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Validity of Networked-Based Inquiry Model to Improve 21st-Century Competencies of Students

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ABSTRACT
This study aims to reveal the validity level of Networked-based Inquiry model to develop 21st-century competencies of students on physics learning in senior high school. Networked-based Inquiry is a learning model that relies on digital technology to provide opportunities for students to carry out scientific investigations, knowledge construction, problem-solving experiences, digital collaboration, and digital communication. This research was research and development using the Plomp model. Instruments used were questionnaires and data were analyzed descriptively based on the score sheet of validation. The product was validated by a pedagogy expert, physics education expert, instructional technology expert, and language expert. Observation results were analyzed by Aiken's V formula. The analysis showed that the average values of Aiken's V were 0.87. The result of the validity showed that Networked-based Inquiry learning model was valid criteria. This finding indicates that the Networked-based Inquiry learning model is decent for use in physics learning to develop students' 21st-century competencies integrated with digital literacy.

Keywords: *Model of Teaching, Inquiry, Networked, 21st-Century Competencies, Physics Learning.*

1. INTRODUCTION

Physics is a science that cannot be separated from observations in experiments. In the study of philosophy of science (The Nature of Knowledge), the physical universe is the object of observation to obtain knowledge. In the 17th-century, the discoveries of Leonardo da Vinci, Galileo, and Newton through observations of the physical universe lead us to physics as it is known today [1]. Therefore, the implementation of physics learning is suggested through a scientific process (inquiry) [2]–[4], because of physics is a science that contains three elements, namely process (a way of investigating), product (a body of knowledge), and attitude (a way of thinking) [5]. This understanding illustrates that studying physics requires the ability of inductive and deductive thinking analysis by using concepts, theories, laws and postulates of physics to explain events related to these concepts, theories, laws, and postulates and to solve problems both qualitatively and quantitatively.

However, in the era of technological disruption that comes in various forms of digital platforms, only applying the scientific process (inquiry) in learning physics is irrelevant. Mastering physics and have scientific skills are not enough to compete in the 21st-century. Physics learning must also be able to prepare a generation with new literacy, such as digital literacy (the ability to take advantage of big data and artificial intelligence), and have human literacy (humanities) through 21st-century learning trends. This literacy is related to 21st-century skills which have become the main subject in recent years, both among educational researchers and educational policy making authorities around the world. These skills are not developed through conventional learning but from ICT-based learning [6], [7].

According to the Partnership for 21st-century in 2007, 21st-century skills are defined in three basic categories, namely (1) life and career skills, (2) learning and innovation skills (21st-century competencies), and (3) information, media, and technology skills. Life and career skills are the characteristics that are the demands of the 21st-century, learning and innovation skills (21st-century competencies) are the core skills of the 21st-century, and information, media and technology skills are literacy that are the demands of the 21st-century. When viewed holistically 21st-century skills can be realized through learning based on increasing 21st-century competencies (creativity, critical thinking, collaboration, and communication), but these competencies are in line with information, media, and technology skills [6], [8]–[10]. Therefore, the core of 21st-century skills is 21st-century competence which is integrated with media, information, and ICT literacy, so that the characters that are the demands of the 21st-century (life and career skills) can be realized.

Therefore, following the 21st-century learning trend, the integration (infusing or transforming levels) of information and communication technology (ICT) in learning activities is a necessity [6], [7], [11], [12], including in physics learning. In addition, the inevitability of integrating technology in learning is an effort to respond to the abilities, interests, and learning styles of the current generation [13]–[15]. The current generation that is "highly mobile" and "always connected" is a generation that is very "visually literate" and "data literate" through various digital platforms. The life of this generation cannot be separated from technology and the internet, because almost all of them have smartphones [15]–[18].

The existing learning models developed by researchers show relatively positive results, such as the development of learning models based on blended learning [19], Project-Based Learning based on STEM [20], based on PAIKEM and discovery [21], and based on 21st-century character values [22]. However, those models are not adequate to accommodate the needs of the industrial revolution 4.0 and the characteristics of 21st Century Competencies. Those models provide effectiveness in improving learning outcomes and problem-solving, but they do not provide benefits in holistic information search, knowledge construction, problem-solving experiences, digital collaboration, and digital communication. It has not combined the constructivist, experiential, cognitive, and connective elements.

Whereas learning that can accommodate the development of 21st-century competencies based on digital literacy is learning that shows a balance between the scientific approach and the use of technology [23] or it can be referred to as high tech and high touch approaches. The STEM-based, conventional inquiry-based, PAIKEM-based, and discovery-based PjBL model emphasizes its scientific approach but does not integrate ICT at an infusing or transforming level. Then the blended learning-based model emphasizes integrating ICT in the infusing level, and ignores the scientific approach, making it less suitable for secondary schools. As a result, these models could not fully accommodate branding, collaboration, and communication following the demands of the 21st century, namely integrated digital literacy.

Based on these issues, there needs to be an innovative learning model based on inquiry and integrated with ICT at an infusing level that can construct students' physics knowledge and develop 21st-century competencies. This learning model is believed to lead students to construct their knowledge and can provide a learning experience that is positive and able to develop the abilities that are the demands of 21st-century education [24]–[26]. Integrating ICT (infusing or transforming) in inquiry learning is a very appropriate combination of learning to improve 21st-century competencies that are integrated with digital literacy. UNESCO (United Nations Educational, Scientific, and Cultural Organization) has created a framework for integrating ICT in learning. There are four levels in integrating ICT in learning, namely: emerging, applying, infusing, and transforming [27]. Infusing and transforming stages are the levels where information technology has become a catalyst for educational change/evolution [27], [28], 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 apply ICT at a transforming level [29]. To apply ICT at the infusing level, an approach that can be applied is networked learning. This is because networked learning is learning to help 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 [30].

Networked learning is defined as a learning approach that relies on ICTs to support connections between students and students, between student and teachers, and between student and learning resources [31]–[35].

Networked learning is one of the more attractive and newest alternatives to 21st-century learning [36], [37]. In networked learning, the teacher as a facilitator guides students to obtain information and the knowledge building process through collaboration and discussion [13], [33], [38]. Networked learning practices must accommodate activities, such as 1) digital collaboration and digital communication; 2) discussion and dialogue in groups; 3) self-assessment in the learning process; access to digital learning resources; and 4) scientific measures [32].

Based on this concept, a Networked-based Inquiry (NbI) learning model was developed that achieves the quality elements of a learning model, one of which is the validity element. The validity of a product developed (intervention) is determined by the relevance of the product content to the content of the subject (content validity) and the consistency and suitability of the product structure (construct validity) [39]. Based on this theory, the criteria for the validity of the NbI learning model developed are consists of three validity. It is content, construct, and the language validity.

Therefore, This study discusses the creation in Senior High School of a valid NbI learning model for physics learning. According to Joyce et al. (2016), the paradigm is based on the psychological reasoning of The Information Processing Family, which will provide students with stimulation from their surroundings. According to Indonesian grammar rules, the vocabulary used in the model is communicative, simple in context, nice and right, the spelling used corresponds to the Indonesian standard, and according to the analysis, it is accurate in using the word. The research explains how the paradigm can be used to increase 21st-century skills.

2. METHOD

The research conducted was design research using the Plomp model of development study type. The development study is at the prototype stage, namely product validation. The components of NbI learning model validity include content, construction, and language. The validity assessment of NbI carried out by experts who are experienced in their fields. Before evaluating the validity of NbI, the validity of the instrument used is tested first. The questionnaire that was filled in by the expert review was analyzed to determine the validity of the instrument. A valid instrument is used to assess the validity of NbI. Furthermore, the questionnaire that was filled in by experts was then analyzed to determine the validity of the developed NbI. Validity analysis uses a Likert scale with steps (a) Giving a score for each answer ; strongly agree (4), agree (3), disagree (2), and strongly disagree (1), (b) Adding up the total score of each expert review for all indicators, (c) Providing validity values using the Aiken's V formula:

$$V = \frac{\sum s}{[n(c-1)]} \quad (1)$$

with: s = r - lo, lo = the lowest validity score (in this case = 1), c = the highest validity score (in this case = 4), r = the number given by the expert review. Validity categories can be seen in Table 1.

Table 1. Validity Category

Value	Category
≥ 0.60	Valid
< 0.60	Invalid

Based on Tabel 3, it can be seen the criteria of the agreement value of the validity obtained. This validity is done by using the Aiken's V formula and is categorized into two values namely valid and invalid. The NbI instrument and the learning model developed can be said to be valid when the value obtained exceeds or equals 0.6.

3. RESULTS AND DISCUSSION

The validity of the NbI learning model begins with the development stage, namely designing NbI learning model in the form of a draft guide containing background, concepts and characteristics of the model comprising syntax, principles of reaction, social systems, support systems, instructional effect and nurturant impact. This draft refers to the results of the analysis at the preliminary research stage that has been carried out. This draft first carried out a self-evaluation to check for errors in design, to get relevant product criteria and based on science, consistency, and have the expected practicality. After that, this draft was asked for opinions from four lecturers of Universitas Negeri Padang to provide input so that a prototype of the NbI learning model was obtained, which would be validated by experts in the related field. Details of the results of the validity are explained as follows.

3.1. Results of Instrument Validity

The instrument to validate the prototype of the NbI learning model was assessed first by three experts using the instrument validity assessment sheet. The components of the instrument validity assessment include the suitability of the statement with the instrument grid, the instrument can reveal the quality of the content, language, and the construction of the NbI learning model, and the instrument is clear and easy to use. The results obtained from the assessment of this validity instrument were 0.89. The average validity value (Aiken's Values) of the NbI learning model instrument from experts is greater than 0.6 in the valid category. Thus, the instrument of the validity of the NbI learning model can validate the NbI learning model.

3.2. Results of the Networked-based Inquiry Validity learning model

The prototype of the NbI learning model is logically validated by five experts in their field, while the results of these experts are shown in table 2.

Table 2. Validity of NbI learning model

Assessed Aspects	V
Content Validity	
• Background to model development	0.93
• The essence of developing a learning model	0.87
• The purpose of developing a learning model	0.87
• Supporting theory is relevant to model development	0.87
• Learning theory underlies the concept of model development	0.87
• The theoretical of the information processing model group	0.8
• Theoretical of inquiry learning	0.87
• The theoretical of Networked Learning	0.84

Assessed Aspects	V
• The concept of applying ICT in learning	0.9
Construct Validity	
• Syntax in learning	0.93
• Social systems in learning	0.87
• Principles of reaction in learning	0.86
• Support systems in learning	0.93
• Instructional and nurturant effect on learning	0.85
Language Validity	
• Languages	0.87
Average	**0.87**

The above results given by each validator show that the NbI learning model is valid with an average value of validity (Aiken's Values) of 0.87 and can be used in physics learning with minor revisions. The revision is related to the suggestions provided by the experts, as can be seen in Table 3.

Table 3. Validator Suggestions

Validator	Suggestions	After Revision
LF	Needs a simpler syntax.	Reduces syntax to five phases.
	Improve the role of teachers in the operational model of the NbI so that it is easy for teachers to implement.	The teacher's role in each syntax has been improved to become more practical and easy to apply.
UM	In the model manual, it is necessary to explain an example of a lesson plan that applies this developed model.	Making lesson plans in the guidebook for implementing the NbI learning model.
AZ	Describe well the approaches, strategies, and methods of learning in the NbI learning model.	Describe the approaches, strategies, and learning methods in the NbI learning model by adding analysis and synthesis.
	Consider how to describe the instructional effects and the accompanying effects of the NbI learning model from the book Model of Teaching.	Instructional effects and nurturant effects have been reformulated based on the way the instructional effects and accompanying effects are described in the book Model of Teaching.
	Describe syntax 1 and 2 properly.	Redescribe syntax 1 and 2 by adding concepts related to how to orient learning and present the problem.
	It is necessary to make an application design (implementation) of the NbI model in the guidebook by applying one of the learning design models.	Creating an NbI model implementation plan based on the ASSURE instructional model.
AR	There are still sentences that are not appropriate.	Sentences that are not suitable have been corrected into appropriate sentences.
	We recommend that English terms that are already known in Indonesian (inquiry learning, creativity, critical thinking) are written in Indonesian.	Replace foreign terms that are already known in Indonesian with standard words.
	Notice again that each paragraph written in the model manual has met the criteria for a good paragraph.	Fixing paragraphs that do not meet the criteria of a good paragraph into paragraphs that are following Indonesian language rules.

Based on the suggestions given by the validators, the prototype of the NbI learning model was revised and a final prototype was obtained which was suitable for physics learning in Senior High School to develop 21st-century competence with the main components, namely:

3.2.1. Syntax

3.2.1.1. Orientation on Network

An activity to prepare students to learn, that is by providing perceptions and motivation to students, and arousing curiosity about the next lesson through the Google Classroom application before learning takes place.

3.2.1.2. Problem Identify from Network Resource

The teacher provides a physics phenomenon in the Google Classroom application that is connected to students' e-books. Students make hypotheses related to these problems with their group members, then each student is required to send the hypothesis to the physics learning database link contained in the students' e-book. Representatives from each group present their hypothesis formulations in front of the audience.

3.2.1.3. Exploration in Digital Environment

Students collect data by experimenting through the Smartphone application, or by reviewing literature through a website that has been prepared by the teacher. Each student is required to send their findings to the physics learning database link in the students' e-book.

3.2.1.5. Report Findings

Students present their findings, provided that each group member who appears must explain the concepts they find. Then the group that appeared was presented with questions from both the teacher and from other students. Here, group members take part actively in dialogue and active interaction by sharing ideas verbally one by one. Students share their findings related to the application of concepts in life through their social media.

3.2.1.5. Closing

The teacher and students conclude the learning that has been implemented. Students reflect on what they learn and assess their appearance. If there is something that is not understood, after learning is complete students can ask questions through Google Classroom, then other students can help explain it through discussions in the Google Classroom.

3.2.2. Principle of Reaction

Teacher activities that need to be realized in the NbI learning model are (a) giving attention to every interaction between students, (b) giving attention to the working of groups, (c) giving attention to the behaviour of dominant students and submissive students, (d) regulating the learning mechanism, (e) managing learning resources that can encourage students to carry out learning activities, (f) providing learning guidance to each group in need, (g) directing students to construct their knowledge, and (h) providing training for dominant learners and submissive learners on how to learn cooperatively.

3.2.3. Social System

The teacher served as a facilitator, moderator, and reflector. As a facilitator, the teacher provides learning resources, encourages students to learn by involving the senses and intellectuality, provides assistance to students in learning and in constructing knowledge optimally, and provides feedback on what has been learned. As a moderator, the teacher creates a condition where students can argue and work together in learning, for example through group discussions. As a reflector, the teacher assesses and observes what has happened during the learning process.

3.2.4. Support System

In NbI learning model, online-based media is needed to support learning. This NbI learning model also requires e-books for teachers and students, lesson plans, and evaluation tools.

3.2.5. Instructional Effects

The Instructional effects of NbI learning model is an increase in 21st-Century Competence of students, namely: (a) The Orientation on Network stage is creativity and critical thinking, (b) The Problem Identify stage from Network Resources is creativity and critical thinking, (c) the Exploration Stage in Digital Environment is creativity, critical thinking, collaboration, and communication, (d) Report Findings stage is creativity, critical, collaboration, and communication, and (e) Closing stage is creativity, critical thinking, collaboration, and communication.

3.2.6. Nurturant Effect

The nurturing effects of NbI learning model are (a) The Orientation on Network stage is curiosity, (b) The Problem Identify Stage from Network Resources is curiosity, (c) The Exploration Stage in Digital Environment is the ability to find information, thoroughness, sincerely, honesty, discipline, obeying the rules, (d) The Report Findings stage is respecting the opinions of others, self-confidence, obeying rules, honesty, and politeness, and (e) Closing Stage is caring, respecting the opinions of others, and confident.

4. CONCLUSION

Based on the process and results of the study, it is concluded that the design of NbI model to Improve 21st-century competencies of students on physics learning in senior high shool is valid in terms of content, construct, and language with an average value of validity (Aiken's Values) is 0.87. It means that the NbI model can be applied on physics learning in senior high school and in theory it can improve 21st-century competency of students.

AUTHORS' CONTRIBUTIONS

The three authors have collaborated on this research in all stages. In conceptualization and the study design the contribution of both authors FF and YH is equal. FN developed the basic idea for the present research and responsible for data collection, conducted the analyses, and wrote the manuscript in consultation with FF and YH.

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