Preliminary research of networked-based inquiry model development to improve 21st-century competencies of students on physics learning in senior high school

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Abstract. This research is based on the important of developing a learning model that emphasizes the balance between the scientific approach and use of technology to develop students’ 21st-century competencies. One of learning models that support the goal is inquiry learning which is integrated ICT at infusing level. The model relies on digital technology to provide opportunities for students to investigate scientifically and authentically through information search, problem-solving, and digital collaboration and communication. This study aims to describe the results of needs and context analysis, review of relevant literature, and designing the theoretical framework and concepts for Networked-based Inquiry model development. This research was research and development using the Plomp model. This research has been done at preliminary research that consists of need and context analysis, literature review, developing conceptual theory. The results of needs and context analysis indicates that 21st-century competencies of students is still relatively low, and the integration of ICT in learning physics has enormous potential. The phase review literature revealed that inquiry learning model can improve students’ critical thinking, creative thinking, collaboration, and communication. Then, networked learning can accommodate the use of ICT in infusing level. These findings indicates that the development of Networked-Based Inquiry models can be a solution in accommodating students to develop 21st-century competencies which integrated with digital literacy.

1. Introduction
The issue of 21st-century competencies has become a major subject in recent years, both among educators, educational researchers and educational policy-making authorities around the world. The cause is the reality of global education has not fully accommodated the needs of the industrial revolution 4.0. Especially in Indonesia, which still applies the academic rank, excellent class, and many favorite schools. As a result, the learning paradigm that formed is to compete. Students compete to get good academic scores (cognitive), and ignoring cooperation and collaboration (affective and psychomotor). It is not relevant to the needs of the industrial revolution 4.0. In the digital era, humans live in an environment filled with the use of technology and easy access to a lot of information, so humans will definitely lose to robots (artificial intelligent) at work if they still use this paradigm.
Therefore, the paradigm needs to change, schools must be able to provide students with experiences and opportunities that can stimulate them intellectually to have 21st-century competencies [1–5], because robots (artificial intelligent) will not possess the abilities in the digital era, such as critical thinking skills, problem solving, communication, and collaboration.

Various learning trends have been pursued in facing this era. The first trend is student centered learning [6] through constructivist approaches, collaboration, and inquiry-based learning [7, 8], especially in physics learning. Physics is a science based on a process (a way of investigating), a product (a body of knowledge), and an attitude (a way of thinking) [9]. Physics as a process implies that understanding physical phenomena is based on a scientifically acceptable scientific method. Physics as a product means that physics produces something that is obtained from scientific activities, in the form of concepts, theories, laws and postulates. Physics as an attitude means that physics instills a scientific character in dealing with a problem in every activity of life. It revealed that physics essentially contains scientific skills and scientific attitudes [10–12]. This understanding illustrates that studying physics requires the ability to think inductively and deductively by using physics concepts, theories, laws, and postulates to explain events related to these concepts, theories, laws, and postulates and solve problems both qualitatively and quantitatively.

Therefore, physics learning is suggested to be carried out through a scientific process (inquiry) [10–12]. Meanwhile, Permendikbud Number 22 of 2016 also suggests inquiry learning so that physics learning can improve the competence of students as a whole. Thus, physics learning must be carried out through learning based on scientific phenomena which enables students to carry out scientific and authentic investigations, so that physics learning aims not only to increase students’ knowledge but also aims to improve students’ attitudes and skills.

The second trend is to integrate information and communication technology (ICT) in learning activities [1, 13–15]. In dealing with education in the 21st century, what educators must realize is that the learning behavior of the millennial generation differs completely from the previous generation [16]. Today’s learners live with ICT. They cannot be separated from technology and the internet, because they all have smartphones [17–20]. Inevitably they are always connected with friends, family, information and various games from waking up to sleeping again. Technology allows them to connect with more people, it is easier to know various information and tricks than the teacher. When new technologies emerge, they will enthusiastically learn about them. This is a serious challenge for educators, because a long learning strategy will make students bored and underestimate educators. Therefore, integrating ICT in learning is a necessity of responding to the abilities, interests, and learning styles of the current generation [19, 21, 22]. Especially with the emergence of the Covid-19 pandemic, this has further confirmed this. Educators who are still talkative about online learning are also “forced” to be open and recognize the importance of ICT integration and understand how and why they should integrate ICT into learning.

One learning model that can be an alternative in the 21st century is inquiry learning that is integrated with ICT at the infusing level. Inquiry learning is learning based on scientific phenomena, students carry out scientific and authentic investigations by generating hypotheses, planning and conducting experiments and analyzing the data they find. Inquiry learning is a learning that can improve the creative thinking and critical thinking skills [23–25], and collaboration and communication skills [26–28] of students. Regarding the integration of ICT, inquiry learning is very effectively implemented by integrating ICT [26, 29–33]. To integrate ICT in the infusing or transforming level, one approach that can be used is networked learning.

Networked classroom activities provide opportunities for learners to gain knowledge and skills, thereby expanding their opportunities for learning, communication, collaboration, and knowledge creation [34]. Networked learning is defined as a learning approach that relies on ICTs to support connections between students and students and teachers, and between learners and learning resources [35–39]. In learning, students not only build their knowledge but also build communication and collaboration skills. 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 competencies which are very much needed in the current era of the industrial revolution 4.0.

Based on these, it is necessary to develop a physics learning model that can build 21st-century competencies for students who are integrated with digital literacy. One of them is the development of a Networked-Based Inquiry learning model to increase the 21st-century competencies of students on physics learning in senior high school.

2. Literature Review

2.1. 21st-Century Competencies

21st-century competencies are part of 21st-century skills. Various 21st-century skill definitions have been presented and have many similarities, such as collaboration, communication, ICT literacy, and social/cultural skills, along with skills such as community participation, creativity, critical thinking, and problem solving [10, 40, 41]. According to the Partnership for 21st Century, 21st-century skills are defined in three basic categories, namely (a) life and career skills; (b) learning and innovation skills (21st-century competencies); and (c) information skills, media, and technology.

Life and career skills according to the Partnership for 21st Century consist of: (a) Flexibility and Adaptability, namely the ability to adapt to changes and be flexible in learning and doing activities in groups; (b) Initiative and self-regulating, namely the ability to manage goals and time, work independently and become self-regulating learners; (c) Social and cultural interactions, namely the ability to interact and work effectively with diverse groups; (d) Productivity and accountability, namely the ability to manage projects and produce products; and (e) Leadership and responsibility, namely the ability to lead group members and be responsible to the wider community.

Learning and innovation skills according to the Partnership for 21st Century consists of: (a) Think critically and solve problems, namely the ability to use various reasons (reason) such as inductive or deductive for various situations, use systems thinking, make decisions and solve problems; (b) Communication and collaboration, namely the ability to communicate clearly and collaborate with other group members; and (c) Creativity and innovation, namely the ability to think creatively, work creatively and create new innovations.

Information technology and media skills according to the Partnership for 21st Century consist of: (a) Information literacy, namely the ability to access information effectively (sources of information) and efficiently (time), evaluate the information to be used critically and competently, use and manage information accurately and effectively to solve problems; (b) Media literacy, namely the ability to select and develop the media used to communicate; (c) ICT literacy, namely the ability to analyze information media and creating suitable media for communication.

From these definitions, it can be seen that life and career skills are the characters that are the demands of the 21st century, learning and innovation skills are the core skills or core skills of the 21st century (21st-century competencies), and information, media, and technology skills are literacy that become 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 go hand in hand with technology and information media skills [15, 43–45]. 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, the core skills of the 21st-century skills can be formulated as follows: (a) Creativity is the ability to use ICT effectively and efficiently to generate new, original ideas, then these ideas can be used to solve problems or become a product that can get around all limitations; (b) 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; (c) Communication is the ability to use ICT effectively and efficiently to deliver information or ideas to others in a proficient manner; and (d) Collaboration is the ability to use ICT effectively and efficiently to develop social relations and work together in groups to exchange information, compromise, and make decisions with mutual respect for one another to achieve common goals.

From this understanding, it appears that the framework of the 21st-century skills requires learning to support 21st-century competencies and make full use of ICT. This of course will be a challenge for educators to be able to implement it. One solution that has been suggested by many education experts in addressing this challenge is ICT-based inquiry learning.

2.2. Inquiry Learning
Inquiry is the ability to think and work scientifically suggested by science and education experts around the world [7, 24, 41]. Inquiry learning is learning based on scientific phenomena, students carry out scientific and authentic investigations by generating hypotheses, planning and conducting experiments and analyzing the data they find [12, 33, 46–50]. There are three dimensions of thinking in inquiry learning, namely concept maps, data tables, and reasoning maps. Concept maps include the conceptual knowledge of the subject that underlies the problem and the relationships between concepts. The data table records problem information, reflected as a set of key variables and their changes over the observation period. The reasoning map is a representation of the evidence relationship between the hypothesis and data or subject knowledge, each hypothesis is supported or rejected by evidence from the data or subject [28]. Inquiry learning is essentially a varied process by providing opportunities for students in activities, such as observing, formulating questions or hypothesizing, collecting information through books and other sources of information critically, planning investigations or investigations, elaborating what they already know, carry out experiments or experiments, analyze and interpret data, and communicate the results they get.

In connection with this 21st century trend, Inquiry learning is very effectively implemented with the help of ICT [26, 29–33]. In the 21st century, the information available online is highly accessible and overwhelming. Networked-based classroom activities provide opportunities for students to gain knowledge and skills, expanding their opportunities for learning, communication, collaboration, and knowledge creation [34]. Therefore, using ICT 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 “up to date”, and learning can accommodate students in developing 21st-century skills desperately needed by themselves.

2.3. Networked Learning
Networked learning is defined as a learning approach that relies on information and communication technology to support connections between learners and students and teachers, and between students and learning resources [35–39]. In learning, students not only build their knowledge, but also build communication and collaboration skills that are in line with the 21st century. The rapid advancement of ICT in the 21st century has led to social media as forming knowledge and skills [51]. Using social media in learning has a positive impact on learning outcomes [52, 53]. Networked Learning can be done in various media, for example Twitter, Facebook, the web, blogs, and others [37]. Using social networks for learning will maximize the quality of learning, because teaching materials are not only fixed on text but can be in the form of images, videos, or other interesting media available on the World Wide Web.

In networked learning, the teacher as a facilitator still plays an important role (especially at the beginning of learning) in guiding students to get information and the knowledge building process by directing which networks (web, blog, etc.), as well as in sharing knowledge with their peers [21, 37, 54]. Characteristics of Networked Learning [39, 55], namely: (a) Openness in the educational process; (b) self-defining learning; (c) aims to communicate and work together; (d) A learning environment that is support; (e) conduct collaborative learning assessments; (f) conduct assessments and formative
evaluations. This characteristic shows that through Networked Learning, the quality of learning can be improved, because it is maximally utilized all the ease of communicating and sharing information held by the media along with its superior features for learning in the 21st century.

3. Research Method

Preliminary research of this research is the preliminary research stage of Plomp's development design. The procedure of activities carried out on this research is shown in Table 1.

| Stages               | Research Analysis                          | Activity Description                                                                 |
|----------------------|--------------------------------------------|--------------------------------------------------------------------------------------|
| Preliminary Research | Needs and context analysis                 | 1. Collecting information about the description of physics learning at class X which is carried out through inquiry learning in SMAN 1 Kota Jambi, SMAN 5 Kota Jambi, SMAN 1 Sungai Penuh, SMAN 3 Sungai Penuh, and SMAN 4 Kerinci. |
|                      |                                            | 2. Collecting information about regarding the 21st-century competency level of learners is carried out at SMAN 1 Kota Jambi, SMAN 5 Kota Jambi, SMAN 1 Sungai Penuh, SMAN 3 Sungai Penuh, and SMAN 4 Kerinci. |
|                      |                                            | 3. Collecting information about the potential for integrated ICT learning at SMAN 1 Kota Jambi, SMAN 5 Kota Jambi, SMAN 1 Sungai Penuh, SMAN 3 Sungai Penuh, and SMAN 4 Kerinci. |
|                      | Theoretical and concepts analysis           | Analyzing theories and concepts related to Networked-Based Inquiry learning model to increase the 21st-century competencies of students on physics learning in senior high school. |
|                      | Design of theoretical and concepts framework| Design a conceptual framework and theoretical framework for the Networked-Based Inquiry learning model to increase the 21st-century competencies of students on physics learning in senior high school. |

The instruments used to collect data are shown in Table 2.

| Analysis                              | Instrument         | Reference                                                                 |
|---------------------------------------|--------------------|----------------------------------------------------------------------------|
| 21st-century competencies of student  | Questionnaire      | R. Kelley, Geoff Knowles, Han, & Sung (2019)                                |
| The potential for integrated ICT      | Questionnaire      | Ng (2012); Munir (2017); Wolff, Gooch, Cavero Montaner, Rashid, & Kortuem (2017) |
| Implementation                        | Observation        | Aditomo et al., 2013; Arsal, 2017; Bevins & Price, 2016; Chen et al., 2018; Fuad et al., 2017; Furtak et al., 2012; Hong et al., 2019; Kaiser et al., 2018; Love et al., 2015; Madhuri et al., 2012; Margunayasa et al., 2019; Marshall et al., 2017; Minner et al., 2009; Sinha et al., 2015; Wartono et al., 2018; Xing et al., 2019 |
The 21st-century competencies of student questionnaire consisted of 32 statements using a Likert scale with four alternative answers, namely always (3), often (2), sometimes (1), and never (0). The potential for integrated ICT learning questionnaire consisted of 29 statements using a Likert scale with four alternative answers, namely strongly agree (3), agree (2), disagree (1), and strongly disagree (0). To analyze the implementation of Inquiry learning, the assessment is carried out by giving a sign (√) to each inquiry learning syntax with four levels, namely very accomplished (3), moderately accomplished (2), less accomplished (1), and not accomplished (0). The scoring of the implementation of inquiry learning refers to the rubric developed based on the references in Table 2. Then the calculation of the resulting data from these instruments is converted on a scale of 0–100.

4. Result and Discussion

This research has done at preliminary research phase on physics learning in senior high school based on Plomp's development procedure. The following phases of this research can be seen as follows:

4.1. Needs and context analysis

Based on the results of observations at SMAN 1 Jambi City, Jambi City 5 SMAN, 1 Sungai Penuh SMAN, 3 Sungai Penuh SMAN, and 4 Kerinci SMAN, we found that the implementation of physics learning carried out through the inquiry process is still not optimal. The overall learning implementation is only 44%. The teacher presents problems which are then observed by students, but questions and hypothesis submissions by students cannot be accommodated as a whole. Only a small proportion of students are active in conducting experiments and discussions. Then the teacher immediately explained the material after doing the experiment and gave practice questions. This process still seems to apply conventional learning methods, which means that the learning carried out has not supported students to achieve the competencies required in 21st-century learning. Reflections on what they learn are also not implemented.

In addition, teachers also do not integrate ICT in learning (infusing). The teacher uses ICT only at the applying level, namely using a laptop and projector to present visuals in learning. Whereas from the observation results, we found that the potential to integrate ICT in physics learning is very large, as shown in Figure 1.

![Figure 1](image-url)

**Figure 1.** The Potential to Integrate ICT in Physics Learning

From Figure 1, it showed that the attitudes of students towards technology are very good, they are very close to technology. The life of this generation cannot be separated from technology and the internet, because they all have smartphones [17–20], so they have taken advantage of sophisticated technology in various activities [56]. They already have the ability to search, share, and apply information sources. But most of them use this ability for just chatting and gaming. They use only a small part for learning. In addition, the competency to interpret and understand digital content (digital
literacy and data literacy) is still low, namely 63.51% and 59.53%. They could not interpret and judge the information they find, whether or not it is valid. These findings suggest that the teacher implements physics learning irrelevant to students.

Then the results of the 21st-century competency analysis also shows that the development is not optimal. This can be seen from the results of the 21st-century competency analysis of students, as shown in the graph in Figure 2.

![Figure 2. 21st-century competency levels of students](image)

Based on the results of the questionnaire, the average 21st-century competency indicator for students was still in the low category and overall the percentage of students’ 21st-century competency level was only 56.70%.

There needs to be an innovative learning model that is constructivist and integrated with ICT at an infusing level that is able to construct students’ knowledge and develop 21st-century competencies. This learning is believed to be able to lead students to construct their own knowledge and can provide positive learning experiences and able to develop the abilities that demand 21st century education [57–59].

4.2. Theoretical and concepts analysis

4.2.1 Effectiveness of Inquiry Learning. Inquiry learning has many positive impacts on learning outcomes, both on attitudes, skills, and knowledge [32, 60]. Many studies have consistently shown that inquiry-based learning can be more effective than other learning methods [61]. In addition, inquiry learning is also very relevant to use today, especially to improve 21st-century competence. There are several studies that report on the effect of inquiry learning as shown in Table 3.

| Competency          | Research                                                                 |
|---------------------|---------------------------------------------------------------------------|
| Creativity          | Aditomo et al., 2013; Duran & Dökme, 2016; Fuad et al., 2017; Love et al., 2015; Madhuri et al., 2012; Marshall et al., 2017; Wartono et al., 2018 |
| Critical Thinking   | Arsal, 2017; Chen et al., 2018; Duran & Dökme, 2016; Fuad et al., 2017; Furtak et al., 2012; Ham & Myers, 2019; Hong et al., 2019; Kaiser et al., 2018; Love et al., 2015; Margunayasa et al., 2019; Marshall et al., 2017; Minner et al., 2009; Wartono et al., 2018 |
Critical thinking is the skill that most can be improved in the application of inquiry learning, followed by creativity, collaboration, and communication. This is because inquiry learning emphasizes the activity of formulating questions that lead students to investigate [12, 23–25, 27–29, 46, 50, 62–65]. Therefore, students can really see the problem in its entirety and explain it in depth.

Creativity is also a skill that is possible to develop in inquiry learning. Inquiry learning includes the process of brainstorming [28, 62] and Make a Plan [12, 23–25, 46, 65] which is the key to generating original ideas to provide problem solutions, so that inquiry learning can be used as a forum for group creativity to generate problem-solving ideas. Furthermore, collaboration and communication skills can also be developed through inquiry learning. Inquiry learning provides opportunities for students to work collaboratively and discussion [26–28, 63, 64], so that students are trained in presenting information clearly and effectively through presentations, demonstrations, and other media, and are trained to help groups solve problems and manage groups. However, the competencies developed through inquiry learning have not been integrated with digital literacy, and the inquiry used has not implemented ICT at the infusing level.

### 4.2.2 Inquiry Learning Components

The inquiry learning components that can improve the competencies according to some researchers can be described as shown in Table 4.

**Table 4. Inquiry Learning Components**

| No | Components                  | Research                                                                 |
|----|-----------------------------|--------------------------------------------------------------------------|
| 1  | Questioning                 | Aditomo et al., 2013; Bevins & Price, 2016; Chen et al., 2018; Duran & Dökme, 2016; Fuad et al., 2017; Furtak et al., 2012; Ham & Myers, 2019; Kaiser et al., 2018; Love et al., 2015; Madhuri et al., 2012; Minner et al., 2009; Wartono et al., 2018; Xing et al., 2019 |
| 2  | Making Hypotheses           | Arsal, 2017; Chen et al., 2018; Duran & Dökme, 2016; Fuad et al., 2017; Kaiser et al., 2018; Margunayasa et al., 2019; Minner et al., 2009; Xing et al., 2019 |
| 3  | Collecting Data             | Aditomo et al., 2013; Arsal, 2017; Bevins & Price, 2016; Furtak et al., 2012; Ham & Myers, 2019; Kaiser et al., 2018; Madhuri et al., 2012; Marshall et al., 2017; Minner et al., 2009; Wartono et al., 2018 |
| 4  | Analysing Data              | Aditomo et al., 2013; Arsal, 2017; Bevins & Price, 2016; Ham & Myers, 2019; Kaiser et al., 2018; Marshall et al., 2017; Minner et al., 2009 |
| 5  | Literature Review           | Aditomo et al., 2013; Duran & Dökme, 2016 |
| 6  | Brainstorming               | Chen et al., 2018; Fuad et al., 2017 |
| 7  | Make a Plan                 | Bevins & Price, 2016; Duran & Dökme, 2016; Kaiser et al., 2018; Madhuri et al., 2012; Minner et al., 2009; Wartono et al., 2018 |
| 8  | Explanations from Evidence  | Arsal, 2017; Bevins & Price, 2016; Chen et al., 2018 |
| 9  | Observation                 | Aditomo et al., 2013; Arsal, 2017; Bevins & Price, 2016; Chen et al., 2018; Fuad et al., 2017; Furtak et al., 2012; Hong et al., 2019; Kaiser et al., 2018; Love et al., 2015; Madhuri et al., 2012; Margunayasa et al., 2019; Marshall et al., 2017; Minner et al., 2009; Sinha et al., 2015; Wartono et al., 2018; Xing et al., 2019 |
If the inquiry learning component according to the researchers above is reduced based on the steps of the scientific approach according to the 2013 Curriculum, then the component becomes several stages in implementing inquiry learning, namely: (a) Problem identification (observing and asking) which consists of Questioning and Making Hypotheses by Brainstorming; (b) Exploration (trying) which consists of Make a Plan (Open Inquiry), Observation through Collecting Data or Literature Review, and Data Analysis; (c) Constructing concepts (reasoning), which consists of Explanations from Evidence, Discussion, and Concept Application; (d) Presentation (communicate), namely Presentation/Communicate; (e) Closing (communicating) which consists of Drawing Conclusion and Reflection.

Learning activities based on inquiry learning shows that the learning process is centered on students, the teacher role as a facilitator and evaluator. The process is passed by presenting complex problems, students instruct or propose hypotheses and ideas that will explain these phenomena, then students play an active role in experiments, and describe the conclusions of these problems. Based on these phases, the Networked-based Inquiry learning model belongs to The Information Processing Family. This learning model explains how individuals respond to stimuli from their environment by organizing data, analysing of problems, building concepts and planning problem solving, and using verbal and nonverbal symbols [67]. This model is based on Piaget and Gagne’s cognitive learning theory which is oriented to the ability of students to process information to build their abilities. This model is designed to teach students to face causal reasoning, build question-asking skills, form hypotheses and construct knowledge [67].

4.2.3 Application of ICT in Learning. The levels of application of ICT in learning can be mapped on various dimensions, as shown in Table 5.

| Table 5. Comparison of ICT application at each level |
| --- | --- | --- | --- | --- |
| **Level** | **Emerging** | **Applying** | **Infusion** | **Transforming** |
| **Pedagogy** | Teacher centered learning. | Teacher centered learning; ICT is collaborative; ICT is | Student centered learning; | Thinking skills; adjustment of learning styles; |
Facilities and resources

| Limited and out-of-date digital resources; limited access. | Various models, platforms; aligned with certain content and pedagogy. | Distributed access to various digital resources. | Diverse learning environments; web-based learning room, can be done distance education, student self-management software. |

Assessment

| The responsibility of each teacher; educational; paper and pencil based. | Teacher centered learning; focus on the subject. | Student centered learning; subject-oriented; integrated ICT; multiple media to show alignment. | Continuous; holistic, open, project-based; learn community engagement. |

Based on Table 4, the infusing and transforming stages are the levels where information technology has become a catalyst for educational change/evolution [68, 69], 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 [70]. 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 the implementation of 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 [55].

In networked learning, the teacher acts as a facilitator who plays an important role in guiding students to obtain information and the knowledge building process through collaboration and discussion [21, 37, 54]. Networked learning practices must accommodate activities, such as: (a) digital collaboration and digital communication; (b) discussion and dialogue in groups; (c) self-assessment in the learning process; access to digital learning resources; and (d) scientific steps [36].

The application of networked learning requires learning management tools / facilities (designing or selecting a course management tools) [38]. Networked learning can be done by means of learning management, such as learning applications or by utilizing social media (Twitter, Facebook, web, blogs, etc.) [37]. There are many learning applications that can be used, but the most practical and free is Google Classroom. Google Classroom is a free application provided by Google to help teachers or other educators in Learning, Google Classroom is available in web and mobile application versions. This application is available for iOS and Android devices. This application ties Google Drive, Google Docs, Google Sheets and Slides, and Gmail together to support the learning process.

4.3. Design of theoretical and concepts framework.

Based on the needs and context analysis and analyzing theories and concepts, design of theoretical and concepts framework the Networked-Based Inquiry learning model to increase the 21st-century competencies of students on physics learning in senior high school is as follows:

- Based on the theoretical rationale for The Information Processing Family according to Joyce et al., (2016), which is able to provide stimulation from their environment to students to organize
data, analysing of problems, build concepts and plan problem solving, and use verbal and nonverbal symbols.

- Based on rational inquiry learning theory according to Aditomo, Goodyear, Bliuc, & Ellis, (2013); Bevins & Price, (2016); Kai et al., (2016); Kaiser, Mayer, & Malai, (2018); Margunayasa, Dantes, Marhaeni, & Suastra, (2019); Marshall, Smart, & Alston, (2017); Pedaste et al., (2015), namely learning based on scientific phenomena, conducting scientific and authentic investigations by generating hypotheses, planning and conducting experiments and analyzing the data they find.

- Based on the theoretical rationale for network learning according to Holmfeld et al. (2012), which is able to accommodate students in activities, such as: (a) digital collaboration and digital communication; (b) discussion and dialogue in groups; (c) self-assessment in the learning process; (d) access to digital learning resources; and (e) scientific steps.

- Based on the ICT application model at the Infusing level, namely: (a) learner-centered and collaborative; (b) ICT as a subject inseparable from learning; (c) Provide distributed access to various digital resources; and (d) assessment based on ICT, student centered, and using several types of assessment.

5. Conclusion

Based on the results of the preliminary research of developing a Networked-Based Inquiry learning model to increase the 21st-century competencies of students on physics learning in senior high school can be summarized as follows: (a) The overall implementation of learning through inquiry learning is only 44%; (b) The potential for the application of ICT in learning at the infusing level is enormous; (c) Students’ 21st-century competency is still in the low category, and overall the percentage of students’ 21st-century competency level is only 56.70%; and (d) The development of the Networked-Based Inquiry learning model to improve the 21st-century competencies of students in high school physics learning is based on the theoretical rational of The Information Processing Family, rational inquiry learning theory, network learning theoretical rational, and rational theoretical model of ICT application in Infusing level.

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