the material to students' needs. The findings from this initial trial were used as the foundation for making necessary revisions prior to implementing a wider scale trial aimed at thoroughly measuring the media's effectiveness.

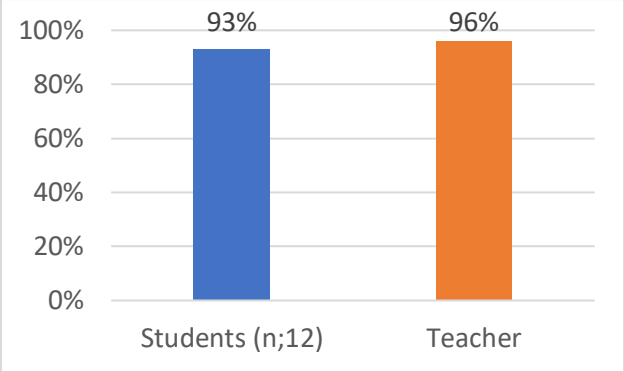


Figure 2. Percentage of responses from students and teachers

Based on the questionnaire results presented in Figure 2, it was found that the average practicality score from students reached 93%, and from teachers reached 96%. Both scores fall into the "Very Practical" category. Students assessed that the media had an attractive visual appearance, was easy to understand, and enhanced learning motivation and engagement. These findings are in line with the research by Karlena et al., (2021) which showed that the use of comic media in biology learning on the topic of pteridophyta can improve student engagement, facilitate the understanding of scientific concepts, and increase interest in learning.

The learning process is easy to implement in the classroom and helps present scientific material in a simple yet scientific manner. Haka & Suhanda, (2018) stated that comics can serve as a medium that simplifies the delivery of biology content because of their ability to bridge complex information through engaging narrative and visual presentation. Therefore, from both student and teacher perspectives, comic media has been proven to have a high level of practicality and supports the effectiveness of biology learning at the secondary education level.

Table 8. Practicality Test Results

Respondent	Statement Item	Score
Students (n;12)	10	46,5
Teacher	10	48
Total Score		94,5
Percentage		95%
Criteria		Very Practical

The overall practicality test results based on the questionnaire responses from teachers and students as presented in Table 8 show that the science literacy based comic media obtained a total score of 94 point 5 with an average percentage of 95% which falls into the category of “Very Practical”. The evaluation was conducted by two groups of respondents namely students with a sample size of twelve and a teacher. The students gave a score of 46 point 5 out of a maximum total of 50 while the teacher gave a score of 48. These results indicate that the media was considered easy to use engaging and supportive of learning in an efficient manner.

Table 9. Results of the Effectiveness Test

Score	Average Score	Maximum Score	N-Gain Score	Criteria
Pretest	44,06	100	0,74	High / Effective
Posttest	85,63	100		

Referring to the data presented in Table 9, the results of the effectiveness test of the science literacy based comic media demonstrate that the students' average pretest score prior to the intervention was 44.06 out of a possible 100. Following the implementation of the instructional media, the average posttest score rose markedly to 85.63. This improvement shows a significant difference between the scores before and after the learning activity. It indicates that students experienced an increase in their understanding of the biology material presented.

This improvement was further analyzed using the N Gain calculation, which resulted in a score of 0.74. According to the criteria proposed by Hake (1999) an N Gain value within the range greater than 0.7 to 1 is categorized as high or effective. This indicates that the instructional media used was able to optimally enhance students’ learning outcomes. This level of effectiveness reflects the success of the comic media in facilitating meaningful learning and promoting the understanding of biology concepts in relation to everyday life. The

developed comic media presents the content in a contextual manner through narrative and illustrations that depict scientific phenomena as they occur in real life.

This success can be attributed to the characteristics of comic media that integrate narrative text elements, visual illustrations, and contextual storylines. The media does not only deliver information but also builds emotional and imaginative engagement among students, which positively influences their comprehension and retention. In addition, the use of simple yet scientific language in the comic allows students to understand complex biological concepts more easily.

The integration of scientific literacy components in comic media contributes significantly to the improvement of student learning outcomes. Scientific literacy entails a comprehensive understanding of scientific concepts, as well as the cultivation of critical thinking, problem solving capabilities, and the ability to apply scientific knowledge in everyday life. Therefore, science literacy based comic media aligns with the demands of 21st century education that emphasizes the mastery of skills to understand and use scientific information in real life contexts (Herlinawati et al., 2024).

In the context of biology education, comic media serves as an effective tool to enhance students' scientific literacy by presenting material in a visual, narrative, and easily understandable format. This is particularly relevant given the low level of scientific literacy among students, which often leads to misconceptions, especially in topics related to the human circulatory system (Sofyan & Miranto, 2017). Therefore, the use of comic media not only helps students grasp concepts at a conceptual level but also encourages them to connect scientific knowledge with real life phenomena.

From a pedagogical perspective, comic media also holds potential for enhancing inclusivity in the learning process. Students with visual and kinesthetic learning styles tend to grasp the material more easily through structured images and narratives. Furthermore, the use of communicative language and engaging visualizations allows students with diverse academic abilities to participate in learning effectively. This positions comic media not only as an effective learning tool but also as an adaptive resource that accommodates a wide range of learning needs in the classroom.

The findings of this research are consistent with the results reported by Karlena et al., (2021) who found that the use of comics as a learning medium in the topic of Pteridophyta significantly improved students' conceptual understanding. In addition, Mukti et al., (2023) also reported that three dimensional digital comics based on scientific literacy were effective in enhancing scientific literacy in science learning, as demonstrated by pretest and posttest results with an improvement percentage of 80%. The support from these various studies strengthens the argument that science literacy based comics are not only innovative in terms of design but also pedagogically effective.

This research demonstrates that the science literacy based comic media has met the three main criteria of instructional media feasibility, namely validity, practicality, and effectiveness. In terms of validity, the media was rated as "Very Valid" with an assessment percentage exceeding 97% in the aspects of media, content, and science literacy. Practicality was reflected in an average score of 95%, indicating the practicality and ease of implementation of the media in learning activities, visually appealing, and supportive of the learning process for both teachers and students. Meanwhile, regarding effectiveness, the increase in scores from the pretest to the posttest with an N-Gain value of 0.74 falls into the high category, indicating that the media significantly enhances students' understanding of the human circulatory system topic.

The researcher hopes that this media can be used as an innovative and engaging alternative for classroom learning while also promoting the development of science literacy among students. This will enable them not only to understand theoretical concepts but also to apply their knowledge of the human circulatory system in real life. With this capability, students will gain more confidence in connecting scientific knowledge with everyday phenomena and be better prepared to compete in the global era.

4. CONCLUSION

Based on the research results, it can be concluded that the science literacy based comic learning media on the human circulatory system material has met the three main criteria of instructional media feasibility, namely validity, practicality, and effectiveness. This feasibility is supported by a very high level of validity, with 96% for the media aspect, 99% for the content aspect, and 95% for the scientific literacy aspect. In terms of practicality, the media was rated as very practical by students with a percentage of 93% and by teachers with 96%. The effectiveness of the media was demonstrated through the improvement in students' learning outcomes, from an average pretest score of 44.06 to a posttest score of 85.63, with an N Gain value of 0.74 which falls into the high category. These findings indicate that the developed comic media is easy to use, engaging, and relevant to students' learning needs. In addition, the use of this media significantly improved students' understanding of the human circulatory system material. The success of the media in integrating scientific literacy also reflects its potential as a learning tool that can promote critical thinking skills, problem solving, and science based decision making in real life contexts.

Therefore, this science literacy based comic learning media is considered feasible for use in the learning process and has the potential to become an innovative, enjoyable, and adaptive learning alternative to meet students' needs in the global era. However, the limitation of this research lies in the development stage, which only reached the develop phase, so large scale implementation could not be carried out. For this reason, further research is recommended to examine the disseminate phase and to expand the development of science literacy based comics to other biology topics and various educational levels.

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