Revisiting Generic Science Skills as 21st Century Skills on Biology Learning

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ABSTRACT

The purpose of this study was to describe the generic skills of students' science who conduct experiments on biology learning grade VIII Junior High School (SMP) in Batusangkar. This study used a descriptive quantitative design. The variables of this research are generic science skills as 21st century skills and students achievement. A total of 295 students were used as populations and the purposive sampling technique was used to select one class as sample of research (n=32 students). Student activities, such as a direct observation, awareness of scale, logical framework, cause-effect, modeling, and the inference was observed by 6 observers. This activity was designed and adapted based on generic science skill and 21st century skill. The percentage of students achievement and generic science skill score was analyzed with descriptive statistics. The student's achievement showed that all students are achieved, with a mean score > 75. The mean score of generic science skills of students is determined as: very good, good and sufficient, and all students were complete the learning. The highest (very good) students perform was on modeling activities with the average percentage of 87.49%. The result indicate that the skills are considered to be part of generic science skill and 21st century skills. The results of this study concluded and suggest the need to re-visit and reaffirm the use of term generic science skills in biology learning, because this skill becomes part or similar to 21st century skill

Keywords: generic science skill, 21st-century skill, biology learning

INTRODUCTION

At years 2010-2018, research on 21st skills was reported by many researchers, such as an investigation of 21st century learners' competencies in China (Cai et al., 2017), teachers' actual and preferred perceptions of twenty-first century learning competencies (Sang et al., 2018), and comparative study about inventive thinking skills in science between students in Malaysia and Brunei (Muhammad & Osman, 2010). Jia et al. (2016) and Ercikan & Oliveri (2016) conducted development and validation of the instrument of 21st century student skill. Boyer & Crippen (2014); Bell (2010); and Duran et al. (2011) conducted the study of the use of certain methods in learning to bring up 21st century students' skills in science classes. In other explanations, the studies listed above show that 21st century skills are a "hot" topic in education of science (Geisinger, 2016) besides the research about nanotechnology and graphene in pure science (Umar et al., 2013; Umar et al., 2103; Umar et al., 2107; Umar et al., 2018). Because 21st century skills required by students to perform their activities in the future (Larson & Miller, 2011), or 21st century skills are beneficial to their lives after graduation (Kaufman, 2013).

In others, the studies about the 21st century skills in learning has also reported by many researchers. For example, the study about assessing and teaching 21st century skills in science has reported by Griffin (2017), and the use of evaluation in 21st century learning has reported by DiCerbo (2014). In others, the study of 21st century skills in information technology is reported by Lambert & Gong (2010); and Fry & Seely (2011). Sibille et al. (2010) conducted research about preparing physicians for the 21st century, and Jang (2016) have identifying 21st century STEM competencies using workplace data. These of the study indicate that 21st century skills are important skills to be given to students in learning and its have to include at curriculum.

But, before the 21st century skill becomes a research trend, research on generic skills and/or science process skills is also a "hot" topic education studies, especially in the field of science learning. Ambross et al. (2014) investigated the implementation and development of science process skills in the natural sciences. Koksal & Berberoglu (2014) investigated the effect of guided-inquiry instruction on 6th grade turkish students' achievement, science process skills and attitudes toward science. Durmaz & Mutlu (2017) investigated the effect of an instructional intervention on elementary students' science process skills. Coil et al. (2010) investigated effective methodology in teaching the process of science. Stone (2014) investigated faculty perceptions and an effective methodology in teaching the process of science. Walters & Soyibo (2010) conducted a study of high school students' performance by applying the integration of five science process skills. Colley (2010)

conducted study about understanding ecology content knowledge and acquiring science process skills through project-based science instruction. Savitri et al. (2017) has conducted enhancement of science students' process skills through implementation of green learning method (GeLeM) with conservation-based inquiry approach.

There are also researchers who conduct the study of generic skills. For example, the study conducted by Jääskelä et al. (2016). This study examines the models for the development of generic skills in finnish higher education. Mulyani et al. (2016) has investigated students' generic skill in science through chemistry learning using ICT-based media on reaction rate and osmotic pressure material. Badcock et al. (2010) conducted developing generic skills through university study. Rhee & Kim (2012) conducted differential pathways to generic skills development of male and female college students in Korea. Natoli et al. (2014) investigated the impact of instructor's group management strategies on students' attitudes to group work and generic skill development. Joseph et al. (2015) investigated relationship between student development activities and core generic competencies among tertiary science and technology students. Cecilia et al. (2017) conducted a review of literature on challenges in the development and implementation of generic competencies in higher education curriculum. The results of this review is shown that there are some generic skills that have been applied in universities examined such as leadership and communication, collaboration and teamwork, globalization and cultural awareness and entrepreneurship. The results of this review is also shown that there are some generic skills that important skills to achieved by students.

The above explanations show that generic science skills are similar to or part of 21st century skills. These explanations is also show that a study about revisiting generic science skills as 21st century skills is important to conduct in learning. In this study, we describe generic science skills in biology learning. Prior to the research, we made a comparison of the generic skill written by George (2011) and 21st century skills written by Greenstein (2012). The comparison results are summarized in Table 1.

Table 1 Comparison of Generic Skill and 21st Century Skill

Generic Skills (George, 2011)		21st Century Skill (Greenstein, 2012)	
Main Skills	Focus Skill	Main Skills	Focus Skill
Thinking	reasoning, critical thinking, creative thinking	thinking	creativity, critical thinking, problem solving and metacognition
computation	following instructions, arithmetic, spatial ability	acting	communicating, debate, collaborating, digital literacy and technology literacy
communication	speech, reading, writing, listening, expression	living	civics and citizenship, global, leaderships and responsibility, work ethic, college/career/workplace, flexibility/adaptability and initiative/motivation
problem solving	analyzing, decision making, applying, verifying		
independent learning	study habits, planning, research, evaluation		
information processing	technology, multimedia awareness, using library		
team management	discussing, cohesion, commitment, cooperation		
self-management	knowing self, managing time, using resources		

Table 1 explains that the main skill of thinking is found in generic skill and 21st century skills. Other skills that are also found in both groups of skills are critical thinking, creative thinking, problem solving, communication, technology and cooperative (colaboration). While living skill with focused civics and citizenship skills, global, leadership and responsibility, work ethic, college or career or workplace, flexibility/ adaptability and initiative or motivation are only found in 21st century skills.This explanations also show that generic science skills are similar to or part of 21st century skills. These explanations is also show that a study about revisiting generic science skills as 21st century skills is important to conduct in learning.

Teaching and learning science in Junior High School in Indonesia to providing students with experiments that contain both skill groups, the generic skill and 21st century skills. To prove this, we

conducted research on the application of generic science skills to science learning in junior high school. So that it can be explained that the problem in this study is that junior high school students in Indonesia have conducted science experiments that contain generic science skills and or 21st century skills in learning biology. The purpose of this study is to describe the generic skills of students' science who conduct experiments on biology learning in grade VIII of junior high school (SMP). The experimental topic is about the motion of living things. Generic science skills of students are observed in experiments of the effect of stimulation on motion on *Mimosa pudica* and analyzing the motion of animals based on the structure of the body and its mass. This study uses a scientific learning approach. In the aspect of skills, scientific learning has stages observing, asking, trying, reasoning, testing and creating (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 22 of 2016).

METHODS

This study is descriptive quantitative (Creswell, 2014). The variables in this study are generic science skills and students achievement. Generic science skills of students are observed and recorded by observers by using observation sheets. These skills are in the form of direct observation, awareness of scale, cause, modeling, logical framework and inference. The population in this study were 295 students in grade VIII Junior High School (SMPN) 1 Batusangkar, West Sumatra. We used purposive sampling technique by taking one class with the number of 32 students.

The instruments used were observation sheets and experimental guides. The observation sheets are used to observe students' generic science skills. The student's experimental guide contains experimental procedures and work sheet. In this study, we adopt the instrument that it has designed and developed by Rahman (2008) and Brotosiswoyo (2001). The activities in this instrument are direct observation, awareness of scale, logical framework, causal-effect, modeling and inference. After the adaptation and theoretical analysis, it was found that the six activities were classified into thinking and skill problems based on the grouping of 21st century skill (Greenstein, 2012) and generic skills (George, 2011). Comparisons of 21st century skills, generic skills and skills based on observed student activity are summarizes in Table 2.

Table 2 Comparison of 21st Century Skills, Generic Skills and Student Activities Observed in Experiment of Motion in Living Things

21st Century Skill (Greenstein, 2012)		Generic Skills (George, 2011)		Student Skill Observed (Rahman, 2008; Brotosiswoyo, 2001)	
Main Skills	Focus Skill	Main Skills	Focus Skill	Skill	Students Activity
Thinking	creativity, critical thinking, problem solving and metacognition	Thinking Skills	reasoning, critical thinking, creative thinking	direct observation	observe and reveal the characteristics of the object with the senses by using the tool or not using the tool
				awareness of scale	using size, quantity and unit and compare objects to one another
				logical framework	group by criteria
		Problem Solving Skills	analyzing, decision making, applying, verifying	cause-effect	explain, link or determine treatment and treatment results
				modeling	performing a particular demonstration or activity to be emulated and describing the data obtained or vice versa
				inference	make conclusions based on observations

The observation sheet was tested for content and construct validity prior to used. The instrument is concluded valid after being assessed by the 4 validators. Then, we revised the instrument based on the suggestion of the validators. The result of validation test show that this instrument is valid with mean score 3.35 (at 1-4 assessment scale) (Creswell, 2014). There are several suggestions from the validator team to revise the instrument are we must revise the research guidelines and the use of instrument language. Both of these suggestions have been accepted for the improvement of research instruments. Then, to test the internal consistency, an instrument reliability test has been performed. Instruments are tested to students who are not samples of the study. The instrument reliability test results show that the instrument has sufficient reliability value with Alpha

value is 0.595>0.355. So it is concluded that this instrument is valid and reliable, and so it can be used to collect data when the research is done.

To collect the data, students are divided into 6 groups of practical work. Prior to the implementation of the experiment, each student was coded with numbers to facilitate the observer in the assessment of each student's activity. The experimental sub-topic of motion in living things done by students is the effect of stimulation on motion on the *Mimosa pudica,* and animal motion based on the structure of the body and its mass. During the experiment, students fill out the student activity sheets in the student book. Generic science skills generated by students are observed and written by observer at the observation sheet. Each group was observed by one observer (n observer = 6 people). Observers are a team of researchers and already have a common understanding of the generic skills science observation procedure. At the end of the learning process, we conducted post-test to determine students achievement and its completeness. To analyze the data, the percentage of generic science skill score was assessed based on criteria: 86-100 (very good); 76-85 (good); sufficient (60-75); less (55-59); very less (55-59) and less once (≤54). Score of students achievement was analyzed with descriptive statistics.

RESULTS AND DISCUSSION

In this study, the student answers the question and write it in the worksheet. For example, on observation of the effect of stimulation to close/open the leaves of *Mimosa pudica*, students perform experimental activities based on the following questions and student answers.

Question 1: What are you trying to do?
Student answers: close and open the leaves of Mimosa pudica.
Question 2: What do you think?
Student answers: (a) Mimosa pudica leaves when touched will be closing
(b) Leaves of Mimosa pudica when given cold excitatory will be closing
(c) Leaf Mimosa pudica when given hot stimuli will be closing
Question 3: What do you provide?
Student answers: (a) Mimosa pudica plant (live)
(b) Ice wrapped in plastic
(c) lighted lighters or candles
(d) stopwatch or timers
Question 4: What are you doing?
Student answers:

(a) *To treat Mimosa pudica as follows; (1) touching it by using the fingertips at the top of the leaf surface; (2) touching it using a fingertip on the petiole; (3) giving cold temperatures by laying ice cubes beneath the leaf surface; (4) gives the heat temperature by placing a flame or a burning candle*
(b) *Observe the motion of leaves and stems of Mimosa pudica*
(c) *Record the speed of plant response to excitatory using stopwatch*
(d) *Repeat steps 1-3 in part a (3 times)*
(e) *Recording the observed data*

Treatment	Time (minute)		
	1st round	2nd round	3th round
	Close at	Close at	Close at
touched on leaf surface	01.43	01.52	01.55
touched on petiole	03.03	03.01	03.04
given cold temperature on beneath the leaf surface	03.14	03.10	03.15
given hot temperature on beneath the leaf surface	06.56	07.02	07.06

Question 5: What do you concluded?
(a) *How does Mimosa pudica respond when given a touch stimulus on the leaf surface?*
Student answer: leaves Mimosa pudica closes and opens in a very short time.
(b) *How does Mimosa pudica respond when given a touch stimulus on the petiole?*
Student answer: leaves Mimosa pudica closes and opens with a short time
(c) *How does Mimosa pudica respond when given cold stimuli?*
Student answer: leaves Mimosa pudica closes and opens for a long time
(d) *How does Mimosa pudica respond when given hot stimuli?*
Student answer: leaves Mimosa pudica closes and opens in a very long time
(e) *Which part is the most sensitive to the touch stimulator?*
Student answers: the most sensitive part of the touch plan is the leaf surface
(f) *Is the response speed different from the different stimuli?*
Student answers: yes, this type of stimulus has a different response speed.

(g) *What can you conclude based on the above activities?*
Student answers: Part of Mimosa pudica plants that are most sensitive to excitatory are the leaves and the slightly sensitive part is the petiole. The most immediate stimuli affect the motion of closing and opening the leaves of Mimosa pudica is a touch.

Observers have made observations based on the question and student answers. the question and student answers have illustrated that students have generic science skills. For example, *Question 1 "What are you trying to do?"* and *Question 2 "What do you think?"* and students' answers to these two questions indicate that students have cause-effect skills. *At Question 4 " What are you doing?"* and students' answers at *(4a) "To treat Mimosa pudica as follows; (1) touching it by using the fingertips at the top of the leaf surface; (2) touching it using a fingertip on the petiole; (3) giving cold temperatures by laying ice cubes beneath the leaf surface; (4) gives the heat temperature by placing a flame or a burning candle"* and students' answers at *4(b) "Observe the motion of leaves and stems of Mimosa pudica"* shows that students have direct observation skills. And student answers at 4(e) "*recording the observed data"* show students have awareness skills about scale. *At Question 5 "What do you concluded"* and students' answers at 5(a), 5(b), 5(c) and 5(d) shows that students already have modeling skills. Students' answers at 5(e) dan 5(f) shows that students already have logical framework skills, and students' answers at 5(g) shows that students already have inference.

The results of observations on generic science skills of students shows that the highest mean score of student generic science skills in motion experiments on living organisms was found in modeling skills with mean score is 87.49% (very good). The lowest means score were found at direct observation skills and awareness with mean score are 74.3% (sufficient) and 71.17% (sufficient). The data of the generic science skills scores of the students in experimental motion on living things are summarized in Table 3. Post-test scores of students achievement on experiment of motion materials in living organisms showed that all students (n=32 students) is achieved, with mean score > 75. This result indicates that all students complete the learning.

Table 3 Scores of Generic Science Skills Students on Experiment of Motion on Living Things

Experiment Group	Percentage Scores of Generic Science Skills of the Students					
	Direct Observation	Awareness of Scale	Logical Framework	Cause-Effect	Modeling	Inference
1	89.58 %	62.50 %	95.83 %	97.91 %	95.83 %	75.00 %
2	70.83 %	41.67 %	79.16 %	72.91 %	83.30 %	70.83 %
3	64.58 %	72.91 %	70.83 %	83.30 %	79.16 %	79.16 %
4	67.70 %	83.33 %	75.00 %	70.83 %	83.33 %	79.16 %
5	66.14 %	66.66 %	70.83 %	68.75 %	83.33 %	75.00 %
6	86.97 %	100.00 %	83.30 %	81.25 %	100.00 %	95.83 %
Σ	445.80 %	427.07 %	474.95 %	474.95 %	524.95 %	474.98 %
Mean	74.30 %	71.17 %	79.15 %	79.15 %	87.49 %	79.16 %
Category	sufficient	sufficient	good	good	very good	good

In this study, students who conduct the experiment systematically indicate that they have observed directly skill. Students who record time is needed the *Mimosa pudica* leaves will be close or open after stimuled, indicating that they have awareness of scale skill. Students distinguish about the types of stimuli was given to the *Mimosa pudica* indicating that they have a logical framework skill. The students which explain and distinguish the cause of closing /open *Mimosa pudica* leaves indicate that they have cause and effect skill. The students write in data in the form of about time is required by *Mimosa pudica* to close/open after being given a stimuli indicate that they have modeling skill. The explanations shows that students who carry out experiments have generic science skills.

The students perform very good on modeling activities. Modeling activities in experiment of motion in living thing is to perform a particular demonstration or activity to be copied and to describe the data obtained or vice versa. These findings indicate that students has done and having generic skills. If it refers to the generic explanation of science skill written by George (2011), the students already have the main skills is problem solving and focus skills: analyzing, decision making, applying and verifying. These finding is also indicate that students having 21st century skill with main skill is thinking, and focus skill is problem solving.This finding is consistent and in line with

explanation of Greenstein's (2012), that as 21st century skill, thinking skill devide to critical, problem solving, creativity and metacognition.

These arguments show that science learning in Indonesia at the junior high school level has actually provided the students with 21st century skills. The findings of this research have proved that learning objectives covering the sphere of attitudes, knowledge and skills have been graduated into a variety of skills in activities core learning. On the standard of the process, the objective of learning aspects of the skills must meet the activities of observing, asking, trying, reasoning, testing and creating (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 22 of 2016).

Another argument to explain that the findings of this study is also the implementation of detailed gradation of attitudes, knowledge and skills in accordance with the standard of educational process in Indonesia is a series of research activities using scientific approach principles, discovery / inquiry learning and project based learning. This is based on the explanation of the researcher who can be seen in the research results. In this section it has been explained that students perform experimental activities based on a series of questions. These questions show that there are scientific approaches, discovery / inquiry learning and project based learning in experimental activities. The experimental sequence also demonstrates the skill of the science process.The results of this study show that the existence of generic skills becomes part of the science process skills that have been conducted and owned by students. Because students doing and having the problem solving and thinking skills. Based on other research findings, both skills are the most important and become part of the science-process skills chosen by the teacher to be given to students (Molefe & Stears, 2014). In other studies it was also explained that generic skills became the most important skill for students (Joseph et al., 2015).

Some 21st century skills in Gray & Koncz's article is leaderships, ability to work in a team, written communication skills, problem-solving skills, strong work ethic, analytical/quantitative skills, technical skills, communication skills (verbal), initiative, computer skills, flexibility/adaptability, interpersonal skills, detail oriented, organizational ability, strategic planning skills, friendly/outgoing personality, enterpreneurial skills/risk-taker, tactfulness dan creativity (Gray & Koncz, 2014). The results of the study in other articles also explain the same results that the thinking and problem solving to be part of the 21st century skills. For example, Greenstein (2012) explains that the 21st century skills are thinking, includes creativity, critical thinking, problem solving and metacognition; working, involves communication and collaboration; information and technology literacies are the tools for working and citizenship, life skills, and personal responsibility are necessary for living in the world. In another article explained that some 21st century skills are needed by students in learning, the skill is problem solving, reasoning, collaboration, self regulation (Ahonen & Kinnunen, 2015).

Based on the results of this study, we consider that the findings of this study indicate and imply that generic science skills similar to 21st century skills. These skills must be possessed by students after learning in science class room. These skills can be generated by students with the help of teachers. Teachers should use certain learning methods to help students have those skills. Because biological learning materials require certain ways to learn it. So the skill required by students in the material can be given by the teacher. For example, computer-assisted learning on spermatogenesis (Haviz, 2018), critical thinking skill on biology (Tiruneh et al., 2016), visual knowledge skill in biology (Kinchin, 2011), cooperative skill on developmental of biology (Haviz, 2015), integrated learning skill on developmental of biology (Haviz, 2016), educational research on biology (Haviz, 2018), teacher-students dialogue on biology (Kinchin, 2010). Because the success of learning science done by the students determined the achievement of skills and students achievement, especially generic science skill and 21st century skill.

CONCLUSION

In this study, students who experiment on motion in living things have done and have activities of direct observation, awareness of scale, logical framework, causality, modeling and inference. The highes (very good) students perform was on modeling activities with average percentage of 87.49% indicating they have generic science skill and 21st century skills. Post-test scores of students achievement showed that all students is achieved, with mean score > 75. This result indicates that all students complete the learning. The results of this study concluded and

recommeded to revisit and reaffirm the use of term generic science skills in science learning, especially in biology learning, because that skill becomes a part of or similar to 21st century skill.

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