A Review on ICT Literacy in Science Learning

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Abstract. The framework of 21st-century learning and Kurikulum 2013 encourages integrated learning with information and communication technology (ICT). Fundamental knowledge in ICT utilization (ICT literacy) is an important thing for the student so they can bring themselves better in the digital of learning era. The development of ICT as learning media has been widely carried out but has not specifically measured the level of mastery student's ICT literacy. This literature study aims to illustrate that ICT literacy assessment can be done through the science learning process in school. The instrument of ICT literacy assessment needs to be continuously developed by raising authentic assessment concept.

Keywords: 21st-century learning framework; ICT literacy; Science instruction.

1. Introduction
The 21st century is characterized by the rapid growth of information and communication technology (ICT). The speed of ICT development encourages people to enhance the mastery of ICT literacy. Trilling and Fadel [1] revealed that ICT literacy is one of the skills that must be owned by 21st-century society. The fundamental of changes that occurred in the 21st century have directly changed the existing learning system. The integration of ICT in the learning system can facilitate e-learning, online courses, electronic library, Computer Assisted Instruction (CAI), mobile learning (m-learning), and virtual reality-based learning. The accuracy between the application technology, the learning process, and the content that is taught is influenced by the knowledge of education practitioners about these three things known as TPCK (technology, pedagogy, content, and knowledge). Angeli and Valanides [2] introduced ICT-TPCK as a strand of TPCK. The ICT-TPCK is explained as knowledge about affordance, pedagogy, content, learners, and context which is synthesized into an understanding of how specific topics that are difficult for students to understand or difficult to display by the teacher can be transformed and taught more effectively with technology which adds value.

The ICT application in the learning process in Indonesia is supported in Kurikulum 2013 that currently applies. Kurikulum 2013 carries a scientific approach. The scientific approach was chosen because of its excellence in helping to develop ways of thinking and working systematically for students. The scientific approach in its implementation can be integrated with research-based learning models, such as discovery or inquiry learning. The learning process by applying those learning models provide opportunities for students to explore information and skills more broadly. Activeness during this learning process that will encourage the integration of ICT in it, while students will seek information not only in the surrounding environment but also through the internet, and communicate both directly and through social media. Howland, et al. [3] explained that technology in the learning
process will make meaningful learning when technology involves students in knowledge construction, conversation, articulation, collaboration, and reflection. Technologies can support meaningful learning when students learn through the use of technology, not from it.

Development model of ICT in Education according to UNESCO [4] consists of four stage, they are emerging (those who have just started their ICT in education journey), applying (those who have developed a new understanding of the contribution to learning), infusing (those who have integrated ICT into existing teaching, learning, and administrative practices and policies), and transforming (those who have used ICT to support new ways of teaching, learning, and administration). There are 3 group countries in South East Asia based that stages. Indonesia is the number of group 2, together with Philippines, Thailand, and Vietnam [5]. Indonesia is mainly at the infusing stage and its already has developed ICT plans and policies in education, but due to the rural-urban gap, there are still some parts of the dimension that is in applying and even emerging stage. That problem occurs because in Indonesia there are still less developed provinces. Among those countries in group 2, Thailand and Vietnam are in a more advanced stage of ICT in education than Indonesia and Philippines.

Data from APJI [6] shows that internet user penetration in Indonesia reaches 143,26 million people. This figure has increased from the 2016 data, where the penetration rate of internet users in Indonesia is only 132,7 million people. The penetration of internet users by age range of 13-18 years old (students) which reaches 75,50%. The data shows that the need for Indonesian people towards the existence of digital information and ICT devices continue to increase and become a primary need.

The dependence of the Indonesian people, especially the younger generation on the internet and other ICT products, needs to be directed towards improving the quality of learning. Considering that ICT in Indonesia's education is still at the middle level and needs to be intensified, the work reviews on ICT literacy studies in the learning process, especially through science learning. The purpose of this literature study is to give an overview to education practitioners of the importance of assessing ICT literacy.

The rest of this paper is organized as follow: Section 2 presents a review on ICT literacy in science learning. Finally Section 3 concludes this work.

2. A Review on ICT Literacy in Science Learning

This section presents a review on ICT literacy in science learning.

2.1 The framework of the 21st-century learning

Learning in the 21st century has changed equip students with certain skills needed to live in this century. Kereluik, et al. [7] describe a 21st-century learning framework that has been synthesized from 15 other 21st-century learning framework, where the framework consists of three main elements namely foundational knowledge (to know), meta-knowledge (to act), and humanistic knowledge (to value). The framework of learning is presents in Figure 1.
The framework of 21st-century learning shows that there are three main components of foundational knowledge, namely core content knowledge, cross-disciplinary knowledge, and digital/ICT literacy. Foundational knowledge is a knowledge that students need to master so they have adequate knowledge. Meta-knowledge is the knowledge of the process to work by utilizing the foundational knowledge already possessed. Meta-knowledge mastery can be seen through creativity and innovation, problem-solving, and critical thinking, as well as communication and collaboration. Humanistic knowledge covers the life and career skills, cultural competence, and ethical/emotional awareness. Humanistic knowledge offers a view of the students themselves and their position in the scope of social and global society.

The 21st-century learning framework gives an overview to education practitioners that the formation of learner's knowledge must be done holistically including mastery of basic knowledge, implementation of knowledge through skills, and mastery of humanistic knowledge. The emphasis on ICT literacy categorized in foundational knowledge provides confirmation that 21st-century learning must support good ICT mastery skills.

2.2 ICT Literacy
The ICT literacy has become a research study of various education experts. The ICT literacy is a foundational knowledge which shows a person's ability to search, organize, and process information effectively from various digital media with a good understanding of technology systems and media forms, while considering moral and ethical values [7].

The ICT literacy is a part of ICT skills characterized by the ability to use technology effectively [8]. The use of technology includes (1) using technology as a tool to search, organize, evaluate, and communicate information, (2) using digital technology (computers), network devices, and social networks to access, manage, integrate, evaluate, and create information to be useful in mastering economic knowledge, and (3) applying a fundamental understanding of ethics and legality when accessing and utilizing information through technology. The ICT literacy according to [9] is the use of digital technology, communication devices, and networks to access, manage, integrate, evaluate, and create information with the purpose of usefulness for society. The ICT literacy combines technical technology processing skills, cognitive skills, and at the same time takes into account the social values within them.

The strong influence given by the development of ICT in the world of education has made ICT literacy adapted in the assessment system in various countries. Australia is a country that has developed the trend of ICT literacy assessment every three years since 2005. The ICT literacy assessment according to Pernia in [10] is based on three main dimensions, namely (a) knowing...
knowledge of technology, (b) relevant skills to use technology, and (c) the addition of an attitude from the reflection of the use of technology. Information about the three dimensions of ICT literacy assessment is more fully presents in Table 1.

| Dimensions | Conceptual Name | Indicators |
|------------|-----------------|------------|
| Knowledge  | Basic knowledge | 1. Accustomed to using smartphone, computer, internet, and other ICT supporters.  
                  2. Having the ability to use ICT support tools.  
                  3. Using the function of ICT in everyday life. |
| Skills     | Technical skills | 1. Having the ability to use applications in ICT equipment  
                  2. Able to access and search through the website  
                  3. Able to use basic internet services  
                  4. Able to search and process an electronic data information  
                  5. Having the ability to convert electronic information into graphic or other visual forms.  
                  6. Using ICT to support critical, creative and innovative thinking skills.  
                  7. Able to distinguish trustworthy or untrustworthy information. |
| Attitude   | Critical assessment skills | 1. Able to use ICT to work individually or collaborate in teams to find solutions to problems.  
                  2. Having sensitivity in using the internet safely and responsibly.  
                  3. Having a critical and reflective attitude when assessing information. |

The ICT literacy assessment framework has been developed as a skill that integrates cognitive skills and technical skills [9]. The integration of these two skills is illustrated in Figure 2. The ICT literacy skills that can be measured are access, manages, integrate, evaluate, and create. The five ICT skills are explained as follows.

a. Access is an activity of knowing what and how to collect and obtain information.
b. Managing is an activity to implement a grouping or classification scheme.
c. Integrating is the activity of interpreting and representing information, including concluding and comparing.
d. Evaluating is an activity to make decisions about the quality, relevance, usefulness, or efficiency of information obtained.
e. Creating means producing information by adapting, implementing, designing, finding, or writing information.

Cognitive proficiency has a relationship with basic skills in everyday life both at school, home, and workplace. Mastery of cognitive skills is indicated by literacy, counting, problem-solving and visual literacy skills. Technical skills are basic components of digital literacy. This skill includes basic knowledge about hardware, application software, networks, and digital technology elements. The integration of cognitive and technical skills forms ICT skills that enable individuals to maximize their technological capabilities. At the highest level, ICT skills will produce innovation, individual transformation, and community change.
Figure 2. The ICT Proficiency in an assessment of ICT literacy [9]

The ICT literacy domain has 6 processes [11], namely:

a. Accessing information. This process includes identifying information and knowing how to find and retrieve information.

b. Managing information. The process carried out is to organize and store information for reuse.

c. Evaluating. Reflecting the use of processes to design and build ICT solutions and make judgments about the integrity, relevance and usefulness of information.

d. Developing new understandings. The process carried out is by creating information and knowledge by synthesizing, imitating, implementing, designing, finding, or writing.

e. Communicating with others. Exchange information by sharing knowledge and making information products that are appropriate to the audience, context, and media used.

f. Using ICT appropriately. Taking ICT decisions that are critical, reflective, and strategic, and using ICT responsibly by considering social issues, legality, and ethics.

The six processes are included in three parts, namely working with information, creating and sharing information, and using ICT responsibly.

The understanding of ICT literacy from various sources above has a common view. The ICT literacy is a process of utilizing information and communication technology to access, manage, integrate, evaluate, and create information that can benefit the community while still considering the ethical values and legality in it. The aspect of assessment ICT literacy can combine aspects from various sources because based on the analysis that has been carried out, these aspects have similarities and suitability. Synthesis of ICT aspects that can be assessed through learning presents in Table 2.

| The indicator of ICT literacy assessment from [10] | Assessment Aspect from [9] | Assessment Aspect from [11] | Aspect synthesis |
|-----------------------------------------------|----------------------------|-----------------------------|-----------------|
| 1. Able to access and search through the website | Access                     | Accessing information       | Information access |
| 2. Having the ability to convert electronic information into graphic or other visual forms. | Manage                     | Managing information        | Manage information |
| 3. Able to distinguish trustworthy or unreliable information | Evaluate                  | Evaluating                  | Evaluation      |
| 4. Having a critical and reflective attitude when assessing information. | Create                    | Developing new understandings | Create          |
| 5. Using ICT to support critical, creative, and innovative thinking skills. | Communicating with others  | Communication               |                 |
| 6. Able to use ICT to                           |                            |                             |                 |
work individually or collaborate in teams to find solutions to problems.

7. Have the sensitivity to use the internet safely and responsibly.

Using ICT appropriately

2.3 ICT Literacy in Science Learning

Learning is a change that lasts long in behaviour or in the capacity to behave in a certain way, where the behaviour is obtained through practice and other forms of experience [12]. Learning has three main characteristics, namely involving change, lasting over time, and going through the experience.

Science in the context of learning is expected to be a vehicle for students to learn themselves and the surrounding environment. [13] explains that science learning is expected to provide knowledge (cognitive), skills (psychomotor), scientific attitudes, habits, and appreciation. Learning that emphasizes on giving meaningful experiences by exploring and understanding the environment needs to be emphasized in order to achieve a comprehensive science learning goal. Learning that supports these goals can be done through the application of various learner-centred learning models. Learning models recommended by the Ministry of Education and Culture through Kurikulum 2013 to support 21st-century learning include project-based learning (PjBL), problem-based learning (PBL), inquiry, and discovery learning.

The learning framework in the 21st century is also required to implement digital-based learning. Learning requires the interaction between teachers, students, and digital technology. The implementation of technology in learning is supported by the ICT-TPCK thinking framework proposed by [2]. The ICT-TPCK is explained as knowledge about the device and affordance, pedagogy, content, learning and the context that is synthesized into an understanding of how specific topics in learning that are difficult for students to understand or difficult to convey by teachers can be transformed and taught effectively through the media technology that can simultaneously increase its value becomes more meaningful. Various researches in education that integrate ICT in the learning process have been carried out. Here are some of these studies is shown in Table 3 below:

| No. | Article Title, Author, & Journal | Year | Substance |
|-----|---------------------------------|------|-----------|
| 1   | The Development of Inquiry by Using Android-System-Based Chemistry Board Game to Improve Learning Outcome and Critical Thinking Ability [14] | 2017 | Students are more challenged by difficulty in playing a game rather than facing the difficulty in understanding the lesson. This research aims to develop a suitable digital game based on Android system. The game can improve learning outcome with n-gain factor 0.703 and critical thinking ability in the good category. |
| 2   | The Development of Enrichment E-Module with Growth and Development of Living Things Topic to Enhance Independent of Learning and Learning Achievement [15] | 2016 | Development of e-modules is carried out to provide material enrichment on the topic of growth and development of living things. E-modules that are developed are suitable for use in learning, proven to be effective in increasing independence, and learning outcomes of students. |
| 3   | The Development of Moodle based Learning Media in Basic Physic Course [16] | 2017 | The research was conducted to develop Moodle-based Basic Physics learning media. Development is done online and offline. The results of expert validation show that the |
The researches that have been studied have implemented ICT in the learning process, but the assessment that focuses on ICT literacy has not been done. The ICT literacy assessment is very important to do because not all young people can learn by themselves how to behave appropriately and take care of themselves when using digital technology [18]. The step of monitoring these competencies is important to emphasize, especially in the school context.

The aspects contained in the ICT literacy assessment are things that are contained in the science learning process. Managing information, creating, and communicating results is a competence that is the focus of the science learning process because it can support the mastery of students' concepts. Howland, et al. [3] supports the process of inquiry by applying technology, from searching for references through the internet, discussing online, to evaluating the work of students. The learning process with the inquiry model is indeed one of the science learning models that can be integrated with ICT.

Banchi and Bell in [19] classifies inquiry from the lower level to the top into 4 groups, namely inquiry confirmation (confirmation inquiry), structured inquiry, guided inquiry, and open inquiry (open inquiry). Kirschner, et al. [20] revealed that the inquiry applied in science learning for students needs to be given by considering teacher guidance appropriately because the learning model is based on constructivism prone to misconceptions that can actually make students confused and frustrated. Joyce, et al. [21] explain that the syntax of inquiry learning models consists of stages (1) identification and determination of the scope of the problem, (2) investigation planning and outcome prediction, (3) investigation to collect data, (4) data interpretation, (5) drawing conclusions, and (6) reflection. The integration of ICT literacy that can be reviewed in the inquiry-based science learning process is presents in Figure 3.

| Inquiry Syntax | The aspect of ICT Literacy |
|----------------|---------------------------|
| Determination of inquiry questions | Access and manage information through digital devices and internet networks |
| Investigation plan | Access, manage and evaluate information; create; communication |
| Investigation | Use of digital tools to support data collection |
| Data interpretation | Access, manage and integrate information; create; communication |
| Conclusion | Information evaluation; create; communication |
| Reflection |                                       |

The research was conducted to develop Moodle-based Basic Physics learning media. Development is done online and offline. The results of expert validation show that the products developed are suitable for use in the learning process. The media developed also received a positive response from students.
In the science learning process, the ICT literacy assessment must be in accordance with what is done by students. [18] explained that the ICT literacy assessment instrument must be able to identify the actual actions and practices of students and measure authentic technology involvement. The ICT literacy assessment has consequences to continue to be developed because of the rapid technological changes. Development of ICT literacy assessment instruments needs to be done to support good ICT literacy mastery.

3. Conclusion

ICT literacy is an important competency in the 21st-century learning framework and Kurikulum 2013. The ICT literacy becomes something that needs to be emphasized to be mastered and assessed using certain instruments. The ICT literacy assessment can be done through science learning. The development of ICT literacy assessment instruments needs to be carried out and continuously updated because of the rapid technological changes that occur.

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