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DEVELOPMENT OF SCIENCE DIGITAL COMIC ON THE THEME OF "MY AIR IS POLLUTED" TO TRAIN CRITICAL THINKING SKILLS FOR SEVENTH GRADE JUNIOR HIGH SCHOOL STUDENTS

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ABSTRACT

This study aims to determine the efficiency of science digital comics on the theme of polluted air to train the critical thinking skills of seventh-grade junior high school students. The research method used is the research and development (R&D) method. They are using the 4-D model (Four D Model) proposed by Thiagarajan et al. (1974) through modifications tailored to the needs. The 4-D model is only implemented until the third stage, namely definition, design, and development. The instruments used are material expert validation questionnaire sheets, media experts and practitioner experts, and student response questionnaire sheets to measure the level of production efficiency. Data analysis is descriptive quantitative, and qualitative. The results of this study indicate that the overall validation results of science digital comics on the theme "My Air is Polluted" to train the critical thinking skills of seventh-grade junior high school students are 92.25%. The efficiency level of science digital comic products obtained 82.27% in the "Efficient" category. For further research, it is expected to continue research with a high depth of material and be able to conduct large-scale trials to maximize research results.

Keywords: science, digital comics, my air is polluted, critical thinking skills

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Introduction

Education implemented in a quality manner will produce skilled educators and human resources who can compete in the international environment. The implementation of education is inseparable from the curriculum, the curriculum used today is the 2013 curriculum. The 2013 curriculum is a curriculum that implements learning with a scientific approach (Safitri, 2018). The 2013 curriculum uses two learning processes, namely, the immediate learning process and the indirect learning process.

The face-to-face learning process is a learning process that improves the cognitive and psychomotor aspects of students through direct interaction according to the learning tools that have been prepared. Meanwhile, indirect learning is a learning process that develops students' affective aspects or attitudes during the learning process (Kemendikbud, 2017). At this time, Indonesian education has entered the 21st century, where learning requires students to have 4C soft skills, which must be demanded. These abilities include (Critical Thinking, Communication, Collaborative, and Creativity).

In a period of global competition, the ability to think critically in the environment of students is an essential ability, such as anticipation to filter information and analyze existing problems. (Astuti et al., 2017). Critical thinking is a person's ability to analyze a problem to get a solution to the problem (Parameswari & Kurniyati, 2020). Critical thinking skills are needed in science learning.

Learning itself is a teaching and learning activity that is useful for proving students' learning achievement so that a learning process arises between educators, students, and the teaching materials used (Lestari et al., 2022). While science learning is an activity of teacher interaction with students related to systematic concepts about nature and emphasizes students' direct experience, students can gain in-depth experience about the surrounding environment and implement it in everyday life (Listyawati, 2012).

The student center learning system must be applied to the current learning process. The science learning process in schools requires the teacher only as a facilitator, and the role of students is more dominant than the teacher. Students are asked to be more active and understand information related to the material studied independently (Matsun et al., 2019). The learning styles of students are different. Learning styles are closely related to the characteristics of students, in line with Maulida et al. (2021) say that a learning style is a form of student learning that is in harmony with the characteristics of each student.

Junior high school science subjects are designed in an integrated manner, combining biology, chemistry, physics, and IPBA materials. Science learning activities are based on a scientific approach, including observing, asking, presenting, concluding, and creating activities (Kemendikbud, 2017). To achieve an effective and efficient science learning process, learning media tools are needed.

Media is everything in the form of tools or objects to be used as a messenger or information to students to achieve learning goals (Mustikawati, 2019). Learning media is a means in the learning process that can be used in delivering material from teachers to students so that students' learning interest arises to the maximum (Nurdiana et al., 2021). According to Hasanah & Nulhakim (2015), learning media has the benefit of encouraging student interest during the learning process in class Kustandi & Sutjipto (2016) argue that media selection can be carried out by reviewing several factors, including Funds/materials, subject matter, students, and types of media.

Based on the results of interviews with teachers at the schools studied, it was revealed that students experienced a decrease in literacy during online learning; most students did not read the material first but immediately completed the tasks given by the teacher. The subject matter arranged in the teaching materials has not been integrated in an integrated manner and tends to have language that is not easily understood by students, thus making students bored to read it because the writing is more dominant than the visual image.

Based on the problems found in the field, a solution is needed to answer these problems by making learning media to be used in the learning process. Learning media that can be developed is learning media based on digital science comics. The media utilizes a touch of technology in the manufacturing process. Media that utilizes technology in it is called interactive multimedia (Oktafiani et al., 2020).

Science digital comics are learning media to convey science material that is realized visually in a story with attractive images and colors that can be accessed easily through mobile devices such as cellphones, laptops, computers, and tablets. The advantage of this digital science comic is that students understand science concepts more easily

through pictures and simple language in the comics so that students don't get bored reading them. Digital comics developed using audio used as sound effects that can describe the atmosphere of the story included in the comic storyline

Based on the problems above, this research develops learning media for science digital comics on the theme of my air is polluted to train the critical thinking skills of seventh-grade junior high school students. The problem in this study is how the efficiency of science digital comics on the theme of my air is polluted to train the critical thinking skills of seventh-grade junior high school students. This study aims to determine the efficiency of science digital comics on the theme of my air is polluted to train the critical thinking skills of seventh-grade junior high school students.

Research Methods

The research method used in this research is the Research and Development (R&D) method (Sugiyono, 2017); his research design uses the 4-D model (Four D Model) presented by Thiagarajan et al. (1974). In this study, the 4-D model was only carried out until the third stage, namely definition, design, and development. The types of data used are quantitative data and qualitative data. The quantitative data were obtained from the assessment of the questionnaire instrument sheet validated by the validator and the student response questionnaire. Qualitative data is obtained from various suggestions, inputs, and validator responses that can be used when improving or revising the developed product.

In this study, validation questionnaires were distributed to validators, and a limited trial was conducted on ten students at SMPN 1 Anyar. The instrument used in this research is a questionnaire, the validation test instrument; the experts used material experts, media experts, and expert practitioners, and a questionnaire instrument for student responses. The flow of this research is depicted in Figure 1:

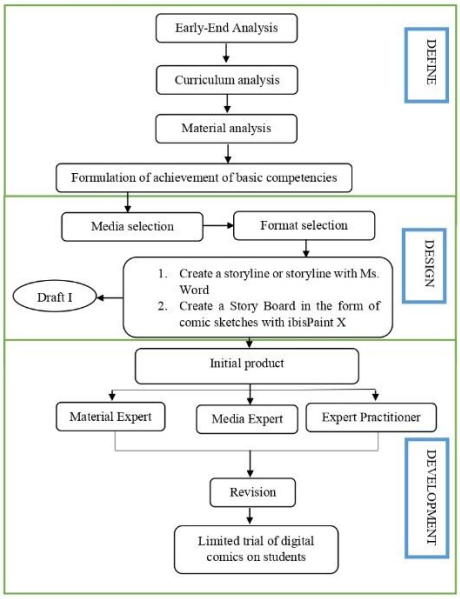


Figure 1. The schematic of the modified 4-D Thiagarajan et al. (1974) model

The categories are determined in the efficiency test by first validating five expert validators, including one material expert, namely a science education lecturer from Trunojoyo Madura University, one media expert, namely a Biology education lecturer at Sultan Ageng Tirtayasa University, and three expert practitioners/educators namely science teachers at SMPN 1 Anyar, SMPN 3 Cilegon and SMPN 9 Cilegon. This study conducted limited trials at SMPN 1 Anyar. Researchers used validation sheets and student response questionnaires to develop learning media for digital science comics. This research was carried out in the even semester 2021/2022 academic year in April-May 2022.

The researchers used validation and student response questionnaires to develop learning media for digital science comics. The results obtained from this science digital comic research were then analyzed. The data obtained quantitatively is processed into qualitative. At the expert validation test stage, it was carried out to measure whether or not digital science comics on the theme of my air was polluted were to train the critical thinking skills of seventh-grade junior high school students as learning media.

The experts used a Likert scale to assess the validation test instrument. The qualitative expert validation sheets obtained qualitative assessments sorted into quantitative ones. The scoring for the Likert scale can be adjusted according to the following assessment criteria:

Table 1. Assessment criteria using a Likert scale

Assessment criteria	Score
Very Good (VG)	4
Good (G)	3
Not Good (NG)	2
Very Poor (VP)	1

Then after knowing the results of the assessment score from the Likert scale, it is calculated using the following formula:

$$Score = \frac{Score\ obtained}{maximum\ Score} \times 100\%$$

(Pranatawijaya et al., 2019)

The results of the validation test from the experts that have been obtained in the form of percentages are remade into a qualitative form that is in sync with the assessment criteria in table 2 to determine the category of the validity level of the digital science Comics that have been assessed.

Table 2. Validity level category

No	Number	Category validity
1	85,1% - 100%	Very valid, or used without revision
2	70,1% - 85%	Valid or usable needs need minor revision
3	50,1 % - 70%	Not valid; it is recommended not to use it because it needs a major revision
4	0,1% - 50%	Invalid, should not be used

(Akbar, 2013)

The results of the student response questionnaires that have been obtained in the form of percentages are remade into a qualitative form that is in sync with the categories in table 3 to determine the category of the efficiency level of science digital Comics that has been assessed.

Table 3. Category of efficiency level

No	Number	Efficiency Category
1	85,1% - 100%	Very Efficient
2	70,1% - 85%	Efficient
3	50,1 % - 70%	Less Efficient
4	0,1% - 50%	Not efficient

Result and Discussion

After the process of making digital comics is complete, the following process is to carry out a validation test to the validator to describe the level of validity and whether it is suitable for use and ideal for testing in schools. Science digital comics were validated by five validator sources and conducted a limited trial of 10 students to determine the efficiency of science digital comics learning media.

Each validator assesses the results of the validation questionnaire sheet. The results and percentages of all descriptors are calculated as well as any criticism and suggestions submitted by the validator to be used as a reference in improving digital science comics. Regarding the overall results from the assessment of each expert, it can be seen that 92.25% can be seen in table 4 below:

Table 4. Overall Results of the Validation Assessment from the experts

No	Validator	Percentage	Information
1.	Material Expert	93,18%	Very Valid
2.	Media Expert	88,46%	Very Valid
3.	Expert Practitioner	95,13%	Very Valid
	Whole	**92,25%**	**Very Valid**

The validation process aims to ensure that the media developed is feasible or unsuitable for use. The validation process is assessed by the validation of material experts, media experts, and expert practitioners. Regarding the purpose of each validation stage, material expert validation is carried out to assess the suitability of the material in the IPA digital comic media. So that the material in IPA digital comics can be said to be feasible or not feasible to use, media expert validation was carried out to assess the presentation, language, and graphics of the developed science digital comics media. So, the science of digital comic media can be said to be feasible or not feasible. The validation of expert practitioners was carried out to assess

material content, language, and media in the IPA digital comic with the theme "My Air is Polluted" so that the digital science comics learning media can be said to be feasible or not feasible to use.

Based on table 4 regarding the results of the validation that has been carried out by material expert validators, media experts, and expert practitioners on IPA digital comic media, different results are obtained. The percentage value obtained from material experts is 93.18% in the "Very Valid" category, the percentage value obtained by media experts is 88.46% in the "Very Valid" category, and the percentage value obtained by expert practitioners is 95.13%.

Then the overall score is obtained based on the percentage of assessment from each expert, which is 92.25% with the "Very Valid" category. With the results obtained from each expert, the digital science comic with the theme of my air polluted "Very Valid" was used in a limited trial in junior high school as a learning medium. The following is a recapitulation of the average validity assessment results given by experts for IPA digital comics, which can be seen in Figure 2 below:

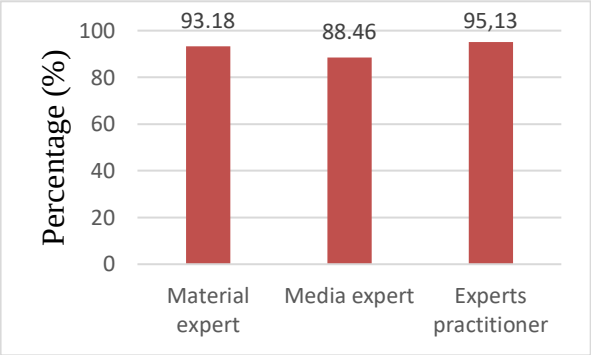


Figure 2. Percentage recapitulation of expert validation results

Based on Figure 2, the digital science comics learning media is sufficient for the specified validity category. However, it still needs a little revision according to the advice and input of each expert. The following are the results of the revised IPA digital comic product:

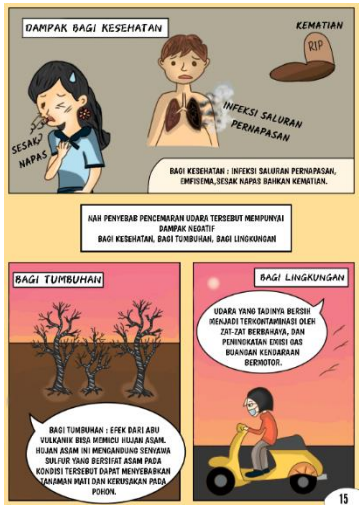


Figure 3. Before revision

Figure 4. After revision

Figure 5. Before revision

Figure 6. After revision

To measure the level of validity of the learning media that has been developed. The components of the IPA digital comics that were

tested included four components given to different validators covering aspects of the suitability of content, language, presentation, and graphics. The validity component to be measured can be seen in table 5:

Table 5. Components of validation based on BSNP combined with comic elements and indicators of critical thinking skills

Criterion	Indicators
Eligibility of Contents	a. Conformity with KI and KD subjects. b. Scientific substance. c. Diversity of social values
Linguistics	a. Readability b. Language logic
Presentation of IPA digital comic media	a. Critical thinking components. b. IPA digital comic presentation techniques. c. Comic elements d. The compatibility between the material and the storyline. e. Presentation of science digital comic learning media
Graphic	a. Size/format of IPA digital comics b. IPA digital comic cover design c. Illustration of comic content d. Image quality in comics

[BSNP, (2007), (Yanti et al., 2019) & Facione, (2015)]

The next stage is a limited trial of digital science comics that have gone through a revision stage from each material expert, media expert, and practitioner expert. This little trial aims to describe the level of efficiency through students' responses to aspects of appearance, function, and students' critical thinking skills through learning media for science digital comics with the theme "My Air is Polluted ."The limited trial was carried out at SMPN 1 Anyar with ten students as a subject.

a. Display Aspect

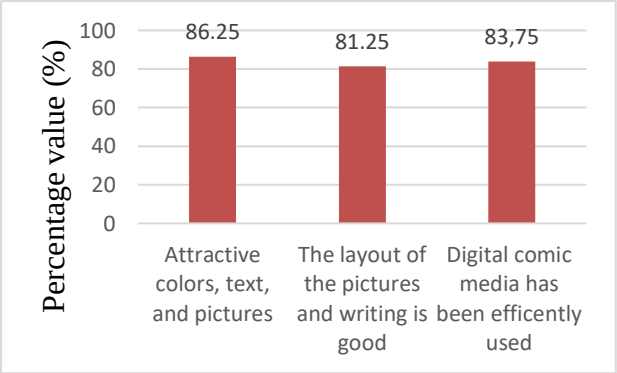


Figure 7. Percentage average of display aspect assessment results

The results of the assessment on the display aspect contained in Figure 7 get a value with a percentage of 84.37% with the "Efficient" category based on the results of the average value of the three indicators assessed, the indicator consists of indicators of color, writing, and attractive images with a value 86.25%, the indicators for the layout of images and writings are good with a value of 81.25, and the indicators for digital comic media are efficient to use with a value of 83.75%.

Students' responses to the indicators of color, writing, and attractive images scored 86.25% in the "Very Efficient" category. These results indicate that students are very interested in reading digital science comics because the images displayed are visible, students like the comic design that is presented because it uses attractive color composition, and students are easy to understand the material because the sentences in the comic can be read clearly and easy to understand, and students feel happy when reading digital science comics because the letters used are simple, attractive and easy to read.

Science digital comics learning media has presented a comic display with very clear images using very attractive color compositions. Students are also very enthusiastic about using this digital science comics learning media because the sentences contained in the comics are quite simple with non-monotonous letter combinations.

Color composition in comics is essential so that comics seem more attractive. Coloring in comics is made with gradations so that readers/students don't get bored and don't look monotonous when reading comics. In line with the statement of Santoso & Syafii (2018) that the gradation presented in the comic aims to make the colored images more attractive and not monotonous.

The type of font displayed in the comic must be adapted to the characteristics of the students. The letters presented are neither too small nor too big so that students can easily read the digital science comics. It can also grow the attractiveness of learning and interest in reading students.

Students' responses to the indicators of the layout of pictures and writings are good, obtaining an average percentage of 81.25% in the "Efficient" category. These results indicate that students like the display presented in science digital comics because they already have a proportional/balanced image layout, and students also like the appearance of science digital comics because they already have a good writing layout.

The layout of the image in the comic must be adjusted to focus on delivering the information. The

information presented was on the material on the theme "My Air is Polluted," which consisted of Basic Competency 3.8 class VII on air pollution, Basic Competency 3.4 class VII on temperature and heat, and Basic Competence 3.9 class VIII on the human respiratory system.

The size of the image in a comic must also be adjusted to make it look more proportional/balanced. IPA digital comics are good at displaying a proportional/balanced image layout. This is in line with the opinion of Santoso & Syafii (2018) that the size of an image in a comic must be made, taking into account the size and point of view of the author. The pictures displayed in comics must be balanced big-small, far-close, and wide-narrow.

Student responses on digital comic media indicators have been efficient to use, obtaining an average score percentage of 83.75% in the "Efficient" category. These results indicate that students are very interested in the audio of the IPA digital comic because it can describe the atmosphere in the story. Students can easily use digital science comics through gadgets.

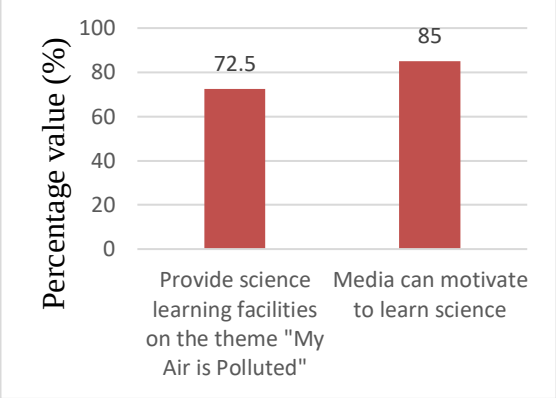
The media needed as learning media are attractive, efficient, and effective media. The sound effects contained in digital science comics are one of the advantages of this learning media. The existence of sound effects can give an accurate impression and new experiences for students in using learning media. The sound effects are by the images presented in the comics. The comic storyline's sound effects make students enthusiastic about learning about polluted air, which is packaged in comic form.

This comic-based learning media can be used as a learning medium because it can streamline learning activities and increase students' interest in learning (Ratnasari & Ginanjar, 2020). According to Kanti et al. (2018), Digital comics were chosen because they have advantages such as growing students' interest in reading, making the material more interesting and easy to understand, and helping students to understand abstract thought.

b. Function Aspect

The results of the assessment of the functional aspects contained in Figure 8 get a value with a percentage of 78.75% with the "Efficient" category based on the results of the average value of the two indicators assessed; the indicator consists of the media indicator capable of providing science learning facilities on the Airku theme Polluted with a value of 72.5%, and the media indicator can motivate to learn science with a value of 85%.

Students' response to the media indicators capable of providing science learning facilities on the theme "My Air is Polluted" obtained an average score of 72.5% with the "Efficient" category. These results indicate that students can understand the material and that my air is polluted well without getting an explanation from the teacher. Students



are also able to obtain material well through an integrated theme.

Figure 8. Percentage average of function aspect assessment results

Science digital comics can be one of the facilities/facilities that can support students when the learning process is carried out online. However, this digital science comic is still lacking in growing independent learning because, from the results of student responses, students tend to have more difficulty learning without an explanation from the teacher.

The science learning process in schools requires the teacher only as a facilitator, and the role of students is more dominant than the teacher. Students are asked to be more active and able to find information related to the material to be studied independently (Matsun et al., 2019). The student center learning system is difficult to implement if students do not learn independently.

The teacher is an intermediary for students to learn and gain knowledge. Teachers are often also referred to as second parents because the task of a teacher is not only to teach the material to students, but the teacher must also be able to educate and develop the attitudes and skills of students. So the role of the teacher in the world of education is very necessary and important. According to Yestiani & Zahwa (2020), teachers have an important role in learning and student development.

Student responses on media indicators can motivate science learning to get an average value percentage of 85% with the "Efficient" category. These results show that students are very serious about reading digital science comics. Students are

also more interested in reading using digital science comics because they are not boring.

This makes students more interested in reading using comics than the available teaching materials. Because this digital science comic is not boring to read. But there are still shortcomings in the science of digital comics learning media. The material developed in the media is not very deep because the language in the comic sentences is quite simple and limited, causing this digital science comic cannot be used as the main teaching material.

c. Aspects of Critical Thinking Ability

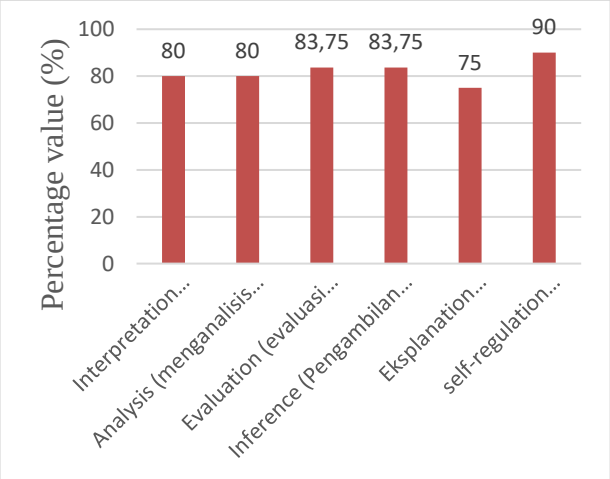


Figure 9. Percentage average of critical thinking skills assessment results

Student responses are based on aspects of critical thinking skills, including six indicators: Interpretation, Analysis, Evaluation, Inference, Explanation, and self-regulation. To train students' critical thinking skills, they can do learning innovations. With innovative learning, students can become someone who has critical thinking skills seen from their skills in interpreting, identifying, evaluating, and concluding (Suparni, 2020).

The results of the assessment on the aspect of critical thinking skills contained in Figure 9 get a value with a percentage of 82% with the "Efficient" category based on the results of the average value of the six indicators assessed; the indicator consists of an interpretation indicator with a value of 80%, an analysis indicator with a value of 80%. A value of 80%, evaluation indicator with a value of 83.75%, inference indicator with a value of 83.75, explanation with a value of 75%, and self-regulation with a value of 90%.

Student responses to the interpretation indicator obtained an average percentage of 80% with the "Efficient" category. These results indicate that the storyline in the digital science comic with the theme that my air is polluted can make it easier for students to convey information related to the causes and effects of air pollution in everyday life.

The presentation in science digital comics has described the material contextually through appropriate image designs in interpreting the causes and impacts of air pollution in the surrounding environment. This allows students to quickly formulate problems related to the theme "My Air is Polluted," This is also closely related to the location taken to conduct the trial. The location chosen for the trial is very by the theme taken because the material presented through science digital comics is very contextual to the problems in the student environment.

Student responses to the Analysis indicator obtained an average score percentage of 80% with the "Efficient" category. These results indicate that students in the process of analyzing a problem are classified as good.

This shows that students have been able to provide a simple explanation of the theme "My Air is Polluted" with the presence of science digital comics media, students are very good at analyzing the effect of air pollution on the health of the respiratory system, and with the presence of science digital comics media, students can do well analyze the impact of hot temperatures on air pollutants that can cause air pollution.

The storyline contains indicators to analyze problems. For example, in the dialogue " "During the day, the air temperature increases so that it can cause the air to dry up; as a result, these pollutants will last longer in the air," said Livy to Rini. The dialogue shows the analysis process carried out by Livy's character regarding the relationship between temperature and air pollution.

In the theme "My Air is Polluted," there are several problems that students can analyze. The analysis process is a process in which students investigate why a problem occurs. According to Junaidi (2015), a person's activity is to think about identifying a problem that exists in certain media.

Students' responses on the evaluation indicators obtained an average of 83.75% in the "Efficient" category. These results indicate that students in the process of evaluating a problem are classified as good. With the existence of digital science comics learning media, students can provide solutions to prevent and reduce the impact of air pollution and describe efforts to maintain a healthy respiratory system.

The digital science comics presented have described and conveyed information related to

solutions related to problems on the theme "My Air is Polluted ."The answer has been described with a good image design so students can evaluate the situation appropriately.

Student responses to the inference indicator obtained an average score of 83.75% in the "Efficient" category. These results indicate that students are classified as good in the process of concluding. This shows that with science digital comic media, students can contextually see the problems of air pollution that often occur. With the science digital comic media, students can draw conclusions regarding the relationship between air pollution, temperature, and the human respiratory system in everyday life.

The storyline contained in the comic already refers to the critical thinking aspect of the inference indicator. For example, in the dialogue, "Oh, that's right. This means that air pollution in our area is mostly due to human activities, right?" The storyline described in an attractive design and the characteristics of the students makes it easier for students to conclude related to the material on the theme "My Air is Polluted."

Students' responses to the explanation indicator obtained an average value percentage of 75% with the "Efficient" category. These results indicate that with the existence of science digital comics media, students can reinforce the causes of the problem of air being polluted. In the comic storyline, there is already an affirmation of a problem my air is polluted.

This is shown in the dialogue, "Yes, sir, here I will explain. So two factors cause air pollution, namely natural factors and human factors. Natural factors such as volcanic eruptions and forest fires. While human factors, for example, burning garbage, vehicle fumes, chemical industry activities, and cigarette smoke. Now the cause of air pollution hurts the health of plants. This affirmation has been described well so that students can convey an affirmation about the problem of my air being polluted.

Student responses to the last indicator, namely self-regulation, obtained an average score percentage of 90% with the "Very Efficient" category. These results indicate that with the existence of digital science comics, students become more concerned about air pollution problems so that they can be motivated to reduce polluted air problems.

This is because science digital comics already have self-regulation indicators. This is shown in the digital science comic because it presents an image design that conveys motivation so that students are more concerned about the problem of air pollution. So that it can foster students' motivation to keep the air clean. It is shown in the dialogue, "OK, sir, after this, Mr. Tejo wants to plant new plants so that there is a lot of oxygen in this house hehe ."The dialogue shows Pak Tejo's desire to reduce the impact of air pollution around the house by planting trees.

Table 6. Overall results of student responses

No	Aspect	Percentage Value	Information
1.	Appearance	84,37%	Efficient
2.	Function	78,75%	Efficient
3.	Critical thinking skills	82%	Efficient
	Whole	**82,27%**	**Efficient**

Based on table 6, it can be seen that the overall assessment of the student response questionnaires obtained a value of 82.27% with the "Efficient" category. This shows that the science digital comic media on the theme “My Air is Tercemar" has been efficiently applied in the classroom learning process.

Conclusion

Based on the results of research and discussion that have been carried out, the results obtained from research and development of digital science comics with the theme "My Air is Polluted ."The results of the efficiency level of science digital comics with a limited trial of 10 students obtained a score of 82.27% in the "Efficient" category, so from the results of the assessment, it can be, concluded that digital science comics on the theme "My Air is Polluted" can be tested on school so that this digital science comic can be applied as a learning media to support science subjects for Junior high school in Class VII.

For further researchers who will develop a digital comic with the theme " My air is polluted" to train the critical thinking skills of Junior high school in class VII science students, it is recommended to continue this research with a high level of material depth, and it is hoped that large-scale trials can be carried out to obtain maximum research results.

Acknowledgment

Thanks to all who helped and supported this digital science comic research, thanks. Hopefully, this comic can be one of the learning media that can be applied to learning at school.

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