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Implementation of Personal Digital Inquiry Assisted by Infographics to Increase Science Literacy in Ecosystem Materials

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Abstract: This type of research is a quasi-experimental study,the research subjects were 70 Grade X students of SMAN X Cimahi. The purpose of this study was to see the effect of applying the Infographic-assisted Personal Digital Inquiry learning strategy on scientific literacy. The results of implementing an infographic-assisted personal digital inquiry learning strategy for science literacy test, the experiment class about indicator explaining the phenomenon scientifically has changed the medium category with an average value 65.14. For indicators evaluating and designing scientific questions even though there is the average value 54.28 still in the medium category on the results. And then, the average value of each indicator aspect of scientific literacy competence has changed, namely the indicator of interpreting data and evidence scientifically from the high category with an average value of 80.6. The Gain score obtained by the experimental class around 69.2% shows that these results are quite effective in learning. This can be seen from the Asymp value. Sig. (2-Tails) ranging from 0.000 <0.05, meaning that there is a significant differences in students' scientific literacy abilities using infographic-assisted digital personal inquiry learning strategies.

Keywords: Ecosystem materials; Infographi; Personal digital inquiry; Science literacy

Introduction

In the globalization period that the 21st century's advancements in science and technology helped to usher in. Numerous issues in daily life are entwined with science and technology (Adi et al., 2017). The industrial revolution 4.0 of the 21st century brought about a number of innovations, including a rise in connectivity, interactivity, artificial intelligence, and the creation of digital systems (Lase, 2019). The educational landscape must evolve to meet the demands of the twenty-first century. In the age of the fourth industrial revolution, education must be creative, inventive, and competitive. In order to achieve the best results, technology and science must be used as effectively as possible in the field of education (Lase, 2019).

Preparing human resources for competition and changes in comprehensive knowledge is a challenge in the 21st century. Critical thinking skills, teamwork skills, creativity skills, and communication skills are competencies that students today must possess (Wijaya et al., 2016). Students also need to be productive, accountable, responsible, flexible, and self-directed, as well as have social and cross-cultural skills, media literacy, information literacy, and technology literacy, and scientific literacy (Redhana, 2019).

Literacy has always been the subject of measurement by various international surveys, including a program initiated by OECD (*Organization for Economic and Co-Operation and Development*) countries called PISA. First held in 2000 with a focus on reading literacy, then in 2003 with a focus on mathematical literacy, then in 2006 with a focus on scientific literacy, and so on alternately (Nasution et al., 2019), PISA focuses on literacy.

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Indonesia has continually scored below the national average and has consistently placed in the bottom 10 since joining PISA in 2000. In the most recent PISA, conducted in 2018, Indonesian student achievement was in the lowest score group with a science score of 396 compared to the OECD average score of 489, a math ability score of 379 compared to the OECD average score of 489, and a reading ability score of 371 compared to the OECD average score of 48 (Schlecheir, 2019). In terms of science, math, and reading abilities, Indonesia has not undergone any substantial changes. These findings make it abundantly evident that Indonesia still faces a challenging undertaking in order to promote literacy.

The results of the PISA assessment of Indonesian students' scientific literacy skills are never satisfying because their scores are consistently lower than the global benchmarks set by PISA and they continue to receive the lowest rankings. Indonesia was ranked number 38 out of 40 nations in 2003, number 50 out of 57 countries in 2006, number 60 out of 65 participating countries in 2009, number 62 out of 69 countries in 2015, and number 71 out of 79 countries in 2018 (OECD, 2019).

By research, the lowest score attained is with indicators indicating assumptions, evidence, and reasoning with relevant information. While the items with indications outlining the potential ramifications of applying scientific knowledge to society had the highest percentage. Scientific literacy competency questions are often more demanding, thus students must have strong analytical skills as well as conceptual understanding to pass the scientific literacy competency test (Wibowo & Ariyatun, 2020).

In this study, the assessment of scientific literacy refers to scientific processes, namely mental processes used in question- and problem-solving, such as recognizing and analyzing data and articulating sound findings. The mental processes involved in answering a question or addressing a problem, such as discovering and analyzing data and explaining conclusions, are referred to as the scientific process (Huryah et al., 2017).

It is evident from a review of the available data on scientific literacy levels in the sector that many people still fall into the low and less group. Therefore, extra care must be taken to learn in a way that can enhance communication and scientific literacy. Inquiry is one of the lessons taught to help students build their learning process skills. The inquiry approach is a set of educational activities that emphasizes the need to think critically and analytically in order to search out solutions to a problem. Students' character was able to be strengthened by Putra (2021) in his research on the use of an inquiry-based approach to science topics.

Inquiry learning is instruction designed to help students locate and use a variety of sources of knowledge and concepts to deepen their understanding of certain themes, subjects, and challenges (Abidin, 2018). Personal Digital Inquiry is a learning technique that gives students the chance to expand their knowledge, discover novel concepts, and find solutions to issues by using digital media as a tool to increase their knowledge capacity (Coiro, 2017). A series in personal digital inquiry exists, and it involves discussion, writing, and reading (Jamaluddin et al., 2019). Then, Fadilah et al. (2020) showed that one can develop a grasp of science by reading comprehension. By digesting material critically and creatively, reading comprehension abilities are used to develop a thorough understanding of science. The foundation and heart of achieving scientific literacy are reading comprehension skills.

Infographics are very helpful for students, especially to facilitate understanding and internalization of learning material within themselves, and are used to implement learning strategies (Susanti & Kumalasari Nurnawati, 2022). The infographics mentioned in this study are to assist students' understanding of the material they are studying. Students in this internalization process must first comprehend the message before they can effectively communicate it (Bobek & Tversky, 2016). Infographics are a great tool to utilize in a class that calls for a lot of reading interest. A high reading interest can be attained by engaging data visualization (Mansur & Rafiudin, 2020). Ecosystem material is one of the biology resources that may be used to improve literacy. Ecosystems have a variety of significant roles in the physical world, including those related to ecology, socioculture, and education. Students must not only comprehend the material, but also be able to apply it to real-world issues (Muhammad et al., 2018).

Consequently, the goal of this study was to determine whether implementation of personal digital inquiry technique will boost high school student's scientific literacy.

Method

The research used in this study was a Quasi-Experimental. There are two classes, the first class is the experimental class, namely the class that is treated with Personal Digital Inquiry strategy while the second class is the control class with inquiry learning. The design in this study is the Nonequivalent Control Group Design.

The research subjects used 70 students class X of Cimahi Senior High School consisting of 35 control class students and 35 experimental class students who were selected by random purposive sampling. The students were then used as a sample in the pilot implementation using an infographic-assisted personal digital inquiry

strategy for experimental class and application of an infographic-assisted inquiry learning for control class.

The design of the research strategy used in this study is shown in Table 1.

Table 1. Nonequivalent Pretest-Posttest Control Group Design

Class	Pretest	Treatment	Posttest
Experiment Class	Q1	X	Q2
Control Class	Q2	-	Q2

Description:

Q1 = Pretest before using the Personal Digital Inquiry experimental class
Q2 = Pretest before using the Personal Digital Inquiry in the control class
X = Learning using implementation of an infographic-assisted personal digital inquiry strategy
\- = Learning using implementation of an infographic-assisted inquiry learning
Q1 = Posttest after using the Personal Digital Inquiry experimental class
Q2 = Posttest after using the Personal Digital Inquiry control class

The data to determine of using implementation of an infographic-assisted personal digital inquiry strategy form of score distribution data obtained student learning evaluations. The effectiveness test was analyzed using the Paired Sample T-test by determining the N-Gain score from the students posttest and pretest results on aspects of scientific literacy. Results students analytical thinking skills were analyzed using N-Gain score formula. The N-Gain scoreformula is as follows:

$$\text{N} - \text{Gain} = \frac{\text{Score Postest} - \text{Score Pretest}}{\text{Score Ideal} - \text{Score Pretest}} \quad (1)$$

The category of acquisition of the N-Gain Score according to Sulzer. The categories of N-Gain acquisition is shown in Table 2.

Table 2. Gain Score Category Acquisition

N-Gain	Category
g>0.7	High
0.3 < g < 0.7	Medium
G < 0.3	Low

Gain Score Obtained results on the application of an infographic-assisted personal digital inquiry strategy. To assess students' knowledge of science through the use of infographic-assisted Personal Digital Inquiry learning strategies. Information on student science literacy test results using Personal Digital Inquiry strategies for learning is shown Table 3.

Table 3. Literacy Science Assessment Criteria (Purwanto, 2010)

Evaluation	Category
86-100	Very High
76-85	High
60-75	Medium
55-59	Low
≤54	Very Low

Result and Discussion

Result

Implementation of an infographic-assisted personal digital inquiry strategy before being implemented on SMAN X Cimahi, students was tested for data normality and data homogeneity. Based on the results of the normality test, it was found that the data were normally distributed. The results of the normality test is shown in Table 3.

Table 3. Normality Test Results

N-Gain Score	Class	Kolmogrov-Smirnov			Shapiro-Wilk		
		Statistic	Df	Sig.	Statistic	df	Sig.
	Cont	.147	35	.023	.905	35	.006
	Exp	.144	35	.017	.909	35	.07

Because the control class data were normally distributed, a hypothesis test was performed using a non-parametric statistical with the Mann-Whitney U Test. The following are the results of the Mann-Whitney U Test is shown in Table 4.

Table 4. Mann-Whitney U Non Parametric Test

Test Statistics[a]	
	N-Gain percentage
Mann-Whitney U	103.000
Wilcoxon	711.000
Z	-5.009
Asymp. Sig. (2-tailed)	.000

a= Grouping variable: Class

The results of Mann-Whitney U Test show Asymp. Sig. (2-Tailed) ranges from 0.000 < 0.05, then H1 is rejected and H0 is accepted, meaning that there is a significant difference in the analytical abilities of students using implementation of an infographic-assisted personal digital inquiry strategy. The data that has been normally distributed is then tested for homogeneity. The results of the homogeneity test is shown in Table 5.

Personal Digital Inquiry which is a learning strategy that provides opportunities for students to

build knowledge, find new ideas and solve problems by using digital media as a tool in developing students' knowledge capacity. Learning strategies that are carried out with the help of infographics, namely to help students understanding of the material they are studying, infographics are very useful for students especially to facilitate understanding and internalization of learning material in themselves.

Table 5. The Results of the Homogenity Test

	Levene Statistic	df1	df2	Sig.
Pretest Based on Mean	4.571	1	136	.006
Based on Median	4.526	1	136	.006
Based on Median and with adjested df	4.526	1	128.892	.006
Based on trimmed meas	4.703	1	136	.006
Posttest Based on Mean	4.321	1	136	.012
Based on Median	4.657	1	136	.013
Based on Median and with adjusted df	4.657	1	127.675	.013
Based on trimmed mean	4.563	1	136	.014

Figure 1. Display Implementation of an infographic-assisted Personal Digital Inquiry strategy

The increase in student's scientific literacy is calculated using the Normalized gain (N-gain) is shown in Figure 2.

Based on the results of the normalized gain analysis in Table 4, it shows that the gain value in the control group is smaller than the experimental group, namely 26.3% in the medium category, while the gain value in the experimental group is 69.2% in the high category. This is because in the control group students were not trained to be able to understand and answer questions based on scientific literacy in the personal digital inquiry learning strategy.

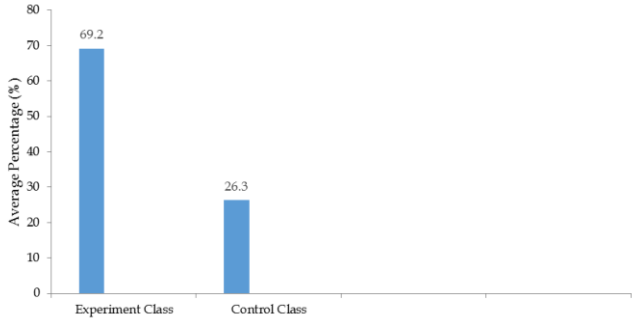

Figure 2. Science literacy normalized gain value

The statistical analysis of the assessment of students' scientific literacy between the control and experimental classrooms yields the conclusion that there is a substantial difference. The posttest results for the experimental class and control class are summarized here, together with the findings from analysis of the indicators of scientific literacy Figure 3.

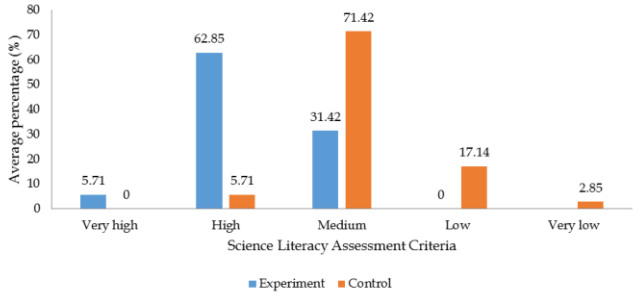

Figure 3. Students in the experimental class and those in the control class met the criteria for scientific literacy

The experimental group in the very high category achieved a percentage of 5.71% for the presentation of the findings of the percentages, while the high category obtained the greatest percentage of 62.85%, and the low category obtained the results of 31.42%. The high category received 5.71% in the control class, followed by the medium category with a percentage value of 71.42, the low category with a percentage of 17.14%, and the very low category with a percentage of 2.85%. This is due to the fact that in the control group, the students were not given the Personal Digital Inquiry learning technique training necessary to comprehend and respond to questions based on scientific literacy.

The average value of student's scientific literacy competency aspects is shown in Figure 4. The aspects of scientific literacy competence studied are the ability to explain phenomena scientifically, evaluate and design

scientific questions and interpret data and evidence scientifically. Data regarding aspects of scientific literacy competence of students seen from the total score of pretest and posttest results regarding indicators of scientific literacy competency questions worked on by all 70 students.

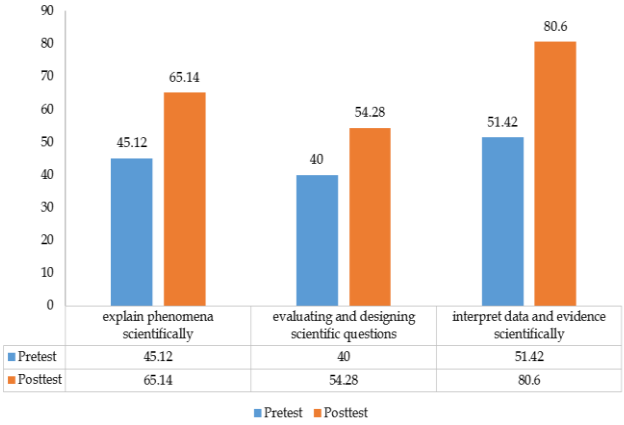

Figure 4. Comparison of the average pretest and posttest scores of students scientific literacy competency aspects

Discussion

Based on the results on the aspect of scientific literacy before implementing an infographic-assisted personal digital inquiry learning strategy, it has a smaller average value for each aspect. while the average value of each indicator aspect of scientific literacy competence has all changed, but what experienced a change from the category, namely the indicator of interpreting data and evidence scientifically from the medium category with an average of 51.42 to a high category with an average value of 80.6, the indicator of interpreting data and evidence scientifically is one of the highest experiencing average change compared to indicators of other competency aspects. Then, the indicator explaining the phenomenon scientifically has also changed from the medium category with an average value of 45.12 to a high category with an average value of 65.14. For indicators evaluating and designing scientific questions even though there is a change in the average value from 40 to 54.28 but still in the medium category on the results of the pretest and posttest. Learning science via inquiry is one technique to increase students' scientific literacy when teaching biology. Learning that seeks to help pupils master scientific ideas that are relevant to their lives. The major objective of inquiry learning is to support students' ability to cultivate intellectual discipline and critical-thinking abilities (Nugraheni & Paidi, 2018).

There was an increase in student's scientific literacy in answering pretest, posttest and normalized gain questions. The results of the increase were also obtained by students based on the implementation of strategies carried out in class. The existence of a Personal Digital Inquiry learning strategy Coiro (2017) that is applied in class is intended to train scientific literacy, especially in solving problems related to ecosystems. Inquiry-based learning strategies for students to ask questions and find new ideas and students have the opportunity to identify problems, generate personal questions, engage in collaborative and apply new knowledge and solutions obtained. The problems that arise are in areas that are difficult for students to reach so that students explore digitally by searching for data and reading from various sources so that they get solutions to these problems. In addition, the infographics presented are regarding problems and the percentage of damage to ecosystem. Learning that is applied with the help of infographics can make it easier for students to read the information presented (Afianah & Hasanah, 2021).

On the first indicator of the competency aspect of scientific literacy, namely explaining phenomena scientifically which includes students' ability to describe or describe a phenomenon scientifically and predict possible changes that may occur. In the implication of Personal Digital Inquiry there are components, namely Wonder and Discover Coiro & Sparks (2018) that are students have the opportunity to be involved with concepts and experiences that encourage questions about a topic to explore and discover new ideas. Questions that might be obtained from students are teachers who stimulate through the infographics that have been presented containing problems in ecosystems (Weiskopf et al., 2020).

The existence of infographic-assisted learning strategies can represent visual data and ideas and has been widely used as a cognitive tool to build knowledge and facilitate readers understanding of a phenomenon (Gebre, 2018). Due to the short amount of time spent studying in school, students can still learn, albeit not to their full potential. Reading can help students learn new things and deepen their understanding. Reading infrastructure, particularly learning materials, will have an impact on readers' interests. Books are the primary teaching tools used in biology classes (Nurbaiti & Mariah, 2020).

After doing personal digital inquiry learning strategy, students ability to explain phenomena scientifically has changed to be high. This shows that there is an influence from the implementation of personal digital inquiry on students ability to explain phenomena scientifically. These changes can be caused because students are able to use their content knowledge to explain phenomena scientifically, which according to OECD (2019) in the indicator of explaining phenomena scientifically requires students to remember appropriate

knowledge in certain situations and provide an explanation of a phenomena.

The second indicator of the competency aspect of scientific literacy is evaluating and designing scientific questions. Evaluating and designing scientific questions requires students to have some understanding of the purpose of scientific inquiry to generate reliable knowledge and to distinguish between questions that can be answered scientifically and questions that cannot be answered scientifically (OECD, 2019). In the implication of Personal Digital Inquiry there are components, namely Analyze and Reflect that is students have the opportunity to analyze (conduct investigations, reviews) in building understanding. (Coiro & Sparks, 2018). In the learning steps in the classroom students are directed to investigate the consequences and solutions of ecosystem damage using digital by searching from various sources in the form of articles or journals. Then, learning step is that students are given the opportunity to analyze investigative data and create a food chain in an ecosystem. These indicator value, there is a change in the average value from 40 to 54.28 but still in the medium category on the results of the pretest and posttest.

This illustrates that the ability of students is quite good in knowing problem and the key characteristics of the situation contained in the problem (Angela & Ramadhani, 2021). According to the analysis's findings, students are generally capable of understanding the science content that is currently taught, but many of them still pay little attention to the reference sources that are used in scientific investigations. If students pay attention to this, however, some of them may be able to decide what steps will be taken to investigate the issue (Arrafi et al., 2022). Student ability in evaluating and designing scientific questions related to cognitive aspects of science they understand the basic concepts of science. Analysis questions on the items (Rusmiati, 2022).

Scientific literacy abilities in this study relate students cognitive aspects with events that occur in everyday life. Cognitive quality contained in the student's memory affects the ability of students in evaluating and designing scientific questions (Rini et al., 2021).

The last indicator of the competency aspect of scientific literacy is interpreting data and evidence scientifically. Students need the ability to interpret data and understand the forms and evidence used to be able to make statements and conclusions (OECD, 2019). In the implication of Personal Digital Inquiry there are components, namely Collaborate and Discuss students have the opportunity to engage in dialogue, discuss, argue and negotiate on different thoughts (ideas) and also Create and Take action students have the opportunity to express new understandings through creative work (Coiro & Sparks, 2018). On the students opportunity for the two components is evidenced by students being able to make comparisons of data in the form of tables or diagrams on ecosystem damage in several areas. After that students make it in the form of posters from the data that has been obtained in the form of examples of biotic and abiotic components, food chains, and make solutions to problems that arise regarding ecosystems (Solikhah, 2021).

The indicator of interpreting data and evidence scientifically from the medium category with an average of 51.42 to a high category with an average value of 80.6, the indicator of interpreting data and evidence scientifically is one of the highest experiencing average change compared to indicators of other competency aspects. This illustrates the ability of students who are already optimal in interpreting data and scientific evidence or draw conclusions from the data presented in the problem. In other words, students are able to describe clear and logical relationships between evidence and conclusions or decisions (Restianty, 2018).

This competency requires someone to be able to interpret scientific findings or be able to interpret scientific findings as evidence to make a decision and can identify evidence and communicate the reasons behind those conclusions (Rini et al., 2021). The achievement of literacy skills on indicators using scientific evidence is illustrated of students ability to interpret scientific evidence and draw conclusions with interpret the data contained in several tables and pictures on the instrument scientific literacy test questions used in this study. In addition, the ability to use scientific evidence is demonstrated by identifying assumptions, evidence, and reasons behind conclusions drawn in solving problems (Huryah et al., 2017).

The findings in this study indicate that personal digital inquiry learning strategies assisted by infographics can encourage students to practice scientific literacy skills. This can be influenced by the factor of students born from a generation that is very close to technological advances. Teachers need innovation to emerge and present learning strategies to meet students' needs. This provides a new paradigm for teachers to become able to always provide appropriate learning to the needs and development of students. The implementation of learning produces good skills in reading comprehension for students. The ability to read comprehension will support someone in understand science content and in reading scientific articles needed to support scientific literacy (Ayu et al., 2018). The application of scientific literacy will be appropriate with the needs of students by holding adhere to the principle

of scientific literacy, namely finding problems, looking for information and literacy, solving problems and decide the best move in facing problems (Muhammad et al., 2018).

Conclusion

The implementation of infographic-assisted Personal Digital Inquiry learning strategies is effectively used in the classroom. This can be seen from the Gain score obtained by the experimental class around 69.2% shows that these results are quite effective in learning. This can be seen from the Asymp value. Sig. (2-Tails) ranging from 0.000 <0.05, meaning that there is a significant differences in students' scientific literacy abilities using infographic-assisted digital personal inquiry learning strategies. these discoveries shows that the implementation of infographic-assisted digital inquiry personal learning strategies provides new understanding for teachers able to improve scientific literacy skills through integration such as digital-based inquiry learning to meet the needs of students in the 21st century.

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This research contributes to the treasury of digital-based learning media that teachers in high schools can use. The author is involved in the overall making of this article.

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Conflict of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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