E-Comic Science Integrated with PBL Model to Improve Problem Solving Skills

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Abstract: Students' problem-solving skills in natural science are considered low. This research aims to find out the feasibility, effectiveness, and practicality of e-comic media in science learning that are capable of improving problem-solving skills. The research is a research and development with ADDIE development procedures (analysis, design, development, implementation, and Evaluation). The validity level is obtained through expert validation sheets, whereas the effectiveness level is identified through a trial using a one-group pretest-posttest design with a paired sample t-test analysis. Student questionnaires are used to gain the practicality level. The research results indicate that the media expert assessment is 4.43 and the content expert assessment is 4.23 and both are very valid. The effectiveness level generates a t-value of 11.379 with a significance level of 0.05, which means there is a significant improvement in problem-solving skills. The average gain score is 0.56 or in a moderate category. Students' questionnaires on the e-comic media resulted in a percentage of 83.54%. The research concludes that e-comic media are feasible to be used in improving problem-solving skills in science learning.

Keywords: E-comic; Problem-based learning; Problem-solving skills

Introduction

The primary skill emphasized in facing 21st-century life is problem-solving skills (Wagner & French, 2010). Along with the time and the change in living conditions, issues arise that require not only knowledge concepts but also problem-solving skills to solve them (Saragih, 2019). The low problem-solving skills will affect the low quality of human resources (Cahyani & Setyawati, 2016).

Problem-solving skills are vital to be improved in science learning since the skills will train students to *develop* creative thinking in solving 21st-century life (Zubaidah, 2016). Science learning should be expanded through improvement in curriculum and the quality of natural science learning media that contain a collection of knowledge in the forms of facts, concepts, and principles, and generate a process or product (Sofyan et al., 2018).

An observation generated information on the low problem-solving skills among students in SMPN 1 Selomerto. The results of an interview with the students on December 3, 2020, indicated that during the science learning activities, many students were less systematic in solving enrichment questions or in the daily assessment in the form of solving a problem. Students also struggled in determining concepts, quantities, symbols, implementation of laws of and formulas in physics since the concepts and problem examples presented in the textbooks are contextual.

Solutions to enhance students' problem-solving skills in science learning include the utilization of problem-oriented teaching materials, models, and learning media (Ridho et al., 2020). Visual learning media is believed to be able to stimulate vision in illustrating a problem through the image presented (Nomleni & Manu, 2018). Electronic comic media are one of the technology-aided visual learning media that save printing costs (Aeni & Yusupa, 2018). Comic characteristics can present stories that integrate problem-solving steps such as creating, implementing, and evaluating plans (Kristianto & Rahayu, 2020). The e-comic media designed that contain illustrations and

problem-solving steps in their storyline are capable of stimulating students' activities to solve problems.

Optimizing problem solving can be done using learning models applied by teachers. One of the trusted and realistic models for science learning is Problem-based Learning (PBL) that involves students' concept thinking and emotional intelligence (Zunanda & Sinulingga, 2015). PBL model can encourage students to read learning sources and uncover strategies using knowledge to organize an investigation of the involved problems (Amalia & Pujiastuti, 2016). The role of PBL as an instructional method by facilitating complex problems as a learning source for students enliven students to work collaboratively in a group to identify what they need in solving the problem (Silver et al., 2019).

The results of a research trial by (Aeni & Yusupa, 2018) stated that e-comic media could provide stimulus and increase students' curiosity to learn the subject. Students' skills in understanding content increase through varied images presented. Overall, the utilization of e-comic media in learning can improve a concept and problem understanding (Putri & Novita, 2014). A study by (Redhana, 2013) suggested that the implementation of problem-based learning models could enhance problem-solving skills and critical thinking since they challenge and motivate university students to solve less-structured problems. The current research is succeeded in achieving the research goal, namely the e-comic media developed can significantly improve the problem-solving skills of students in Grade VIII.

Method

Research design

The research method employed was research and development using the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). According to (Sugiyono, 2012), the R&D method is used to produce and examine the effectiveness of a certain product developed. The development stages in the research are illustrated in Figure 1.
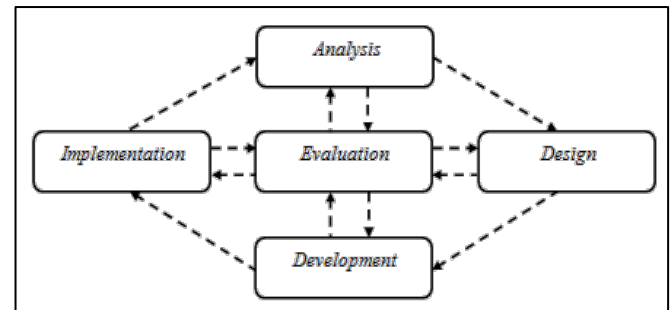

Figure 1. ADDIE Model Stages

Media implementation was carried out using a one-group pretest-posttest technique to measure the achievement indicators of the students' problem-solving skill improvement. The e-comic media were implemented in a structured in the science learning through a lesson plan designed. The learning steps utilized a Problem-based Learning model syntax as indicated in Table 1.

Table 1. Learning operational

Steps	Learning phase		Learning Operational Steps
Opening	Apperception& Pretest	The teacher conveys problem orientation to students by providing examples of the implementation of respiratory system concepts that followed by initial pretest	Students work on the pretest questions independently
Core activities	Stimulation & problem statement	The teacher organizes students to generate information in the comic	Students organize information contained in the e-comic media distributed by the teacher
	Data collection	The teacher and students perform an open discussion on the presented problems	
	Posttest	Teacher provides posttest questions on problem-solving skills	Students answer the posttest questions independently
Closing	Conclusion	Teacher and students summarize the content studied and reflect on the discussion results	

Population and research sample

The research subjects included all students of Grade VIII in SMP Negeri 1 Selomerto that consisted of four classes and one class was selected as a sample. The selection of the research sample employed a purposive cluster sampling technique with the following criteria 1) homogeneous class and 2) students have a compatible Smartphone to access the e-comic media.

Research Instruments

The research instruments were questionnaires and tests. The questionnaire instruments comprised expert

validation questionnaire and media validation questionnaire. The test instruments were based on the problem-solving indicators, namely understanding (understanding problems), analysis (analyzing problems), planning (determining and planning problem alternatives); implementation (implementing problems); and evaluation (evaluating problem solving) (Yuriev et al., 2017). The examples of the problem-solving questions contained in the e-comic are presented in Table 2.

Table 2. Example of Questions to Measure Problem-Solving Skills

Question	Problem-solving Indicator
Since 2019, a new virus occurs that is hard to eradicate. It spreads rapidly and has a mortality risk. The primary target of the virus is the main organs of human respiration, namely the lungs. In infecting the lungs, what organs are passed through and attacked by the Coronavirus?	Understanding
In a snippet where Mak Cik was out of breath, a note states that her asthma flared up after meeting many people. This could occur due to the decrease in oxygen supply to the lungs, whereas asthma sufferers with narrow blood vessels require more oxygen flow. When experiencing the above situation, what actually happens with Mak Cik's respiratory mechanism?	Analysis

The research validity tests consisted of content validity and construct validity. Two content experts performed the content validity test of the question items by providing assessment and suggestions for improvement on the question items before implementing them to the research subjects. Of the 10 questions, 8 items were in the very valid category, whereas the remaining two items were in the valid category; the trial thus could be conducted. The construct validity test of Pearson Product Moment correlation that employed SPSS 22 calculation with a significance level of 0.05 indicated that the test instruments used for measuring problem-solving skills were valid. The r-table obtained based on the number of samples, which was 10 students, was 0.623 and the r-value produced is presented in Table 3.

Table 3. Results of Test-Instrument Construct Validity

Question Item Indicator	r value	Conclusion
Understanding	0.675	High Validity
Anaysis	0.579	ModerateValidity
Planning	0.627	High Validity
Evaluation	0.724	High Validity
Implementation	0.909	Very High Validity

The reliability test was carried out based on the construct validity results to identify the level of accuracy of the questions used in the research. The reliability test used a Cronbach's Alpha method and was analyzed using an SPSS 22 program. The reliability coefficient produced was 0.744 suggesting that the test instruments had high reliability since it located in the alpha range of 0.70-0.90; therefore, it was reliable. The detailed test results can be seen on Table 4.

Table 4. Results of Question Item Reliability

Problem-solving Indicator in the question	Alpha Number	Conclusion
Understanding	0.715	Reliable
Analysis	0.761	Reliable
Planning	0.739	Reliable
Evaluation	0.681	Reliable
Implementation	0.560	Reliable

Data *Analysis*

The data analysis technique used a parametric test with prerequisite tests of homogeneity and normality tests. The normality test employed the Liliefors method with requirements of interval or ratio data, single data, and sample size of n<30. The homogeneity test was processed using Microsoft Excel with a significance level of 0.05. The goal of the prerequisite tests was to find out whether the data produced met the requirement for the parametric test to be conducted. The media feasibility analysis technique was a validity test by using a 5-point Likert Scale as presented in Table 5.

Table 5. Validity Criteria

Formula	Interval	Criteria
$X > \bar{X}i + 1{,}80\ Sbi$	X > 4.2	Very Valid
$\bar{X}i + 0.60\ Sbi < x \leq \bar{X}i + 1.80\ Sbi$	3.4 < X ≤ 4.2	Valid
$\bar{X}i - 0.60\ Sbi < x \leq \bar{X}i - 0.60\ Sbi$	2.6 < X ≤ 3.4	Fairly Valid
$\bar{X}i - 1.80\ Sbi < x \leq \bar{X}i - 0.60\ Sbi$	1.8 < X ≤ 2.6	Less Valid
$\bar{X}i - 1.80\ Sbi < x \leq \bar{X}i - 0.60\ Sbi$	X ≤ 1.8	Invalid

The media effectivenes analysis technique was carried out using two types of calculation, namely paired-sample t-test and N-gain test. The t-test indicates the influence of one independent variable on dependent variables significantly. If the t-table<t-value, then Ho is accepted and Ha is rejected. The N-gain test aimed to

identify to what extent the improvement in students' problem-solving skills after the application of the e-comic media. The normalized gain criteria are presented in Table 6.

Table 6. Normalized Gain Criteria

Normalized Gain Value	Interpretation
$0{,}70 \leq g \leq 1.00$	High
$0.30 \leq g < 0.70$	Moderate
$0.00 < g < 0.30$	Low
$g = 0{,}00$	No improvement
$-1.00 \leq g < 0.00$	Decreasing

The media practicality test used the Likert Scale measurement. The practicality test aimed to measure the ease of use of the developed media in enhancing problem-solving skills. The practicality criteria of the Likert Scale can be seen in Table 7.

Table 7. Practicality Criteria

Formula	Interval	Criteria
$X > \bar{X}i + 1.80\ Sbi$	$X > 4.2$	Excellent
$\bar{X}i + 0.60\ Sbi < x \leq \bar{X}i + 1.80\ Sbi$	$3.4 < X \leq 4.2$	Good
$\bar{X}i - 0.60\ Sbi < x \leq \bar{X}i - 0.60\ Sbi$	$2.6 < X \leq 3.4$	Fair
$\bar{X}i - 1.80\ Sbi < x \leq \bar{X}i - 0.60\ Sbi$	$1.8 < X \leq 2.6$	Poor
$\bar{X}i - 1.80\ Sbi < x \leq \bar{X}i - 0.60\ Sbi$	$X \leq 1.8$	Bad

The average score of the practicality was then interpreted into a percentage scale with the Formula 1.

$$\text{Practicality (\%)} = \frac{\text{Emean of scores obtained}}{\text{Emean of maximum score}} \times 100\% \qquad (1)$$

Result and Discussion

E-Comic Media Feasibility

The media experts and content experts validated the e-comic media with a theme of BUANA KITA as an science teaching material for Grade VIII in the subject of "human respiratory system" that was created by the authors. The results from media and content experts are elaborated as follows.

a. Media Expert Validation

Table 8 presents the results of media validation by the media experts.

Table 8. Media Expert Validation Results

Assessment Aspects	Average
Anatomy Display of the E-Comic Media	4.30
The Use of Words and Language	4.62
Presentation of Problem Solving Skills	4.30
Access to E-Comic Media	4.50
Total average	4.43

Based on the assessment results from both media experts, aspects with the lowest average assessment were the first and third aspects. The first aspect namely anatomy display of the e-comic media had an average score of 4.3 from the maximum score of 5.0. The low score in the aspect was due to the less suitable placement of the comic anatomy, such as color gradation, word balloons, continuity between cover and content, and less dominant characters. This is consistent with suggestions from the validators to improve less suitable points in the aspect of anatomy display of the e-comic media. Therefore, improvement was conducted for this aspect as indicated in Figure 2.

Figure 2. Display of the E-Comic Media Before and After the Revision

The next aspect with the lowest average score was the third aspect, which is the presentation of problem-solving skills with an average score of 4.3 of the maximum score of 5.0. The cause of the low score was due to the e-comic that presented less problem solving.

The result was congruent with the validators' suggestion to present more problem solving. The suggestions were followed-up by improving the e-comic media by accommodating problem-solving skills in one of the episodes to train students in solving problems in a story.

Figure 3. Problem-solving Steps Before and After Revision of the E-comic

b. Content Expert Validation

The results of the content validation by the content experts aimed at identifying the content validity level of the media as presented in Table 9.

Table 9. Results of Content Expert Validation

Assessment Aspect	Average
Content Substance	4.20
Language	4.50
Presentation of Problem Solving Skills	4.00
Total Average	4.23

Table 9 suggests that the aspect of the presentation of problem-solving skills received an average score of 4.0 of the maximum score of 5.00. The low score in the aspect compared to the two aspects was due to the less content on problem solving in the e-comic stories. This is congruent with suggestions given by the validators to add problem solving in the comic that refers to concepts in the learning indicators. As the follow-up action on the suggestions from validators, the improvement was by adding problem solving in the comic. The revision results on the e-comic media in the aspect of the presentation of problem solving-skills are indicated in Figure 4.
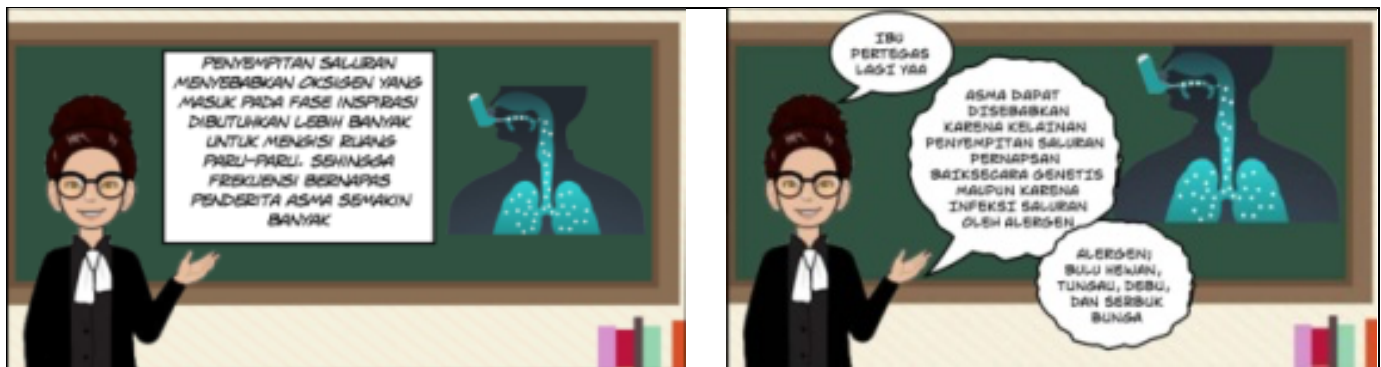

Figure 4. Presentation of Problem-Solving Skills Before and After the Revision

The average assessment score of the content in the e-comic media was 4.23 with a feasibility percentage of 84.6%; therefore, the result was in the very feasible category to be tested in science learning. The e-comic media had to go through an improvement stage before its implementation to students to enhance the media quality in transferring the content concepts according to the basic competencies. Table 10 presents the summary of validity scores from the media and content experts.

Table 10. Justification of the E-comic Media Feasibility

Assessor	Average	Percentage (%)	Criteria
Media Expert	4.43	88.60	Very Feasible
Content Expert	4.23	84.60	Very Feasible

The research results indicate that the e-comic media as science teaching material in Grade VIII of junior high school was feasible and effective and can be applied in learning, especially in the basic competence of "Analyzing Human Respiratory System and Respiratory Disorders". Based on the assessment results, the validity percentage by the media experts was 88.6% and 84.6% by the content experts, or both were in a very feasible category.

The Effectiveness of E-Comic Media in Improving Problem-Solving Skills

Media that had been revised or in the form of a product would be tested on students in Class VIII D of junior high school 1 Selomerto. The test sheet used as a measuring instrument of students' problem-solving skills had gone through validity and reliability stages

and the results can be seen in Table 7 for the validity test and Table 11 for the reliability test.

Table 11. Test Validity Results

Item	V I	V II	Average	Category
1	4	4	4.0	VV
2	4	4	4.0	VV
3	4	5	4.5	VV
4	4	4	4.0	VV
5	5	4	4.5	VV
6	4	4	4.0	VV
7	3	4	3.5	V
8	3	4	3.5	V
9	5	4	4.5	VV
10	5	4	4.5	VV

The validation results suggested that question items no. 1,2,3,4,5,6,9, and 10 were in the very valid category (VV), whereas question items no. 7 and 8 were in the valid category (v). The reliability test employed a Cronbach's Alpha by measuring the skills of 10 students before the test instruments were tested on the research subjects. The criteria of the alpha coefficient are presented in Table 12.

Table 12. Criteria of Alpha Reliability Coefficient

Interval α	Criteria
> 0.90	Perfect Reliability
0.70 – 0.90	High Reliability
0.50 – 0.70	Moderate Reliability
< 0.50	Low Reliability

The reliability test analysis was performed using the Microsoft Excel program and resulted in a reliability score of 0.743. The calculation results indicated that the question instrument had high-reliability level. The analysis results can be interpreted that the problem-solving skill test was reliable and consistent in producing a relatively similar measurement. The result of the reliability test for each question with problem-solving indicators can be seen in Table 13.

Table 13. Results of Question Item Reliability

Indicator	Alpha	Conclusion
Understanding	0.675	Reliable
Analysis	0.578	Reliable
Planning	0.627	Reliable
Evaluation	0.723	Reliable
Implementation	0.908	Reliable

a. Prerequisite tests

Two prerequisite tests were employed to determine whether the generated data were parametric, namely normality and homogeneity tests. The data normality test that used Microsoft Excel 2007 with Liliefors method generated a value of Lo ≤ L table, which was 0.135 ≤ 0.161. The Lo value indicated that the data were from a normally distributed population. Hence, it can be inferred that the testing data were parametric. The F-value obtained from the homogeneity test was 1.216, whereas the F-table was 1.86. The results can be interpreted that F-value was smaller than F-table thus the variance of the pretest data was equal to the variance of the posttest data indicating that both samples were homogeneous.

b. Hypothesis Testing

The research used two hypothesis tests aimed at identifying the enhancement in the score of the problem-solving skills of the students in Grade VIII, namely the t-test and N-gain test. The effectiveness of the e-comic media in learning was tested using a one-sample t-test. The hypotheses were:

H_O: "There was no difference in the result of problem-solving skill test before and after the utilization of the e-comic science in a theme of Buana Kita in Grade VIII junior high school 1 Selomerto."

H_a: "There was a difference in the result of problem-solving skill test after the students utilize the e-comic science in a theme of Buana Kita in Grade VIII junior high school 1 Selomerto."

The students' average gain before and after the utilization of the e-comic science is illustrated in Figure 5.
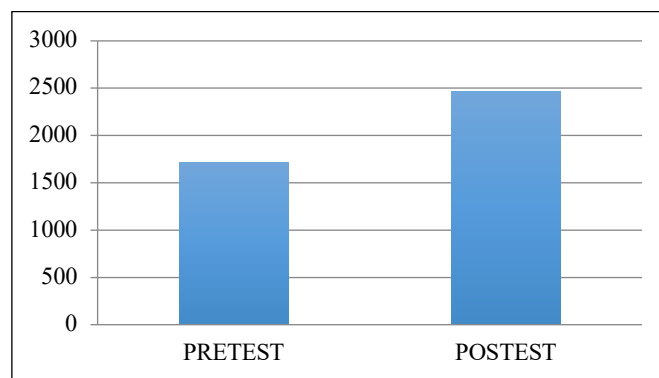

Figure 5. Score Gain Chart

The parametric data of the test results of the problem-solving skill pretest- posttest for 30 students that had been normally distributed and homogeneous were analyzed using a t-test to find out the average difference between both data. At α (significance value) = 5% and dk (degree of freedom) = (30-1) = 29, the t-table = 2.00 and the t-value = 11.379. The calculation results concluded that the t-value was not in the area between (-) t-table and t-table; thus, Ho was rejected and Ha was accepted. This meant that there was an average difference in the results of the problem-solving skill test before and after the utilization of the e-comic media. Hence, the e-comic sciene had a significant influence on the students' problem-solving skills.

Next, the N-gain test was employed to find out the degree of improvement in the problem-solving skills in

the pretest and posttest data of 30 students. The criteria of the normalized gain to interpret data can be seen in Table 8. The N-gain test was carried out using Microsoft Excel and it resulted in a gain value of 0.56 with a category of moderate improvement. This can be interpreted that the e-comic science tested to the students was less maximum in enhancing the problem-solving skills.

Table 14. Categorization of the N-Gain Results of Grade VIII Students

N-gain score	Category	Number of students
0.70 ≤ g ≤ 1.00	High Improvement	11
0.30 ≤ g < 0.70	Moderate Improvement	16
0.00 < g < 0.30	Low Improvement	2
-1.00 ≤ g < 0.00	Decrease	1

Table 14 shows that 29 Grade VIII students experienced an improvement in their pretest and posttest results, whereas one student experienced a decrease. The less-than-optimal results of the e-comic media were due to several factors and one of them is that in the online learning process, some students paid less attention to discussion and problems with unstable signals.

The Practicality of E-Comic in Science Learning

The assessment by 30 students after the utilization of the e-comic science employed a Google Form with 10 question items. The results of the students' responses recapitulation were calculated for their average score of each item and were categorized using Likert Scale analysis in Table 3. Each answer selected by the students had a different score weight. The scoring in the response questionnaires and the categorization can be seen in Table 15.

Table 15. Recapitulation of Student Response Questionnaire

Assessment Aspect	Average
Practicality	4.25
Display and Language	4.10
Problem-solving Activities	4.16
Total average	4.20

The three aspects assessed by the students indicated a very good interpretation in the practicality aspect and a good interpretation in the display and problem-solving activities aspects. The display and language aspect in question item number 3 received the lowest score. Taken as a whole, problem illustration conveyed through images in the e-comic was less optimum. The calculation results of the students' assessment on the practicality of the e-comic media utilization in science learning referred to a good

category based on the Likert Scale interpretation, which were an average score of 4.20 and a percentage of 84%.

The research is superior since it generates a product, which is a-comic learning media as alternative teaching material in the science learning process that assists students in solving problems. The e-comic media implemented using a problem-based learning model was proven effective in improving students' problem-solving skills. Hence, it is recommended for future researchers to align teaching materials to the learning models employed to improve students' problem-solving skills. The e-comic media of "Buana Kita" that has received high feasibility from the expert assessment still bear some limitations. The developed e-comic media has not been tested for its readability; thus, the effectiveness of sentences presented in the stories has not been identified yet. In the access aspect, students complained about the difficulty to read when the signal was unstable since images in the e-comic have high resolution and are only available online. This becomes the researchers' consideration to improve the access system of the online media to simplify readers in understanding content and storyline.

As a visual communication medium, comics can be a means in education since they can convey information effectively and efficiently and are suitable to students' needs (Valerie et al., 2020). The t-test results of the students' pretest-posttest gained a t-value = 11.379 and did not include in the area of t-table=2.20. The results suggested that the e-comic media had an influence on the improvement of students' problem-solving skill tests. The gain score obtained was 0.56 indicating that the student's problem-solving skills experienced a moderate improvement. Several characteristics or advantages of the e-comic media "Buana Kita" can improve problem-solving skills. For example, image illustrations aims to illustrate problems more clearly in the e-comic (Rosidah, 2016). This statement is supported by a research trial by (Aeni & Yusupa, 2018) stating that through image variation, students' skill in understanding content operated using mobile phones stimulates and enhances students' curiosity to study a subject.

According to (Yuriev et al., 2017) storylines presented in the e-comic to train the five-steps of problem-solving to students can improve problem-solving skills as indicated in the improvement of posttest scores of the grade VIII. This is consistent with a study by (Gumilang et al., 2019) that comic media with a problem-posing model could increase problem solving by 85% in the posttest since students gained easiness in the study in working on questions solved using the problem-solving steps. E-comic accessed by utilizing technology comes in a practical and efficient digital form; hence, it is easy to guide students in understanding the contained content concepts

(Syarifuddin & Sumbawati, 2016). This is in line with research results by (Fuldiaratman & Minarni, 2021), that there was an increase in students' learning outcome of 88.57% after a treatment in the class activities managed using digital comic media.

The research results are also congruent with the function of learning media stated by (Widodo & Wahyudin, 2018), which is as a learning source that conveys messages; therefore, it can manage learning styles, senses limitation, intelligence, and geographical and time barriers. The e-comic media implemented to students were capable of overcoming the learning styles of Grade VIII students who are passive in a discussion. This is supported by (Moma, 2017) study that the assistance of discussion method can significantly improve problem-solving skills with an average score of 74.711 of the ideal score. The distance learning system (PJJ) has an impact on the science learning process that is less responsive in the online class. The application of the e-comic science "Buana Kita" in the learning with PBL method and discussion, however, was capable of improving students' activities to be more responsive. A study by (Makrufi & Hidayat, 2018) supported this by stating that there was a difference in the learning outcome between the experimental class that used the PBL model aided with online discussion with students in the buffer compounds subject with an average percentage of 84.05% and the control class without online discussion assistance with an average of 78.14%.

Conclusion

Based on the research results and discussion, a conclusion could be drawn that the e-comic science of Buana Kita in the basic competence of "Analyzing Respiratory System and Respiratory Disorders" developed through the 5 stages of ADDIE development is stated as very feasible to be tested to students of Grade VIII by the experts based on the assessment of the media and content experts. The image presentation that illustrates problems and storylines in the e-comic aimed at training the solving steps are deemed effective in improving students' problem-solving skills measured using pretest and posttest. The analysis indicated a moderate improvement category in students' problem-solving skills after the utilization of the e-comic media. The e-comic science of "Buana Kita" is very practical to use as an independent learning source in science subject as suggested by the practicality value generated from 30 student respondents and the percentage of the response questionnaires. It is anticipated that the development of the e-comic learning media can become the school and the science teachers' program in developing learning media in other Basic Competencies. It is better to have the e-comic media implementation in other schools to find out the benefits of the media to the schools. The

implementation process of the media that apply a problem-based learning model is expected to use virtual applications, such as Zoom Meeting or other platforms that could observe student activities directly in participating in the distance learning. Activities of reading and analyzing problems and their solution by students require considerable time; therefore, the learning activities are less efficient. These facts trigger a follow-up study by developing e-comic media into audio-visual media for easy access and utilization for students.

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