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The Influence of Interactive Digital Worksheets Based on Level of Inquiry Towards Science Process Skills in Elementary School

Anastasya K. Dewi[1*], St Y Slamet[2], Idam R. W. Atmojo[3], Ahmad Syawaludin[4]
[1-4]Universitas Sebelas Maret, Indonesia

Abstract

The challenge of learning science during the COVID-19 pandemic in elementary schools focuses on the need for digital learning materials for Science Process Skills (SPS) through the perspective of science as an investigation process. This study aims to investigate the influence of interactive digital worksheets based on level of inquiry towards science process skills during the covid-19 pandemic in elementary school. In the study a quasi-experimental research design with pretest-posttest control groups was adopted. The participants were composed of 124 fifth grade elementary school students. The data were collected via the SPS test through measurement indicators of observation, classifying, communication, measuring, inference, and prediction aspects. The obtained data were analyzed using independent sample t-test after going through the assumption test of normality, homogeneity and balance. The results of calculating the hypothesis test obtained p = 0.000 at a significance level of 5% indicating that there is a difference between IDW and student SPS. The effect size test was obtained by a percentage of 66.18% so that it can be concluded that the use of IDW based on LoI can effectively increase SPS in elementary school students. Interactive facilities and ease of access as well as the suitability of work stages based on the LoI contribute to student independence and stimulate student SPS in elementary schools during learning during the pandemic.

Keywords: Interactive digital worksheets, science process skills, elementary school

Introduction

Science learning in elementary school is a way for students to understand the natural surroundings scientifically through investigation. Scientific inquiry requires a practical skill called Science Process Skills (SPS). SPS is the ability of students to apply the scientific method through understanding, developing and finding the knowledge needed to solve problems (Aydogdu et al., 2018; Darmaji et al., 2020; Ulger & Cepni, 2020; Vuran et al., 2020). SPS is achieved by providing opportunities for students to develop a concept, investigate a problem and draw conclusions on problems in everyday life (Kurniawan & Syafriani, 2020; Malau et al., 2020). Through SPS, science learning will be more interesting and provide important benefits for students to be actively involved, train to plan experiments, and make students learn the application of science in everyday life (Garza & Cavazos, 2020; Irmi et al, 2019; Mirici & Uzel, 2019; Ozkan, 2021). Thus, PPP in science learning has a very important role for the construction of scientific concepts through scientific thinking.

Preliminary studies in this study found that the importance of SPS has not been matched by real conditions. In the aspect of measurement and communication, the category is quite good (1.51-2.50). In the aspects of observation, inference, classification, and predicting aspects, the results are in the poor category (<1.50). These results indicate that the KPS of elementary school students needs to be improved. The observation findings of the science learning process during the Covid-19 pandemic in elementary schools in one of the cities in Indonesia show that online learning is like a form of material completion. Students have not been involved in science experiments. The teacher lacks an explanation of a material, the teacher only sends material in the form of a pdf format file and gives assignments via Whatsapp Group (Utomo et al., 2021). In the interview, most of the parents admitted that they did their children's assignments in order to get high grades. Initial studies through pretests on students generally show poor SPS results.

The COVID-19 pandemic situation requires teachers and students for digital-based learning (Handel et al., 2020; Hodges et al., 2020; Prasetyo et al., 2021; Naqvi & Sahu, 2020). Currently, hybrid learning is applied to support learning during the pandemic and limited face-to-face meetings

Corresponding Author: anastasyakd17@student.uns.ac.id
https://orcid.org: 0000-0003-0370-804X

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(Li et al., 2021; Handayani & Utami, 2020; Triyason et al., 2020). To support this, learning needs to be supported by digital worksheets that facilitate interactive functions so that students have control over their learning. Therefore, it is necessary to develop interactive digital worksheets (IDW) as an interactive digital worksheet created to support students in experimenting with science (Constantine & Jung, 2019; Hacıoglu & Donmez Usta, 2020).

Digital Worksheets are needed during the pandemic as practical and efficient teaching materials so that students have strong conceptual mastery and high creativity (Lindenbauer, 2020; Serth et al., 2019). The development of interactive digital student worksheets so that learning becomes optimal because there is not only a one-way relationship like student worksheets in general (Aliman & Mutia, 2021; Lindenbauer & Lavicza, 2021). These digital worksheets are an alternative solution for students so that they can continue to carry out science learning that accommodates simple independent experiments.

Previous research related to the development of worksheets was reported to be able to improve science learning outcomes in elementary schools. Wibawa's research (2018) develops creative digital worksheets based on mobile learning that is effective in improving learning outcomes. Ichsan (2020) also developed digital worksheets based on the Innovation Learning Model for Natural Science and Environmental Learning (ILMIZI) that effectively support online learning. Students do not have to go out of the house because the instructions and contents of the worksheets only focus on analysis, evaluation, and problem solving. Previous research recommends that the use of digital worksheets is needed by students today.

In contrast to previous research, the novelty of this research is in the form of a digital worksheet that facilitates interactive functions and is based on the Level of Inquiry (LoI) model. The LoI model has the opportunity to develop skills in intellectual and scientific processes in a systematic and comprehensive manner so as to obtain the expected learning outcomes and leave a more impression so that it becomes long-term knowledge for students (Wenning, 2011; Yanto et al., 2019). LoI learning stages include discovery learning, interactive demonstration, inquiry lesson, inquiry lab, real-world application, and hypothetical inquiry (Wenning, 2006). The three initial levels are suitable to be applied to elementary school students (Atmojo et al., 2017). Thus, the development of LoI-based IDW is considered appropriate to meet the needs of students in science learning.

This study aims to implement interactive digital worksheets based on level of inquiry for science process skills during the covid-19 pandemic in elementary school. The formulation of the research problem is: ***Can the use of LoI-based IDW effectively increase student SPS at the elementary school?***

Method

Research Design

In the study, a quasi-experiments research method was used. Quasi-experiments research aims to identify whether a treatment can make a difference in certain outcomes (Cook, 2015). This study uses IDW media as the treatment given to groups of students and aims to determine the results of the treatment. The research design used a pretest-posttest control group design. This design involved two groups that were treated (called the experimental class) and one group that was not treated (called the control class). The study began by measuring the initial abilities of students in both groups. The experimental group used LoI-based IDW, while the control group used a regular worksheet. At the end of the lesson, the students' final SPS measurements were taken. The measurement results are then presented and a different test and effect test are performed to determine the effect and effectiveness of LoI-based IDW for SPS.

Participants

The participants were selected randomly using a cluster random sampling design. This method is carried out with the

Table 1: Science Process Skills Assessment

No	*Aspect*	*Indicator*
1	Observing	Students use all senses; collect and use relevant facts.
2	Classifying	Students record each observation separately to look for differences and similarities, compare, find the basis for grouping, and relate the results of observations.
3	Communicating	Changing the form of presentation, providing an overview of experimental data through graphs, tables, or diagrams, compiling and submitting reports systematically, explaining experimental results, reading experimental results, discussing experimental results.
4	Measuring	Measures using appropriate units with the appropriate level of accuracy, using both standard and non-standard measurements to describe object dimensions and make comparisons.
5	Predicting	Using the pattern of observations, suggests what might happen in circumstances that have not been observed.
6	Inferring	Propose explanations for phenomena based on observations, analyze cause and effect, logically organize observed data for possible solutions.

consideration that the target of treatment is students who are seen as groups of students in one class, not individuals. The sample was obtained as many as 124 students at the fifth-grade level in an elementary school in one of the cities in Indonesia.

Data Collection

The data collection instrument of the study was the SPS assessment rubric, which refers to Harlen (1999), Tezcan & Meric (2013), and the Minister of Education and Culture (2015) through observing, classifying, communicating, measuring, predicting, and inferring aspects. The test was conducted on students in the experimental and control groups. The time of the test was carried out twice, first before the SPS learning (pretest) and at the end of the SPS learning (posttest). The indicators developed in the SPS test are presented in Table 1.

The validity of the developed SPS test is obtained through the Aiken validity with the Aiken's V coefficient value of 0.842 so that it has adequate validity. As for the reliability of this SPS measurement instrument using Cronbach's Alpha value obtained at 0.72 > 0.60, the SPS measurement instrument has been declared reliable.

Data Analysis

The data obtained were analyzed through the independent sample t-test. Prior to the analysis, the assumptions were tested including normality test, homogeneity test and balance test. Normality test using Kolmogorov-Smirnov and homogeneity test using Levene's test. As for knowing the balance of the initial abilities of the two groups, a balance test was carried out using the t test. The proposed hypothesis consists of:

H0 = There is no difference in SPS between the experimental and control groups
Ha = There is a difference in SPS between the experimental and control groups

The hypothesis test of this study used the Independent Sample t-test. After that, in order to find out the effectiveness of using IDW, an effect size test was carried out (Cohen et al., 2007).

Findings

SPS learning in this study was applied in online learning situations during the covid-19 pandemic. The experimental group used IDW while the control group used a worksheet in the form of instructions via the regular WhatsApp Group. Before and after treatment, SPS measurements were carried out, covering aspects of observing, measuring skills, predicting skills, grouping skills, and communication skills. The results of the study presented the results of the SPS measurement using the SPS performance test instrument. The results are presented in table 2.

The results above indicate that there are differences in the mean data between the experimental group and the different control groups. If it is seen from the average of the two groups, it shows that the experimental group using IDW has better SPS posttest results than the group. However, in order to investigate

Table 2: Primary Student's Science Process Skills Description

Group	*Condition*	*Data*	*Statistic*	*Score*
Experiment	Using Interactive Digital Worksheets	Pretest	Mean	3.07
			Minimum	1.75
			Maximum	4.66
			Std. Deviation	81.955
		Posttest	Mean	4.359
			Minimum	3.16
			Maximum	4.92
			Std. Deviation	50.932
Control	Using other Worksheets	Pretest	Mean	3.062
			Minimum	1.17
			Maximum	4.63
			Std. Deviation	83.400
		Posttest	Mean	3.506
			Minimum	2.03
			Maximum	4.86
			Std. Deviation	69.954

Table 3: Normality Test, Homogeneity Test, and Balance Test

Test	Method	Results	Conclusion
Normality Test	Kolmogorov-Simonov	Sign. = 0,042 > 0,05	Test distribution is normal
Homogeneity Test	Levene's Test	Sig. = 0.020 > 0,05	Data comes from populations that have the same variance
Balance Test	T-test	Sig. = 0,723 > 0,05	The initial abilities of the two groups are balanced

Table 4: Results of Independent Sample t-Test and Effect Size

Test	*Data*	*Results*	*Conclusion*
Independent Sample T-Test	SPS Posttest	Sign. = 0,000 < 0,05	SPS in the experimental group is better than the control group
Effect Size	SPS Pretest and Posttest	NGain Persen = 66,18%	IDW is quite effective to increase SPS

the effectiveness of the IDW implementation, it is necessary to analyze the independent t test and effect test. In statistical testing using an independent t-test, the assumption test is carried out first, including the normality test, homogeneity test, and balance test. The results of testing assumptions are presented in Table 3.

Table 3 shows that the data obtained were normally distributed and came from a homogeneous population. The balance test showed that the two groups had a balanced initial ability which was known through the t test results which showed Sig. = 0.723 > 0.05. Furthermore, hypothesis testing and effect testing were carried out to determine the effectiveness of IDW implementation. The results are presented in table 4.

The data in table 4 shows that the SPS test results between the experimental and control groups concluded that there was a difference in the average SPS. SPS in the experimental group using IDW was better than the control group using other worksheets. The test was continued using the effect test to find the value of the effectiveness of IDW. NGain with the effect test found that the use of IDW has an effectiveness value of 66.18% in increasing the SPS of elementary school students.

Discussion

A person will have a skill if that person trains it through activities. Likewise, the science process skills in students will increase if they have the experience to perform or practice these skills (Wenning, 2011). The discussion of the results of this study is explained on the effect of using IDW based on LoI in three stages of LoI consisting of discovery learning, interactive demonstration, and inquiry lesson in the perspective of using IDW in science. There are some of the LoI-based IDW displays that have been developed.

The effect of discovery learning-based IDW on SPS

The use of IDW on the basis of discovery learning (DL) stages focuses not on finding applications of a concept or knowledge, but rather on building understanding or knowledge based on student experience (Dockendorff & Solar, 2018; Purwaningsih et al., 2020). DL-based IDW uses sequential questions during or after the learning experience is given, students are directed to a conclusion, as well as questions for learning discussion. The implementation of DL-based IDW during online learning uses synchronous and asynchronous methods. Teachers and students meet through asynchronous method using zoom to equalize perceptions about the use of DL-based IDW.

Fig. 1: IDW based on LoI Main Menu Display

Fig. 2: IDW based on LoI Theory Display

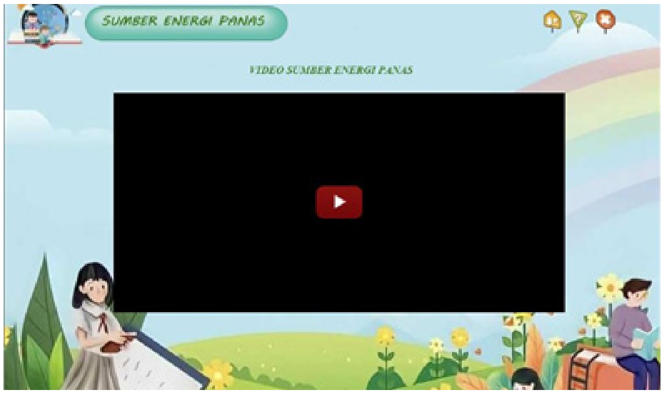

Fig. 3: IDW based on LoI Multimedia Display

Fig. 4: IDW based on LoI Experiment Display

Fig. 5: IDW based on LoI Worksheets Display

Through IDW, the teacher introduces the phenomenon of heat transfer (conduction, convection, radiation) through animated videos which are accessed through the "Did you know?" menu. Through question and answer students take the initiative to convey their arguments about the heat transfer phenomena they have seen, more specifically about what phenomena and how it occurs. The process of identifying phenomena in the three types of heat transfer is carried out through activities through the "Match It" menu, where

The communicating aspect is obtained by students when conveying their arguments about the phenomenon of heat transfer in everyday life and during discussion activities with teachers and other students. The interactions that occur in the communication process of heat transfer events do not only occur in teachers and students but also increase interactions between students (Ahdhianto & Santi, 2020; Owens & Hite, 2022). These communication skills are recorded when students respond to other students with different arguments on the three types of heat transfer processes. Indicators of this aspect also appear when students give examples of different and unique heat transfer events, for example, a student exemplifies the activity of a campfire as a process of convection and radiation heat transfer simultaneously.

Effect of interactive demonstration-based IDW on SPS

The application of IDW based on LoI stages on interactive demonstrations directs students to find their own knowledge through observations of demonstrations conducted by teachers (Jerrim et al., 2020, Al Mamun et al., 2020). At this stage the teacher demonstrates, develops and asks questions of an investigative nature. LoI-based IDW on interactive demonstration in its application is carried out through observation, manipulation, generalization, verification, and application. The observation stage presents experimental demonstrations of the heat transfer process in everyday life accompanied by explanations through the "video demonstration" menu. In manipulation, students were asked to describe the factors resulting from the heat transfer process. The generalization stage involves students to generalize their findings about the heat transfer process. The verification stage presents the same phenomenon but in a new situation about the heat transfer process, then students verify individually or in groups in a discussion. The application stage assigns students to apply concepts in other phenomena that are the same but in different contexts.

The skills that can be trained to students in the application of IDW based on interactive demonstration models consist of observing, predicting, inferring, communicating and recognizing and analyzing the model (Al Mamun et al., 2020). Observing skills were stimulated at the observation stage of the IDW. SPS stimulation at the manipulation stage trains communicating and predicting skills. At the generalization and verification stage students are trained to collect and process data, formulate and revise explanations based on logic and evidence about the phenomena displayed. Furthermore, students apply the same concept but in other phenomena, at this stage students are expected to have the skills to recognize and analyze models and alternative explanations of a phenomenon.

The effect of inquiry lesson-based IDW on SPS

The use of LoI-based IDW at the inquiry lesson stage is almost similar to interactive demonstrations but in inquiry activities it shifts subtly towards the process of scientific experimentation (Maass & Engeln, 2018). The teacher slowly relinquishes responsibility for research activities and guides students to carry out scientific investigations. The teacher is responsible for providing guidance in the form of questions that lead to investigation activities. The teacher helps students formulate experimental activities, identify and control the variables to be investigated. The teacher gives explanations to students regarding scientific investigations. Students carry out scientific inquiry activities under the guidance of the teacher. The inquiry lesson model helps students fully understand the scientific inquiry process. This form of inquiry lesson is very important to bridge the gap between interactive demonstration and laboratory experience (Wenning, 2011).

The inquiry lesson-based IDW design includes the same steps as interactive demonstration, consisting of observation, manipulation, generalization, verification, and application. In order of use, students observe phenomena about heat transfer processes in everyday life accompanied by explanations through the "heat transfer video" menu; students describe the influencing factors of the heat transfer process; students record and generalize findings about heat transfer processes; students do a simple experiment about the heat transfer process, then students verify individually or in groups in a discussion; and students apply the results of the investigation to complete the questions on the "Quiz" menu in IDW.

SPS stimulation through inquiry lesson-based IDW includes observing, classifying, measuring, predicting, inferring, making tables of observations, planning experiments, and explaining relationships. However, the application of LoI-based IDW in online learning practices cannot be separated from the obstacles that occur, such as students who focus on learning, daydreaming, and operating their cellphones which have nothing to do with learning (Dhawan, 2020; Kamble et al., 2021). The effort made by the teacher is to provide virtual star-shaped points stored in IDW for students who have been active in order to increase student motivation to be more active in participating in learning. Students' difficulties were also found when conducting their own experiments from home. Collaboration with parents and the delivery of the tools and materials needed to carry out the experiment a few days before learning is required. Collaborative roles of teachers and parents are also needed so that it is possible to conduct experiments independently.

Conclusion

The use of Interactive Digital Worksheets based on Level of Inquiry through quasi-experimental research has shown effective results to improve SPS in elementary school students. The novelty of this research is that it offers an interactive digital teaching tool in the form of a flexible worksheet to be used in science learning practices both in online and offline situations. Interactive facilities and ease of access as well as the suitability of work stages based on the LoI contribute to student independence and stimulate student SPS in elementary schools during learning during the pandemic.

Suggestions

This study recommends that teachers in elementary schools can choose the right learning tools for certain purposes such as increasing SPS. IDW based on LoI is proposed as one of the recommended teaching material to be applied by teachers to support online learning. The implementation of IDW based on LoI provides opportunities for students through the stages of the inquiry model, including discovery learning, interactive demonstration, and inquiry learning. Recommendations for students to be able to use IDW as a medium that helps direct the process of science practice outside the classroom, it is necessary to support parents to facilitate smartphones or tablets.

Limitations

The implementation of this experimental research is limited to efforts to determine the effectiveness of IDW as a teaching material based on LoI on one specific instructional goal, namely the SPS. The implementation of science learning as a product such as mastery of science concepts needs to be investigated through further research. In addition, the sample involved in this study still needs to be added with the aim of knowing the effectiveness of LoI-based IDW media which has been tested for its effectiveness in increasing SPS.

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