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The 21st Century Science Learning: HOTS and Digital Literacy Junior High School Students in Semarang, Indonesia

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ABSTRACT

The 21st-century skills was broadly discussed in all sectors. It challenges education to equip next generation with all important skills to face the digital technology transformation. The focus of this study was to identify profile of student's higher-order thinking skills (HOTS) and digital literacy among junior high school students in science learning. Mixed method, a combination of quantitative and qualitative was used in this study. A total number of 170 of grade 7th students in private and public junior high school in Semarang City were administered in the integrated science test (IST). IST were used to measure student's HOTS through constructed-multiple choice test. 17 science teachers were the key informant of HOTS and digital literacy in science learning. Rasch model and descriptive analysis used to identify HOTS and digital literacy based on gender and type of school. The results reveal that : (1) most of junior high school students HOTS performace were at low slight to moderate level (2) female students performs better than male students in HOTS, (3) type of school significantly impact on students' achievement, and (4) teachers' operation and thinking skills as basic skill of digital literacy were still unsufficient to provide digital-based learning. However, it is necessary to accustom implementation of HOTS assessment as well as digital technology in the science learning environment.

Key words: 21st-century learning, Digital literacy, HOTS, Rasch, Integrated science test

Introduction

The 21st-century education characteristics are student centered, collaborative learning, contextual, and social issues orientation (Amran, Ananda, Festiyed, & Sumarmin, 2018). Education orientation was to develop students' skills through relevant complex experience so they can solve the problem in the real world (Saido, Siraj, Bakar, Nordin, & Saadallah, 2015). Education should prepare the students to meet the community and industrial criteria (Heong et al., 2011; Shukla & Dungsungnoen, 2016). The advancement of technology in the 21-st century and disruptive era transforms learning environment into digital-based learning to enganged students in active and creative learning (Setuju, Setiadi, Ratnawati, Widowati, & Wijayanti, 2018).

The 21st-century education emphasizes the digital literacy (Dewi, Wardani, Wijayati, & Sumarni, 2019) and higher order thinking skills (HOTS), especially in science education framework (Balakrishnan, Nadarajah, Vellasamy, Gnanam, & George, 2016). Rapid changing of digital technology challenge the educators utilized it to achieve the learning goals (Setuju et al., 2018). Interaction of technology and pedagogy provides fundamental aspects of content delivery (Chua, Jr, Reading, Doyle, & Gregory, 2017). Interactive digital learning media implementation and virtual environment through e-learning are one of most strategy used by teacher to improve digital literacy and HOTS (Dewi et al., 2019).

It is difficult to define digital literacy since many study discussed about it. In the disruptive era, literacy are evolve into digital or ICT based. Ability to use digital technology to collect analyze and evaluate information was the basic definition of digital literacy (Acar, Alabbasi, Runco, & Beketayev, 2019). It is implies that digital literacy focus on mastery the technology device. Techataweewan & Prasertsin, (2018) define the digital literacy in four aspects that is operation, thinking, collaboration and awareness skills. The terms of thinking skills and collaboration skills in this definition similar to HOTS in digital-based.

Many reseachers explain about student HOTS level broadly through their developed assessment instrument in specific subject matter (Abosalem, 2016; Hamdi, Suganda, & Hayati, 2018; Serevina, Sari, & Maynastiti, 2019). The limitation of those studies are not in the integrative science approach and doesn't meet the digital era characteristics. The previous research was carry out the development of IST in order to measure junior high school students level of HOTS in integrated approach (Widiyawati, Nurwahidah, & Sari, 2019). This instrument provides HOTS definition of PISA framework and Marzano. It is urgent to measure students' level of HOTS to profile the students and describing which competency are need to improve based on integrated science approach. The teacher digital literacy in science learning is also need to discover since it is contributes to improve students' HOTS in digital based learning. Therefore, this research was focus on identifiy the profile of junior high school students HOTS and digital literacy in science learning.

Materials and Method

Participants

This research were carry out in Semarang City during 2019-2020. Mixed-method design (Creswell, 2013) was used in this research to provide comprehensive information about HOTS and digital literacy of junior high school students in science learning. A total number of 170 students of grade 7th in Semarang, Indonesia were participate on paper and pencil test to investigate their profile of HOTS. All students had been studied science topics provided in the test. The demographic data of the students can see in Table 1.

Interview technique were used to collect furthermore information about HOTS and digital literacy of students. A total of 6 science teachers of junior high school in Semarang City were administered in interview session with open-ended questions about HOTS, digital literacy, project based learning, and e-learning. Online questionnaire to the 17 science teacher were

used to support the information gathered. These quetions also used to triangulate students' HOTS from test.

Table 1. Students Demographic

Demographics	N	Percentage (%)
Gender		
Male	82	42.8
Female	88	57.2
School Category		
Private	128	75.3
Public	42	24.7
Total	170	100

Instrument

Integrated science test (IST) developed by Widiyawati, Nurwahidah & Sari (Widiyawati et al., 2019) were used to measure students HOTS in the science topics for grade 7th. IST is combination of constructed response and multiple choice so that students should give their best reason and explanation to response each items served. This type of test is an alternatives to reveal students' logical and reasoning thinking (Ku, 2009; Scully, 2017) as well as HOTS. The answer categorized into 3 level, 0 for false choice and reason, 1 for true choice or reason, and 2 for true choice and reason. IST consist of 35 items based on PISA framework (OECD, 2018) combine with Marzano HOTS indicators (Heong et al., 2011). Three main competecies of IST are (1) explain scientific phenomena; evaluate and designing scientific investigation; and (3) interpreting the data. According to Rasch analysis of IST with 170 participants, 15 items are not fit with the model and indicate that the item must be delete to acquire the accurate calculation. The final IST consist of 10 items of explain scientific phenomena, 3 items of evaluate and designing scientific investigations and 8 items of interpreting the data and evidence scientifially. The map of final IST competency, indicator and item code provide in Table 2.

Table 2. The map of IST HOTS competencies and indicators

Competency	Indicator	Item Code
Explain scientific phenomena	Remembering and using appropriate scientific knowledge to solve the problem	AA1, AA2, AA3, AA4, AA5, AA6, AA7
	Formulate hypotheses	AB1, AB2
	Make an appropriate prediction	AC1
Evaluate and designing scientific investigations	Select an observable scientific questions	BA1
	Designing a procedure to solve the problem scientifically	BB1, BB2
Interpreting the data and evidence scientifially	Change the data representation form	CA1, CA2
	Analyzing and interpreting data as well as make a correct conclusion	CB1, CB2
	Identifying assumption, evidence and reason based on sceintific problem served	CC1, CC2
	Argument classifying based on scientific and non-scientific evidence as well as theory	CD1, CD2

Open ended questions in interview session used to investigate students' HOTS and digital literacy in science learning. HOTS indicators in this research define as IST indicators combine with 4C (creativity, critical thinking, collaboration and communcation skills) (NEA, n.d.). Digital literacy indicators in this research adopted from Techataweewan & Prasertsin (2018) which is consist of four main aspects: operation, thinking, collaboration and awareness skills. Science teacher as a respondent were asking the following indicator of questions:

1. The importance of digital literacy,
2. Science teachers' and students' digital technology operating skill,
3. Information gathering skills through digital technology,
4. Frequency of using technology to enhance science learning effectivity,
5. Science teacher skill in develop digital learning media,
6. Strategy to improve students digital literacy,
7. Ethical awareness importance for teacher and students,

8. Impact of digital technology implementation towards HOTS,

Data Analysis

WINSTEPS software were used to analyze the HOTS profile based on Rasch model. This software transformed the 3 scale of IST score (polytomous) into logarithm function namely log odd unit (logit) which is give equall interval to meet measurement criteria (Adams, Sumintono, & Mohamed, 2018; Sumintono & Widhiarso, 2014) and assess the person fit (students' ability) as well as overall instrument fit (Bond & Fox, 2015; Sihombing, Naga, & Rahayu, 2019). The characteristic of IST based on Rasch analysis provided in Table 3. Independent t-test were used to investigate difference HOTS based on gender whereas Mann Whitney were used to test effect of type of school towards students' HOTS based on non-parametric statistics.

Table 3. IST Characteristic

	Mean	*S.D*	*Separation*	*Reliability*
Item	0.00	0.79	5.52	0.97
Person	-0.46	0.85	1.32	0.63

Result and Discussion

This research is conducted to investigate (1) the profile of junior high school students' HOTS based on gender and type of school difference, and (2) the digital literacy importance in science learning.

Students' HOTS Profile

Low of index separation in HOTS measuring indicates that students are not accustomed with this kind of test or the items are too difficult for them. In the other hand, item index separation >2.00 which means test takers comes from all levels of ability.

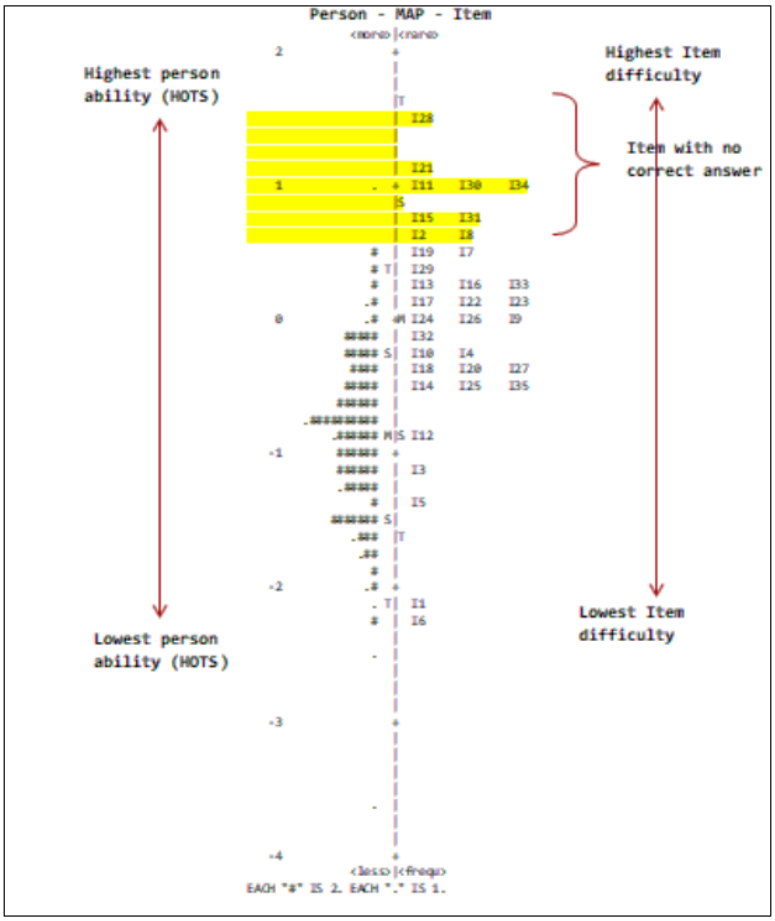

Figure 1. Person map item of initial IST (35 items)

Students HOTS in this research were analysed through Rasch model. In the initial IST with 35 items, a total of 9 items are too difficult and students can't answer it (see Figure 1). One of those is item I21 which assess the ability to design a procedure to solve the problem scientifically (see Figure 2). In this case, students are expected to analyze the given problem and solve it into experimental design. Students need to provide appropriate materials and tools in order to obtain effective inquiry.

21. Based on the research, wavelength of red and blue rays in sun light are the most effective rays for photosynthesis. Experimental materials required to investigate it are.....
    A. LED lamps, fertilizer, *Zea mays* plants in different size, dark and bright rooms, thermometer
    B. *Zea mays* plants in equall size, plastic pot, soil from the same source, dark and bright room, thermometer, Ohause scale
    C. Different colored of lamps, *Zea mays* plants in equall size, plastic pot, soil from the same source, lux meter, caliper, ruler
    D. Lamps, *Zea mays* plants in equall size, caliper, ruler.

Figure 2. I21 of initial IST

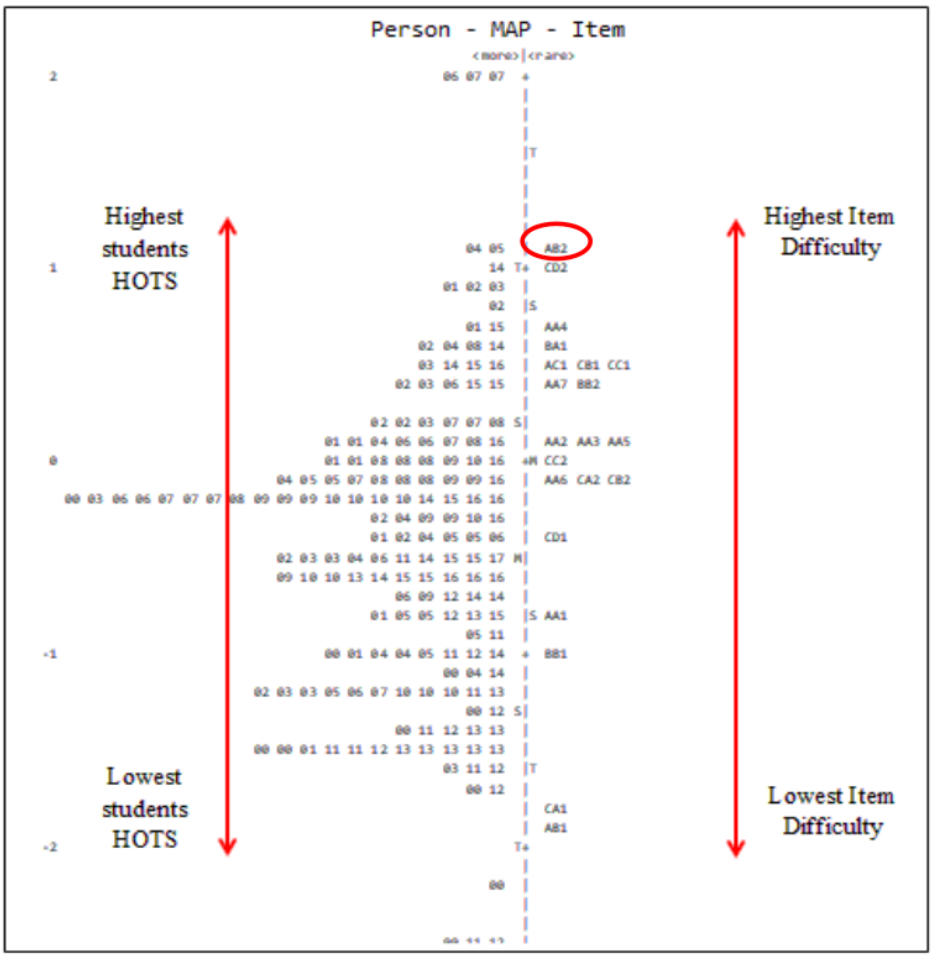

Figure 3. Person map item of IST (21 items)

According to the Figure 3, the most difficult item is AB2 which is assess the ability of student to formulate the hypotheses. This item provide an article about *Pognoa vitticeps*

thermoregulation and illustration of color changing of its body in warmer environment. Students need to analyze the facts provided and connect each other in order to create the correct hypotheses. They also have to be able explain their argument in conscructed response. Integrated approach in sub-discipline of science i.e physics, biology and chemistry promotes the comprehensive and in depth thinking because connect to the real world context (Amran et al., 2018). Integrative learning process conduct the direct experience of students so they can discover and construct their concept holistically, actively and meaningfully (Wiyanto & Widiyatmoko, 2016). Integrated approach involving students into an experience in which give an opportunity to enhance their think skills. Figure 4 show the HOTS level of students through integrated approach in IST.

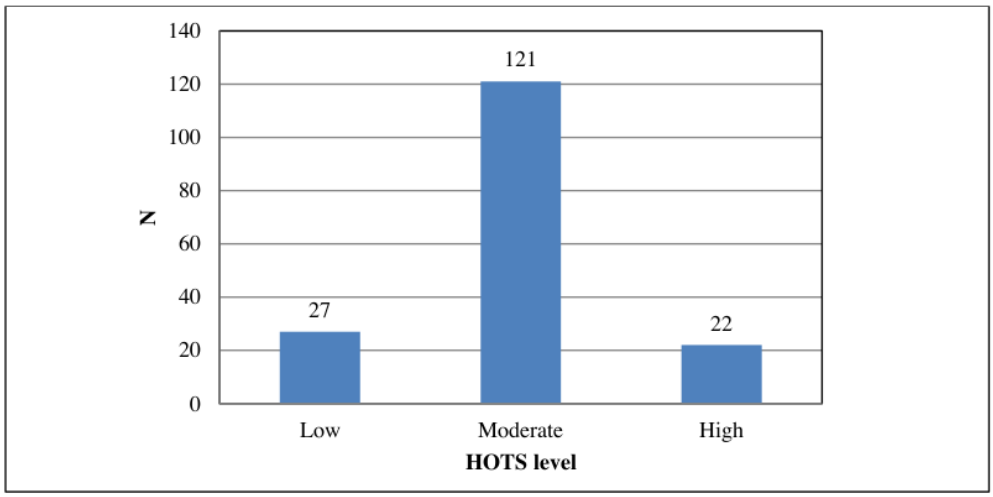

Figure 4. HOTS level of junior high school students

Students HOTS are low slight to moderate level according to the Figure 4 since they're not train regularly to think deeply and apply the science concepts into reality. However, teacher performace were the key factor to provide HOTS during learning process. According to the interview, science teacher education background in term of physics and biology are an obstacle for them to develop proper HOTS acitivies and materials integratively. They face many problems due to their limitation of mastery the biology, physics and chemistry

knowledge (Rubini, Pusitasari, Ardianto, & Hidayat, 2018). Teacher perception about HOTS were also different with the ideal condition expected by the curriculum.

Most of Indonesian science teachers were not able to create their own standardised HOTS assessment. The lack of knowledge of teacher about whole concept of HOTS impact on HOTS implementation during learning process (Retnawati, Djidu, Apino, & Anazifa, 2017). They need to attending the proper training programme to foster their skills in develop science HOTS assessment (Abdullah, 2017).

Difference HOTS level based on Gender and Type of School

Independent sample t-test were performed to establish the difference of HOTS based on gender. Output of WINSTEP in logit were calculate through SPSS. There is significant difference of HOTS performance in IST between female and male students' (*sig. 2 tailed p-value* = 0.012), with female Mean score = -0.3069 (N=88) and male Mean = -0. 6332 ($p<$ 0.05). Female students' performance in IST express HOTS better than male students.

Mann Whitney test were examine difference HOTS level of public school and private school students. Non-parametric statistic used since the samples not meet the homogenity data assumption. The results show that public school students HOTS score better than private one. There is significant difference relatef to type of school.

This finding align with Sihombing et al., (2019) research in which show the difference achievement according to the gender and type of school. Abdullah, (2017) is also show that dmeographic factor of gender contributes to the difference of knowledge and practice of HOTS.

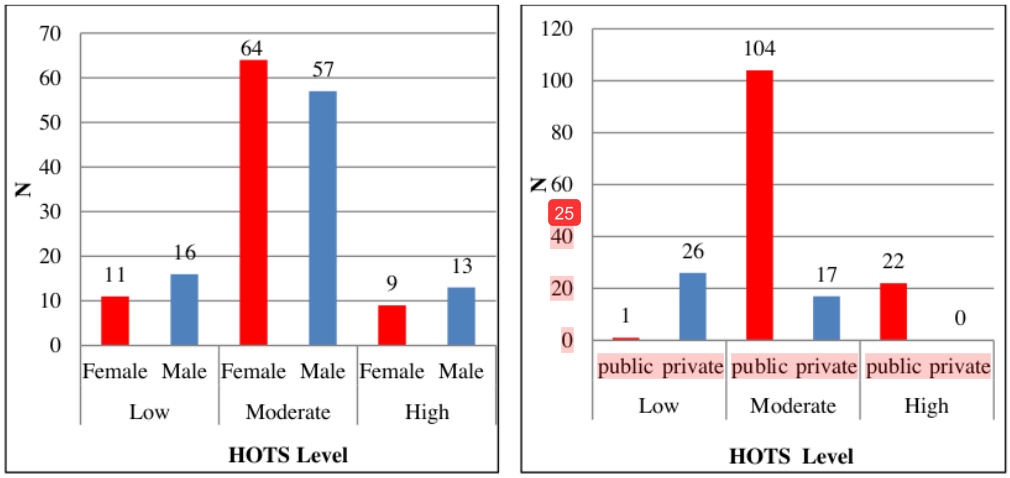

Figure 4. difference of HOTS level based on gender (left) and type of school (right)

Digital Literacy in Science Learning

Rapid changing of the nature of generation-z in digital consumption necessary to underline. Skills to operate, thinking and evaluate the up to date digital technology found in various aspects of live are vital for young learner (Pangrazio, 2016). The content analysis of digital literacy, interview session and online questionannaire result were used to explore digital literacy of science teacher in the learning process. Digital literacy definition by Techataweewan & Prasertsin (2018) were adopted that is consist of operation, thinking, collaborative and awareness skills to meet the junior high school learning needs. Thinking and collaborative skills were included in the 4C as the other definition of HOTS. Deep exploration about teacher knowledge and performance in digital technology implementation necessary to do since it is contributes to enhance students thinking ability.

The 6 science teacher as key informants in this research comes from public and private school in Semarang, Indonesia. The interview session and online questionnaire filling conducted before COVID-19 pandemic. The first deep question ask about internet accessibility and frequency of used to the private school science teacher. Here some of the answer from science teacher:

> "*This school have computer labs and students can access internet through school wifi facilitation. But sometimes, students are allows to access materials or information through their gadget to support learning during my class, of course I have to control the utilization.*"

Other science teachers from public school state that accessibility of internet in their school is good since the National Examination was held in computerized. In contrast, science teacher from one private school stated that her school wasn't have the computer labs and there's no access to the internet. An open ended questions lead teacher to share wide explanation about their digital technology implementation experiences as well as e-learning, here some summary of the interview session:

> *" I have used e-learning to support my learning process. I also use some of (Learning Management System) LMS for example is schoology, google classroom. Sometimes I use this LMS to give an assignment so student can access it through their gadget from home. I have take several training programme to use Moodle because our school are mandatory to use it."*

This informant is a young teacher and have a good performance in operation skills to use digital technology. He also use any kind of digital source from internet to support his learning as well as allowing student to do so. It is contrast with another teacher from the same school that not obtaining well operation skills.

In this research, online questionnaire was used to support the data from interview session. Online questionnaire were asked science teacher to define the digital literacy and its importance through several certain indicators, and teacher are let to choose one or more indicators according to their knowledge. All teacher inform that digital literacy is very important to gain effective science learning. Digital literacy definition according to the science teacher knowledge presented in the Figure 5.

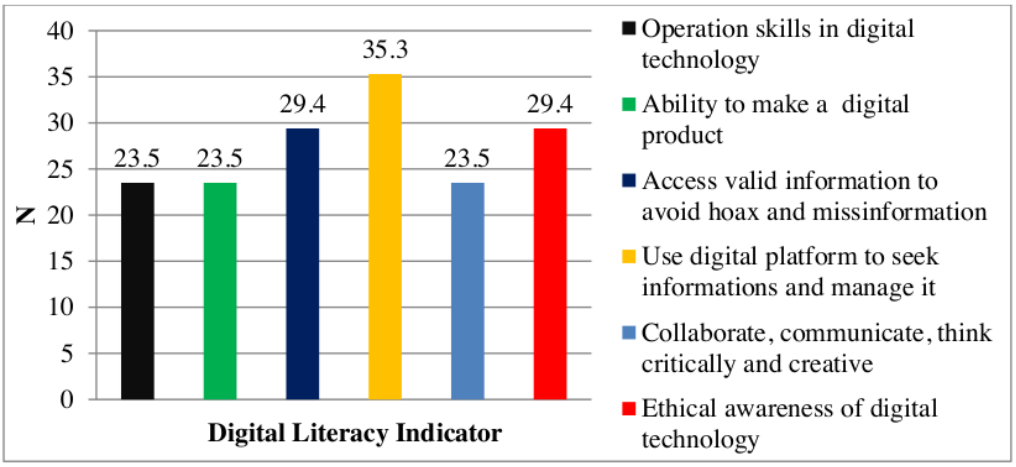

Figure 5. Digital literacy definition based on its indicator

Teacher are unfimiliar with digital literacy terms in the interview session, thus the question are rearrange and directly expressed the indicators of digital literacy. Each of four aspects of digital literacy that is operation (e.g operation skills, ability to make digital product), thinking (analysis and access valid information to prevent hoax as well as missinformation), collaboration (collaborate, communicate, think critically and creative to share information through digital platform) and awareness skills (ethical awareness skills) divide into specific indicators (see Figure 5). None of teacher has their own explanation about digital literacy and some of which define the digital literacy as thinking skills, followed by ethical awareness, operation skills and collaboration skills. The teachers conception about explore and manage information through digital platform are the most popular for digital literacy definition since in this disruptive era information spread so fast and sometimes relate to "hoax". Hsu, Wang, & Runco, (2012) research showed that middle school teachers were most confidence with the basic digital skills e.g operating computer, manage document, followed by thinking skills (collaboration, communication, problem solving) and digital information related. Integration of Information and communication technology (ICT) brought learning to meet the 21st

century requirements so academic community are necessary to enhance the mastery of digital literacy (Lestari & Prasetyo, 2019).

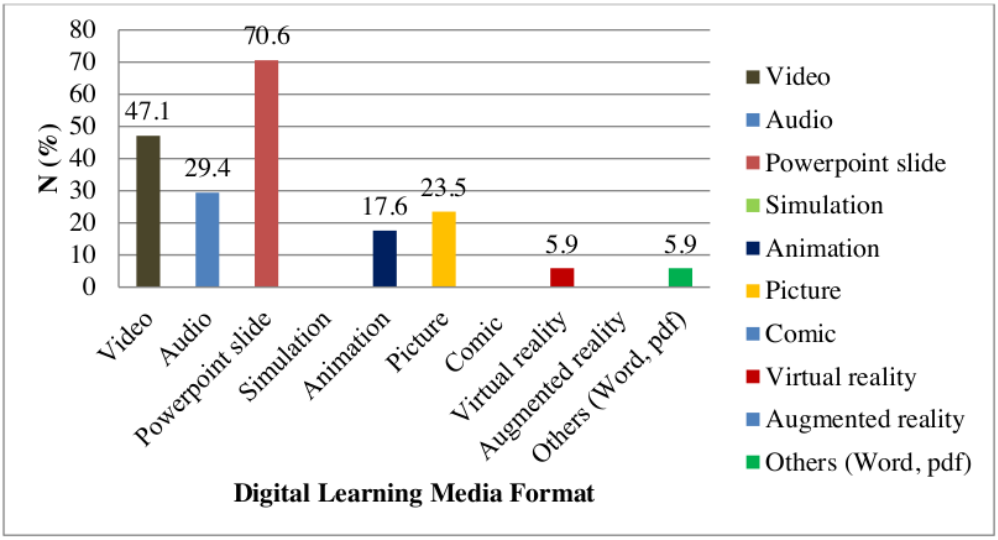

Figure 6. The digital learning media format frequently used by science teacher

The next question was about teacher skills to use variuous kind of digital format of learning media regarding to the presentation skills acording to the digital literacy definition (see Figure 6). Powerpoint slide, video, and audio are the most popular digital learning media format used by teacher contrast with simulation, comic as well as augmented reality. It seems that most of the teacher has no adequate information and invention skills ralate to the up to date learning media such as comic, simulation, and mixed reality (virtual reality and augmented reality).

Young students are immersive in digital world and have the good ability to use digital technology and often namely digital natives (List, 2019). They must be accomodate with appropriate task or learning process in vairous digital format by competence teachers. It is important for teacher to upgrade their skills according to the digital media utilization. ICT utilization shift the educational paradigms into new face of learning environment, and it is expected not only as the teaching aide. If teachers have no sufficient compentency to engange

student in the revolution of education, students will left behind in the traditional learning environment (Steiner, 2017).

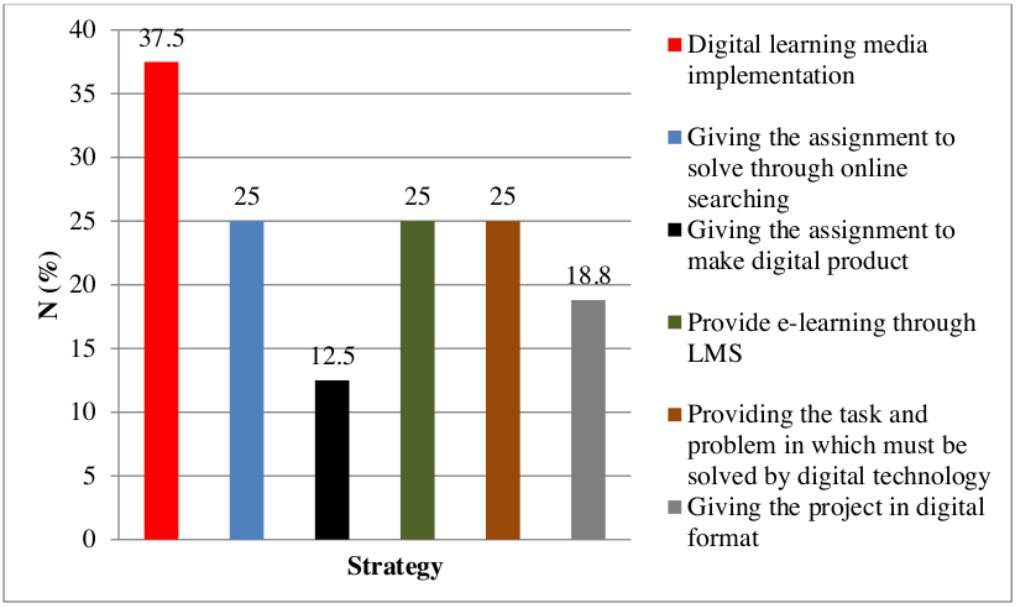

Figure 7. Effective strategy to improve students' digital literacy

In the online questionnaire teacher also asked about the effective strategy to improve students' digital literacy as present in the Figure 6. The total 35.5% of science teacher belief that digital learning media impelementation will enhance students' digital literacy whereas only 12.5% of science teachers give an assignment to the student to make a product using digital technology. Teachers ability to make a learning media in digital format (see Figure 5&6) relates to their belief in appropriate strategy to enhance students digital literacy. The academic qualification and teacher competence standards emphasize the digital literacy as fundamental skill so that teachers must encourage students to get use with this term. Based on the interview result, teacher developed student's digital literacy on science learning by giving the task about simple practice. For example, in the science object and its observation topic, teachers ask the student to take measurements using measuring instruments at home, such as

a ruler, weighing scale, thermometer. Students are asked to take photos of the measurement process carried out and describe the measurement results.

One of 21-st century learning requirement is digital-based in which propose TPACK about technology, pedagogy, concent mastery (Lestari & Prasetyo, 2019). Digital technology integration into scince learning promotes many benefit and improve students comprehension (Güne & Bahçivan, 2018) since they can discover, analyze and use many appropriate resources from the internet. Traditional paradigms transforms into modern with digital learning media in which engaged student into teacher-student interaction on virtual learning. Students became active, independent learner and addresing better HOTS performance through e-learning environment. Teacher necessary train their digital literacy as well as content knowledge tend to comprehensive science learning goal.

Conclusion

This research was focus on the investigating students' profile of HOTS based on gender and type of school as well as digital literacy in science learning. According to the analysis of Rasch model and result of the research, it can concluded that (1) students HOTS were at low slight to moderate level, (2) there significant difference of HOTS level between female and male students, (3) public school students perform better in HOTS than private school students, (4) teachers operation and thinking skills as indicators of digital literacy were at low level thus they can't provide appropriate strategy to enhance students digital literacy. It is recommends to explore deeper about factors impacts on teachers digital literacy related to appropriate learning media production.

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