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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 conducted experiments on biology learning grade VIII Junior High School (SMP) in Batusangkar. This study used a descriptive quantitative design. The variables of this research were generic science skills as the 21st-century skills and students achievement. A total of 295 students were used as the populations and the purposive sampling technique was employed to select one class as the research sample (n=32 students). The 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 the generic science skills and 21st-century skills. The percentage of students' achievement and generic science skills score was analyzed with descriptive statistics. The students' achievement showed that all students were successful, with a mean score > 75. The students' generic science skills mean scores was categorized as: very good, good and sufficient, and all students were completed the learning. The highest (very good) performance was on the modeling activities with the average percentage of 87.49%. The results indicated that the skills were considered to be part of generic science skills and 21st-century skills. The results of this study concluded and suggested the need to revisit and reaffirm the inclusion of generic science skills in biology learning because this skill becomes part of or similar to the 21st-century skills.

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 the 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., 2017; 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).

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Moreover, the studies about the 21st-century skills in learning have also reported by many researchers. For example, the study of assessing and teaching 21st-century skills in science has been investigated by Griffin (2017), and the use of evaluation in 21st-century learning has reported by DiCerbo (2014). Furthermore, 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.

However, before the 21st-century skill becomes a research trend, research on generic skills and/or science process skills is also a "hot" topic in 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) pointed out the effect of guided-inquiry instruction on 6th-grade Turkish students' achievement, science process skills and attitudes toward science. Durmaz & Mutlu (2017) studied 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) elucidated 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 a study about understanding ecology content knowledge and acquiring science process skills through project-based science instruction. Savitri et al. (2017) have enhanced science students' process skills through an implementation of green learning method (GeLeM) with conservation-based inquiry approach.

There are also researchers who conducted the study of generic skills. Jääskelä et al. (2016) examined the models for the development of generic skills in Finnish higher education. Mulyani et al. (2016) have investigated students' generic skill in science through chemistry learning using ICT-based media on reaction rate and osmotic pressure material. Badcock et al. (2010) developed the 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) examined the relationship between student development activities and core generic competencies among tertiary science and technology students. Cecilia et al. (2017) carried out a review of the literature on challenges in the development and implementation of generic competencies in the higher education curriculum. The results informed that there are some generic skills that have been applied in universities such as leadership and communication, collaboration and teamwork, globalization and cultural awareness and entrepreneurship which are important to be achieved by students.

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

Table 1. The Comparison of Generic Skills and 21st-Century Skills

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	Cmmunicating, debate, collaborating, digital literacy and technology literacy
Communication	Speech, reading, writing, listening, expression	Life	Civics and citizenship, global, leadership 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 the 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 both in generic skills and 21st-century skills. Other skills found in both groups are critical thinking, creative thinking, problem-solving, communication, technology, and cooperative (collaboration). While the living skill focusing on the 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 indicate that generic science skills are similar to or part of 21st-century skills. These explanations also show that a study of revisiting generic science skills as 21st-century skills is important to conduct in learning.

Teaching and learning science in Junior High School in Indonesia should provide students with experiments containing both skill groups; the generic skill and 21st-century skills. To examine this matter, the researchers conducted a research on the application of generic science skills to science learning in junior high school. The aroused research problem was; how do the junior high school students conduct science experiments covering the generic science skill and/or the 21st-century skills in learning biology? The purpose of this study was to describe the generic skills of students' science who conducted experiments on biology learning in grade VIII of junior high school (SMP). The experimental topic was about the motion of living things. The students' generic science skills were observed during the experiments of the stimulation effect on the motion of Mimosa pudica and analyzing the motion of animals based on the body structure and its mass. This study employed the scientific learning approach. In terms of skills, the 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 was descriptive quantitative (Creswell, 2014). The variables in this study were the generic science skills and student achievement. The students' generic science skills were observed and recorded by observers using observation sheets. These skills were in the form of direct observation, scale awareness, cause and effect, 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 the observation sheets and experimental guides. The observation sheets were to observe the students' generic science skills. The students' experimental guideline comprised experimental procedures and worksheet. The instruments were adopted from Rahman (2008) and Brotosiswoyo (2001). The activities consisted of direct observation, scale awareness, logical framework, causal-effect, modeling, and inference. After the adaptation and theoretical analysis, it found that the six activities were classified into thinking and skill problems based on the grouping of the 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 summarized in Table 2.

Table 2. The Comparison of 21st-Century Skills, Generic Skills and Student Activities Observed during the 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	Observing and revealing 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	Grouping by criteria
		Problem Solving Skills	Analyzing, decision making, applying, verifying	Cause-effect	Explaining, linking or determining treatment and treatment results
				Modeling	Performing a particular demonstration or activity to be emulated and describing the data obtained or vice versa
				Inference	Drawing up conclusions based on observations

Prior to use, the observation sheet was tested for its content and construction. The instruments were declared valid after being assessed by 4 validators. Then, the researchers revised the instruments based on the validators' suggestion. The validation test results informed that the instruments were valid with a mean score of 3.35 (at 1-4 assessment scale) (Creswell, 2014). There were several suggestions from the validator team to revise the instrument, research guidelines and language. All of the suggestions have been accepted for the improvement of the research instruments. Then, to test the internal consistency, the instrument reliability test was performed. The instruments were tested on the students who were not the research sample. The instrument reliability test results showed that the instrument owned sufficient reliability value with the Alpha value of 0.595>0.355. Therefore, it concluded that the instruments were valid and reliable.

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

RESULTS AND DISCUSSION

In this study, the student answered the questions and wrote it on the worksheets. For instance, during the observation of the stimulation effect on closing/opening the leaves of *Mimosa pudica*, the students performed experimental activities based on the following questions and student answers.

Question 1: What are you trying to do?
Student answers: closing and opening the leaves of Mimosa pudica.

Question 2: What do you think?
Student answers: (a) Mimosa pudica leaves close when you touch it.
(b) Mimosa pudica leaves close when given cold excitatory
(c) Mimosa pudica leaves close when given hot stimuli

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) Treating the Mimosa pudica; (1) touching it using the fingertips at the top of the leaf surface; (2) touching it using the fingertips on the petiole; (3) giving cold temperatures by laying ice cubes beneath the leaf surface; (4) giving the heat temperature by placing a flame or a burning candle
(b) Observing the Mimosa pudica leave and stem
(c) Recording the speed of plant response to excitatory using stopwatch
(d) Repeating steps 1-3 in part a (3 times)
(e) Recording the observed data

Table 3. The Example of Students' Record during the Observation

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

Question 5: What are your conclusions?
(a) How does Mimosa pudica respond when given a touch stimulus on the leaf surface?
Student answer: The leaves of 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: The leaves of Mimosa pudica closes and opens in a short time
(c) How does Mimosa pudica respond when given cold stimuli?
Student answer: The leaves of Mimosa pudica closes and opens in a longer time
(d) How does Mimosa pudica respond when given hot stimuli?
Student answer: The leaves of 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 each stimulus?
Student answers: yes, this type of stimulus has a different response speed.
(g) What can you conclude based on the above activities?
Student answers: The most sensitive part to excitatory are the leaves while the slightly sensitive part is the petiole. The most immediate stimuli affecting the motion of closing and opening is a touch.

The observers have made observations based on the question and student answers. the question and student answers have illustrated that the students owned the generic science skills. The students' answer to the Question 1 and 2 indicated that they have acquired the cause-effect skills and their answers at the 4a and 4b described their direct observation skills. Furthermore, the students' answer at the 4e showed their awareness of the scale. In addition, the students' answer at the 5(a), 5(b), 5(c) and 5(d) pointed out their modeling skills, while the answer of 5(e) and 5(f) indicated logical framework skills. Finally, the answer of 5(g) elucidated the students' inference skills

The observation results on the students' generic science skills informed that the highest mean score was found in the modeling skills, 87.49% (very good). The lowest means score were found at the direct observation skills 74.3% (sufficient) and awareness 71.17% (sufficient). The data of the students' generic science skills scores in experimental motion on living things are summarized in Table 3. The post-test scores of the students' achievement on the living organism motion showed that all students (n=32 students) succeeded in having the mean score > 75. This results indicated that all students completed the mastery learning.

Table 4. The Scores of Generic Science Skills on the Experiment of Living Things Motion

Experimental 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

The students carrying out the experiment systematically indicated that they have acquired the direct observation skills while those recording time needed during the experiment showed that they got the scale awareness. Moreover, the students distinguishing the stimulus types elucidated their logical framework skills. Additionally, the ability to explain the cause of the closing/opening of the Mimosa pudica leaves showed the students' cause and effect skills, and their activity of recording the data indicated the modeling skills. Therefore, it was said that the students have got the generic science skills.

The students performed very well during the modeling activities. The modeling activities in the experiment were to hold a particular demonstration or activity to describe the obtained data. These findings made clear that the students have got the generic skills. When referring to the generic explanation of science skills written by George (2011), the students already had the main skills of problem-solving, focusing, analyzing, decision-making, applying and verifying. These findings also elucidated that the students acquired the 21st-century skills of thinking, focusing, and problem-solving skills. This is in line with the explanation of Greenstein's (2012), that as the part of 21st-century skills, thinking skills were divided into critical, problem-solving, creativity and metacognition.

The above explanation informed that science learning in Indonesia at the junior high school level has actually provided the students with 21st-century skills. The research findings have proven that learning objectives covering the aspect of attitudes, knowledge, and skills have been accomplished through a variety of skills in the core activities. In accordance with the established standard, the learning should cover the observing, asking, trying, reasoning, testing and creating activities (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 22 of 2016). This research was a true implementation of Indonesia's 2013 Curriculum covering the aspect of attitude, knowledge, and skills realized through the series of activities containing the scientific approach principles, discovery/inquiry, and project-based learning. The activities also demonstrated the generic science skills which belonged to the science process skills.

Some 21st century skills in Gray & Koncz's (2014) article are the leadership, teamwork, written communication skills, problem-solving skills, 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, entrepreneurial skills/risk-taker, tactfulness dan creativity (Gray & Koncz, 2014). Furthermore, Greenstein (2012) explained that the 21st-century skills of thinking include creativity, critical thinking, problem-solving and metacognition, communication, collaboration, information, and technology literacies are the tools for working. On the other hand, the citizenship, life skills, and personal responsibility are necessary for everyday life. Referring to Ahonen & Kinnunen (2015), some 21st-century skills needed by students in learning are problem-solving, reasoning, collaboration, self-regulation (Ahonen & Kinnunen, 2015). Therefore, the researchers agreed that the findings of this study indicated the similarity between generic science skills and the 21st-century skills. These skills must be possessed by the students after learning in the science classroom, also, could be generated by the students with the help of teachers. Thus, teachers should make use of certain learning methods to help students acquire those skills. Some aids or methods that a teacher could adopt in their science class are the computer-based game (Annetta et al, 2009), critical thinking skills on biology (Tiruneh et al., 2016), visual knowledge skills in biology (Kinchin, 2011), cooperative skills on biology (Haviz, 2015), integrated learning skills on biology (Haviz, 2016). A good teacher should know what the students need, therefore, s/he has to conduct an educational mini research in her/his class (Schenzel, 2013) and optimize teacher-student dialogue (Kinchin, 2010).

CONCLUSION

The students have done several steps during the experiment on living thing motion which comprised the generic science skills in the form of direct observation, scale awareness, logical framework, cause and effect, modeling, and inference. The highest score was on the modeling having an average percentage of 87.49%. The post-test scores showed that all students have passed the mastery learning having the mean score > 75, indicating that they have acquired the generic science skills which are part of the 21st-century skills. Therefore, the researchers suggested that the educators revisit and reaffirm the generic science skills in science learning, especially in biology learning.

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