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**INTEGRATED MEASUREMENT OF STUDENTS'S ANALYTICAL THINKING
SKILLS AND SCIENCE PROCESS SKILLS****Irwanto*, Nugraheni, S., Puspita, A.R., Astuti, S.R, Prasetyo, Y.D.***Department of Chemistry Education, Graduate School of Yogyakarta State University***E-mail: irwan_uny@yahoo.com***Abstract**

The learning of chemistry which becomes increasingly complex in the 21st century demands the students to develop a number of cognitive as well as psychomotoric skills throughly. There are skills which students have to master such as analytical thinking skills and science processing skills. However, in reality, there are many obstacles faced by the teachers to measure those two variables. Therefore, a test which is able to measure the ability of the students both in cognitive and psychomotoric and to optimize the potency of the students is needed. The objective of this study is to solve the problem of assessment in chemistry learning which only measures thinking skills on lower level and gives little attention on science processing skills of students. The interview results conducted towards chemistry teachers in several SMA/MA in Yogyakarta, show that the teacher have not been fully assessed in correct manner in practical learning process. On the other hand, one of competencies which teachers must possess is to develop assessment instruments. Moreover, there are a lot of learning results, instruments used by the teachers which have not been able to measure the students analytical thinking skills and science processing skills effectively and efficiently. A good assessing instrument is an instrument which is able to develop the students's ability to solve the problems, to find solutions, as well as to increase their analytical thinking skills through chemistry learning based on science processing skills. Therefore, the measurement of analytical thinking skills and science process skills of the students integratively has to be conducted to embrace the demand of 21st century chemistry learning.

Key words: measurement, analytical thinking skills, science process skills

INTRODUCTION

Assessment is a very important thing in learning process. Assessment will be meaningful in learning process if the result of assessment being used and followed up correctly by the teachers (Muhson et al., 2015). Assessment has to be more than a test of final learning process, and so has to be integrated part of a learning that capable to inform, guide, and increase the learning result of students (Purnomo, 2013; Isandespha, 2013). This is appropriate with Pantiwati's research (2013) as explained that assessment is capable to increase students's cognitive ability in school. So that learning process and learning result assessment are two components that can't be separated.

Learning result assessment aims to evaluate students's result attaining, thoroughly from cognitive dimension (knowledge), affective dimension (attitude), also psychomotor

dimension (skill). One of the learning activities that can train the students to develop their three competencies is practicum activity in laboratory (Sunyono, 2008). Practicum activity requires process skills approach, because through skills process, students are able to solve the problems, so students will discover and develop the fact, concept, and scientific developing (Jelita, 2013).

Subali (2011) explained that science process skills are cognitive skills that can be measured using written test. One kind of written test assessment is commentary question. The excess of commentary question is capable to measure various aspects of students's science process skills, so that commentary question possessed potency to be developed as science process skills instrument (Fatmawati, 2013).

Students's learning result assessment on cognitive and psychomotor dimension are often found problems. A problem that is often to be occurred for example, teachers choose the form of class assessment without considering about how would they assess and what would they assess (Wenno, 2010). Beside that, science process skills assessment haven't be done by teachers optimally. Based on the results of Suwandi's research (2011) that teachers's capability in preparing and doing assessment aren't enough, even so there are many teachers that don't have sufficient understanding about assessment system.

Presentation of questions that dominantly using short answers that are only limited by knowledge, understanding, and application will make used of students's ability to solve low level cognitive questions (Sastrawati et al., 2011). Yet in the 21st century, students are demanded not to only have lower order thingking, but extended to the capability of higher order thingking (Istiyono et al., 2014). Beside that, learning results instrument that used by teachers for daily tests or used by schools for general tests haven't fulfilled the conditions as a good test (Mardapi et al., 2011).

Based on that explanation, there is a need to measure analytical thinking skills objectively all including various science process skills aspect in chemistry practicum learning in laboratory. This is because the laboratory activities are effectively able to develop intellectual ability, scientific inquiry, and students's skills in solving problems (Hastuti, 2014).

DISCUSSION

Chemistry Learning on 21st Century

21st century is a new era of science development in every sector. The challenges of 21st

century that more and more complex are affected problems on lowering cultural awareness and quality of education problems. Every problem needs solution through learning. Slameto (2003: 2) expressed that learning is a process or effort that did by someone to obtain a new change of behavior as a result of his own experiences in interaction with his environment. That behavior changes are:

- a. Conscious changes, someone that is learning, will sense the changing that is occurred inside himself;
- b. Continuous and functional changes in learning, an occurred changes inside someone that will cause next or another changes and it is useful for his life or the next learning process;
- c. Positive and active changes in learning, more and more effort to learn the more and better changes he will get. Active means that changes won't be happen by itself, but it is because of that individual's effort;
- d. Non temporary changes, behavior that occurred after learning will be permanent;
- e. Changes in purposed and focused learning, behavior changes are occurred because there are goals to be achieved;
- f. Changes included all behavior aspects, if someone learned something he will experience behavior changes thoroughly in attitude, skill, knowledge, and etc.

Meager (Sumiati & Asra, 2009: 10) explained that the purposes of learning are intention that was communicated through statement that describes about changes that are being expected by students. Futhermore, Daryanto (2005: 58) explained that the purposes of learning are intention that describes knowledge, ability, skill in the form of observable and measurable behavior.

21st Century is a civilization that needs competency to be able to interact with other people and to work in a group. The characteristic of 21st Century in the world of education is development of technology and science that needs to be supported by adequate skills. Trilling & Fadel (2009: 48) explained that the main skills that need to be develop to face againts 21st Century, are:

- a. Problem solving skills;
- b. Communication and collaboration skills;
- c. The skills to be active, innovative, and to equip himself with science;
- d. Creative and analytical thinking skills.

Analytical Thinking Skill

Fauziyah et al. (2013) described that analytical thinking as a thinking skill that should be using a logical approach towards a single answer. Logical-analytical thinking is often to be called as convergent thinking, it is because this thinking method has tighten tendency and aimed a single answer. Kind of questions that have the capability to analyze are often being used to measure students's high level cognitive skills based Bloom's taxonomy. Bloom et al. (1956: 18) grouped cognitive taxonomy into six divisions, they are recognition, comprehension, application, analysis, synthesis, and evaluation. Anderson et al. (2001) revised Bloom's taxonomy and divided into six cognitive domains, they are recollect, comprehension, application, analyze, evaluate, and create.

Bloom (Edwards & Briers, 2000) clarified cognitive domain into two divisions, they are higher order thinking skills and lower order thinking skills. Capability that are belonging to lower order thinking skills are included recollect, comprehension, and application. Capability that are belonging to higher order thinking skills are included analyze, evaluate, and create (Anderson et al., 2001: 30).

Analytical skills included the skill to elaborate an information into smaller element with purpose to clarify the meaning (Pardjono & Wardaya, 2009). Therefore, students need to be trained about how they capable to express the reason of relationship of a thing and capable to create structured solution, so that their analytical skills are progressing. This is appropriate with Carr & Sparks's opinion (2011), it is expressed that conscious thinking skills have relatively limited capacity in the brain, so that need to be trained with various scientific approaches. In other words, analytical thinking skills can be trained with exercise. More often doing exercise, students will be more trained in analytical thinking. Learning design that are capable to train students in analytical thinking is through a practicum based chemistry learning. Generally, practicum activities are special characteristic of chemistry learning, so that practicum is inseparable from the chemical learning to obtain laboratory experiences, investigate experiences, attitudes improvement toward chemistry and science process skills (Susilaningsih, 2012).

Science Process Skills

Science process skills are thinking skills that often used by scientists to develop the knowledge of problem solving (Özgelen, 2012). Al-Rabaani (2014) stated that science process skills are capable to improve the knowledge to build students's skills in obtaining and

developing that knowledge. Process skills approach is learning approach which accentuates students's learning process, activity, and creativity in case of obtaining knowledge, skill, value, and attitude (Mulyasa, 2005: 99), along with applying it in daily life (Karsli & Şahin, 2009). Science process skills development enable the students to build and solve problems, critical thinking, also to decide and find the answer of their curiosity (Karamustafaoğlu, 2011).

There are seven kind of skills that are developed through learning activities based on science process skills approach, they are (Hamalik, 1995: 150-151):

- a. Observing; students should be able to use their senses, such as seeing, hearing, touching, smelling, and feeling;
- b. Classifying; students have to be skilled to know the differences and similarities of their observation results of an object, and conduct classification based on specific characteristic, purpose, or particular interest;
- c. Interpreting; students have to own skills to interpret facts, data, informations, or events;
- d. Predicting; students have to own skills to relate data, facts, and informations;
- e. Applying; students have to be able to apply the concepts they have learned and mastered into a new situation or experience;
- f. Research planning; students have to be able to determine the problems and variables which will be studied, the purposes, and the scope of the research;
- g. Communicating; students have to be able to arrange and communicate the report systematically and communicate their results, both learning process or learning results to the other students.

Subali (2011) expressed that the science process skills are cognitive skills which can be measured using written test. The form of written learning result test can be commentary questions or multiple-choice questions. The purpose of learning result test measurement are to obtain informations and students's skills accurately (Bauer, 2000).

Integrated Measurement

According to Allen & Yen (1979: 2) measurement is determining number on the individuals in a systematic way that reflects the nature (characteristic) of the individual. Miller (2008: 2) defined the measurement as quantitative description of students's individual achievement on a single test or multiple tests assessment. Basically, measurement is a number determining activities of an object systematically or related to the finding or

determining process of quantitative values (Mardapi, 2008: 2). Carin (Nasution, 2007) proposed that measure is quantitative observation by comparing it to the standards. In the world of education, as stated by Cangelosi (1995: 21) measurement is the process of collecting data through empirical observation. Therefore, the integrated measurement is the process of collecting data with giving number or value for students in cognitive and psychomotoric dimension can be integrated through learning outcome in integrated assessment. Cognitive dimension in chemistry learning is analytical thinking skills, while psychomotor dimension is science process skills.

CONCLUSION AND SUGGESTION

Based on the results of literature review, it can be concluded that the challenges of chemistry learning in 21st century which is more complex demands the students to develop amounts of cognitive or psychomotor skills. The success of chemistry learning is determined through an integrated measurement of students's abilities and skills. The urgency of integrated measurement in chemistry learning is the key of success of learning process. This is because the measurement is made of effective and efficient combination between students's analytical thinking skills and science process skills. Therefore, in order to prepare young generation with high competitiveness, the chemistry teachers have to applicate the integrated measurement of analytical thinking skills and science process skills at once to solve the problems through chemistry learning.

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