The Effect Of Networked-Based Inquiry Model On 21st-Century Skills

Fuja Novitra, Festiyed, Yohandri

Abstract: This study aims to examine the effect of the Networked-based Inquiry Model on students' 21st-Century Skills in physics learning. This study used a nonequivalent control group design model with a 2x3 factorial design. The research subjects comprised 6 classes from 3 different schools with 120 students. The research data were analyzed descriptively and the two-way analysis of variance (ANOVA) was based on a significance level of 5%. The findings show that the Networked-based Inquiry Model has higher effectiveness than the inquiry-based learning model in improving students' 21st-Century Skills. Therefore, the Networked-based Inquiry Model can be a solution in implementing learning to follow the demands of the 21st-Century, especially in developing students' 21st-Century Skills.

Index Terms: Networked-based Inquiry, Inquiry learning, 21st-Century Skills, Digital learning

1 INTRODUCTION

Physics is a science that is systematic in understanding various natural phenomena and uncovering the mysteries they contain. From the nature of knowledge viewpoint, physics combines aspects of realism and idealism to reveal the secrets of nature and explain the behavior, order, and structure of the universe. In the philosophy's study of science (the nature of knowledge), namely the Earth-Centered Philosophies section, which describes how the discoveries of the physical sciences through realism and idealism [1]. Like Leonardo Da Vinci, Galileo, and Newton who made the physical universe as an inquiry project to make observations and elaborate reasoning to give birth to the physics we know today [1], [2]. Likewise, in studying physics for students, observing and elaborating reasoning (combining aspects of realism and idealism) like a scientist is the best way for students to gain a mature understanding of physics [3]. Therefore, implementing physics learning through a scientific process (inquiry) is a method suggested by experts [3], [4], [5]. Several quantitative studies support the effectiveness of inquiry-based learning as a learning model. The integration of inquiry learning has been proven to be accurate to improve the students' critical thinking skills [6], [7], [8]. Inquiry learning encourages the development of creativity and improves learning outcomes [9], [10]. Inquiry learning also encourages students' skills in communicating and collaborating [11], [12], [13], [14], [15]. These successes reaffirm that inquiry learning is an important approach in building a scientific literate generation [16]. However, in the last few decades, the phenomenon of the industrial revolution 4.0 which is synonymous with the era of technological disruption has led to debates about the relevance of implementing physics learning in the "old way" with a life order full of technology, machines, robots, or artificial intelligence. In this case, the goal of learning physics in schools is certainly not to produce a reliable physicist but to produce an output that has a mature understanding of physics and has new literacies such as digital literacy (the ability to utilize big data and artificial intelligence) and humans literacy (humanities) who will equip it to face the challenges of the era of technological disruption. To realize this kind of learning, the application of high tech and high touch approach is an approach that is relevant today. Learning that can accommodate the demands of the 21st-century based on digital literacy is learning that shows a balance between scientific approaches and technology integration [17], [18], [19]. One alternative is inquiry learning that is integrated with ICT at the infusing level, namely the Networked-based Inquiry Model. Networked-based Inquiry Model is an inquiry learning model that applies ICT at the infusing level in its activities [20]. In previous studies, this model was declared valid by experts in the fields of education and technology to improve students' 21st-Century Skills. Therefore, this research examines the effect of the Networked Inquiry Model on the improvement of students' 21st-Century Skills compared to ordinary inquiry-based learning.

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2 LITERATURE REVIEW

2.1 Inquiry Learning

Inquiry-based learning is learning that is very popular in science curricula, projects, and teaching. Suchman (1966) states that inquiry learning is learning that presents problems related to concepts that will be solved by students through activities, such as questioning these problems, collecting and analyzing data, until students find answers to those questions. This can be defined as a "discovery" process, with students making hypotheses, then conducting experiments, interpreting data, and communicating them [21]. In this process, of course, students are the center of learning in contributing to their knowledge [22]. However, it is important to know that the "findings" that students get in inquiry learning are not the discoveries to the world as scientists have done. It should also be noted that investigative activity in inquiry learning does not always involve empirical testing, but can be done by collecting various information from various reference sources [23]. Based on this definition, inquiry learning is operationalized through activities such as observing problems, making hypotheses, conducting investigations, analyzing data, and communicating findings.

2.2 Technology-Supported Inquiry Learning

Various types of technology have been used in learning along with the development of these technologies, especially after the emergence of Web 2.0 which makes it easy to prepare ICT-based learning [24], [25], [26]. It cannot be denied that ICT provides a variety of tools that can make it easier for students

to learn. However, it should be emphasized that the interaction between teachers, students and technology is inseparable for the development of student competence [17], [18], [19]. The way of learning has also developed with the increasing number of online learning tools such as video tutorials, blogs, podcasts, wikis, virtual communities, and others [27], [28], [29]. Of course, this must be addressed by adjusting the educational approach to the learning behavior of the millennial generation that differs completely from the previous generation. Therefore, inquiry learning needs to be supported by the right technology to accommodate students to carry out relevant scientific activities. Inquiry learning has flexibility when combined with various types of ICT [30], such as computer simulation-based inquiry [31], virtual experiment-based inquiry [32], and e-learning-based inquiry [33]. These models provide effectiveness in improving learning outcomes and problem solving, but they do not provide benefits in holistic information search, knowledge construction, problem-solving experience, digital collaboration, and digital communication. It has not combined the constructivist, experiential, cognitive, and connective elements. UNESCO has created a framework for integrating ICT in learning. There are four levels in integrating ICT in learning, namely:

1. Emerging
   At this level, teachers still apply conventional learning systems, but have recognized the importance of ICT in learning.
2. Applying
   At this level, the teacher has tried to apply ICT in learning. Teachers have used ICT as a tool to assist the learning process, such as using computers and projectors as media to present learning material.
3. Infusing
   At this level, the teacher applies ICT in the classroom, not only in presenting learning material but also in conducting assessments. Teachers can explore a method by utilizing ICT in their productivity and professional work.
4. Transforming
   At this level, ICT has become an integral part of schools. All operational activities in schools have been based on ICT. Teachers and staff have mastered professional level ICT in supporting learning [34].

Of the four levels, the infusing and transforming stages are the levels where information technology has become a catalyst for educational change/evolution [34], [35], however, in Indonesia, the infusion stage is the most ideal level to be applied. This is because secondary education in Indonesia does not yet have sufficient resources to implement ICT at the transforming level [36]. To apply ICT at the infusing level, an approach that can be applied is networked learning. This is because networked learning is learning to assist teachers in implementing learning that aims to develop students' thinking skills by accommodating collaboration, communication, and access to digital learning resources of students through integrating ICT in every step of their learning [37]. Therefore, integrating networked learning in inquiry learning allows a variety of investigative activities (such as data collection, data analysis, and communication and discussion of results) that are more complex and relevant today, while also accommodating students in developing 21st Century Competencies which are very much needed in the era of the industrial revolution 4.0

2.3 Networked-based Inquiry Model

Networked-based Inquiry is inquiry learning that relies on ICT. Networked-based Inquiry is defined as learning that relies on ICT to provide opportunities for students to carry out scientific and authentic investigations through digital interactions between students and peers, learning resources, and teachers to generate hypotheses, conduct experiments and analyze data, and summarize their findings. Learning like this can provide benefits in information search, knowledge construction, problem-solving experience, digital collaboration, and digital communication [20]. The Networked-based Inquiry model includes five phases (see Table 1 for definitions): Orientation on Network, Problem Identify from Network Resource, Exploration in Digital Environment, Report Findings, and Closure.

TABLE 1

PHASES AND SUB-PHASES OF THE NETWORKED-BASED INQUIRY MODEL

General phases	Definition	Sub-phases	Definition
Orientation on Network	The process of preparing students to have prior knowledge to face classroom learning through brainstorming on physics phenomena presented via smartphones.		
Problem Identify from Network Resource	The process of formulating theory-based questions and/or hypotheses.	Observing	The process of observing physical phenomena.
		Sending-Hypotheses	The process of generating hypotheses is based on the stated problem and sending the hypotheses.
Exploration in Digital Environment	Collect data by experimenting through the Smartphone application, or by reviewing literature	Collecting Data	The process of exploration is related to the problems presented in the second syntax through virtual experiments or by review the literature from online materials.
		Analysing Data	The process of making meaning out of collected data.
		Explanations- from Evidence	The process of synthesizing new knowledge.
Report Findings	The process of presenting finding	Presenting Findings	The process of presenting the findings.
		Sharing Findings to Social Media	The process of sharing findings related to the application of concepts through social media.
Closure	The process of drawing conclusions from the data. Comparing inferences made based on data with hypotheses	Drawing Conclusion	The process of making conclusions from the learning that has been implemented.

General phases	Definition	Sub-phases	Definition
		Network Reflection	The process of exchanging ideas, sharing information, and so on regarding the learning material that has been studied and its application after learning in class takes place via a smartphone.

Orientation on Network is a phase that exposes students to videos of physics phenomena that aim to cause cognitive conflicts in themselves, then trigger them to brainstorm about these phenomena. This first stage is carried out through student gadgets before learning in class takes place, which is accommodated by e-books interactive link with Google Classroom. Problem Identify from Network Resources is the initial phase when classroom learning takes place. In this phase students are also faced with videos of physics problems, then they brainstorm to making their hypotheses. Students send their hypotheses through the links in interactive e-books. Exploration in Digital Environment is a phase of data collection carried out by virtual experiments or by review the literature from online materials. These activities are accommodated by an interactive e-book. Then students analyze the relationships of the data obtained and make interpretations so they gain new knowledge. Report Findings is the phase of delivering the results of student exploration in the previous phase through presentations to the class. Then students communicate the findings on their social media accounts. Closure is the phase of evaluating the process and achievements in learning that have been implemented and concluding it. Then after learning takes place, for students who are not satisfied or do not understand the learning material they have implemented in the classroom, they are facilitated to exchange ideas, share information, and so on regarding the learning material that has been studied and its application. This activity is accommodated by an interactive e-book that provides a discussion link on the Google Classroom application.

2.4 21st-Century skills

There have been many definitions of 21st-Century skills, such as creativity, critical thinking, collaboration, communication, ICT literacy, and social/cultural skills, and problem-solving [4], [38]. Partnership for 21st Century, states that 21st-century skills comprise: (1) life and career skills, (2) learning and innovation skills (21st Century Competencies), and (3) information, media, and technology skills [39]. If viewed as a whole, life and career skills are the characters that are the demands of the 21st century, learning and innovation skills (21st-century competencies) are the core skills or core skills of the 21st century, and information, media, and technology skills are literacy that are the demands of the century 21. To develop these skills in the classroom, it can be realized through efforts to increase 21st-century competencies (creativity, critical thinking, collaboration, and communication), but these competencies in line with technology and information media skills [40], [41], [42], [43]. Therefore, the core of 21st Century Skills is 21st-century competencies (creativity, critical thinking, collaboration, and communication) which are integrated with media literacy, information, and ICT, so that the characters that are the demands of the 21st century (life and career skills) can be realized. Based on this concept, core skills from 21st Century Skills can be formulated as 21st-century competencies that are integrated with digital literacy. Creativity is the ability to use ICT effectively and efficiently to generate original new ideas, then these ideas can solve problems or become a product that can get around all limitations. Critical Thinking is the ability to use ICT effectively and efficiently to think clearly and rationally in assessing various information obtained based on reflective reasoning and argumentative thinking. Communication is the ability to use ICT to effectively and efficiently convey information or ideas to others. Collaboration is the ability to use ICT effectively and efficiently to develop social relationships and work together in groups to exchange information, compromise, and make decisions with mutual respect for each other to achieve common goals [44]. So far, the literature review shows that previous researchers have not examined the effectiveness of inquiry learning for 21st-Century Skills integrated with digital literacy. Therefore, in this study the proposed hypothesis are:

H_{01}: There is no difference in the level of 21st-Century Skills of students using the Networked-Based Inquiry learning model with Inquiry-based Learning.

H_{02}: There is no difference in the level of 21st-Century Skills of students using the Networked-Based Inquiry learning model based on school categories.

H_{03}: There is no interaction between the Networked-Based Inquiry learning model and the school category in determining the 21st-Century Skills level.

H_{a1}: There is differences in the level of 21st-Century Skills of students using the Networked-Based Inquiry learning model with Inquiry-based Learning.

H_{a2}: There is differences in the level of 21st-Century Skills of students using the Networked-Based Inquiry learning model based on school categories.

H_{a3}: There is an interaction between the Networked-Based Inquiry learning model and the school category in determining the level of 21st-Century Skills.

3 METHOD

This study was a quasi-experimental study using a 2x3 factorial design shown in Table 2. The sampling technique used was purposive sampling.

TABLE 2
TWO-WAY ANOVA TEST DESIGN DESIGN

School Category \ Learning Model	Networked-Based Inquiry	Inquiry-based Learning (Control)
High	A1B1	A2B1
Medium	A1B2	A2B2
Low	A1B3	A2B3

The school category is determined from the results of the 2019 Senior High School National Examination in Sungai Penuh City and Kerinci Regency, Jambi Province, Indonesia. The instrument in this study is an observation sheet consisting of performance assessments and peer assessments. The instrument was developed based on the development of a survey instrument for the 21st century skills as defined by the P21 framework. Data analysis used ANOVA 2x3 with a significant level of 5% with the condition that the data were normally distributed and homogeneous. This analysis uses the SPSS 26 for Windows. The decision making criterion is that if

the significant value (p) at the SPSS output is less than 0.05 then Ha is accepted.

4 Result and Discussion

In this study, the Networked-Based Inquiry learning model was applied 4 times in straight motion material. The Networked-Based Inquiry learning model is actualized in the classroom using interactive e-books. The interactive e-book contains the steps of the Networked-Based Inquiry learning model: (1) Orientation on Network Section, (2) Problem Identify from Network Resources Section, (3) Exploration in Digital Environment Section, (4) Report Findings, and (5) Section Closure Section. Each of these sessions is contained instructions for developing 21st-Century Skills. Besides, the Physics Student e-book for Class XI Senior High School was developed, which includes a connection feature with many learning resources from various simulation applications, websites, and YouTube videos. The results of the 21st-Century Skills assessment of students were obtained from observations of these competencies during the learning process using the 21st Century Skills assessment instrument. The results obtained at each school are as shown in Table 3. The data shows that the last ability of the experimental class is better than in the control class. Before being tested using analysis of variance, the prerequisite data are tested first. These tests are the normality test (see Table 4 for results) and the homogeneity test (see Table 5 for results). The results of this prerequisite test indicate that the data for the six groups are normally distributed and homogeneous. Therefore, it can be tested with parametric statistics, namely two-way ANOVA.

TABLE 3
ASSESSMENT OF 21ST-CENTURY SKILLS

School Category		N	Min	Max	Mean	Std. Deviation
High	Experiment	20	75.46	94.33	84.62	5.68930
	Control	20	67.13	85.88	71.11	4.10687
Med	Experiment	20	75.93	95.14	85.70	5.30690
	Control	20	64.35	84.03	69.59	4.68554
Low	Experiment	20	73.26	93.29	83.83	6.21909
	Control	20	64.12	84.26	70.19	5.51235

TABLE 4
KOLMOGOROV-SMIRNOV NORMALITY TEST RESULTS

		High		Medium		Low	
		Experiment	Control	Experiment	Control	Experiment	Control
N		20	20	20	20	20	20
Normal	84.62	71.11	85.70	69.59	83.83	70.19	74.77
Parameters[a,b]	5.68	4.10	5.30	4.68	6.21	5.51	5.56
Most Extreme	0.133	0.237	0.130	0.178	0.136	0.188	0.136
Differences	0.099	0.237	0.103	0.178	0.101	0.188	0.136
	-0.133	-0.166	-0.130	-0.132	-0.136	-0.135	-0.130
Kolmogorov-Smirnov Z		0.594	1.061	0.582	0.798	0.610	0.839
Asymp. Sig. (2-tailed)		0.872	0.210	0.887	0.548	0.850	0.483

TABLE 5
LEVENE'S HOMOGENEITY TEST RESULTS

F	df1	df2	Sig.
1.616	5	114	0.161

TABLE 6
TWO-WAY ANOVA TEST RESULTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5995.912[a]	5	1199.182	40.565	0.000
Intercept	724050.620	1	724050.620	24492.342	0.000
Learning Model	5952.039	1	5952.039	201.339	0.000
School Category	28.010	2	14.005	0.474	0.624
Learning Model * School Category	15.862	2	7.931	0.268	0.765
Error	3370.105	114	29.562		
Total	733416.637	120			
Corrected Total	9366.017	119			
a. R Squared = 0.640 (Adjusted R Squared = 0.624)					

4.1 Effect of Networked-Based Inquiry Model on 21st-Century Skills

The significance value of the aspects of the learning model is smaller than 0.05, which is 0.000. This shows that H_{01} is rejected. The test results shown in Table 6 suggest that there is a significant difference between the 21st-Century Skills results between students learning using the Networked-Based Inquiry learning model and students learning using the Inquiry-based Learning model. The calculation of the observation data shows that the application of the Networked-Based Inquiry learning model achieves a better score than the results obtained from the application of the Inquiry-based Learning model. This means that the Networked-Based Inquiry learning model is proven to have a better effect on 21st-Century Skills, compared to 21st-Century Skills. This finding is under previous research which states that learning that can accommodate the development of 21st Century Competencies based on digital literacy is learning that shows a balance between a scientific approach and the use of technology [17], [18], [19]. Networked classroom activities also provide opportunities for students to gain knowledge and skills, thereby expanding their opportunities for learning, communication, collaboration, and knowledge creation [28]. Besides, the use of smartphones owned by students in learning provides efficiency and

effectiveness benefits in learning [45],[46], [47], [48], [49], and student motivation [50], [51]. Therefore, the Networked-Based Inquiry learning model builds not only students' knowledge but also builds communication and collaboration skills that are appropriate to the 21st century. Therefore, integrating networked learning in inquiry learning enables various investigative activities (such as data collection, data analysis, and communication and discussion of results) which are more complex and relevant today, and being able to accommodate students in developing 21st-Century Skills which are very much needed in the current era of the industrial revolution 4.0.

4.2 21st-Century Skills use the Networked-Based Inquiry learning model based on school categories

Based on the results shown in Table 6, the significance value of aspects of the school category is greater than 0.05, namely 0.624. It indicated that the H_{02} is accept. It's means that there is no difference in the level of 21st-Century Skills of students using the Networked-Based Inquiry learning model based on school categories. These results indicate that the Networked-Based Inquiry learning model has the same effect in each school so it can apply to various school categories to improve students' 21st-Century Skills. This is also confirmed based on the significant value of the interaction aspects of the learning model with the school category greater than 0.05, namely 0.765. It indicated that the H_{03} is accept. It's means that there is no interaction between the Networked-Based Inquiry learning model and the school category in determining the level of 21st-Century Skills. Therefore, it can be stated that the Networked-Based Inquiry learning model can a choice for education practitioners to develop 21st-Century student skills.

5 Conclusion

The conclusions of this study are: (1) there is a significant difference between the level of 21st-Century Skills of students in physics subject using Networked-Based Inquiry learning model using Inquiry-based Learning model; (2) there is no difference in the level of 21st-Century Skills of students using the Networked-Based Inquiry learning model based on school categories; (3) there is no interaction between Networked-Based Inquiry learning model and school category in determining students' 21st-Century Skills level. The results of this study indicate that the Networked-Based Inquiry learning model is effective in improving students' 21st-Century Skills. This report shows optimism about the potential of networked-based inquiry learning for the development of 21st-Century Skills in the future, although this study is still not perfect, but we believe this learning is the answer to the challenges of 21st-Century learning.

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