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ANALYSIS STUDENTS' SCIENCE PROCESS SKILLS IN SENIOR HIGH SCHOOL PRACTICUM BASED ON SMALL SCALE CHEMISTRY (SSC)

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Abstract

Experiment is integral part of chemistry. Through experiments, everyone can verify and or find something new as an alternative solution to attract interest in meaningful chemistry learning. Innovative experimental packaging can be done with Small Scale Chemistry (SSC) to establish the importance of understanding and application related to the use of small amounts of reagents and reduce waste produced during chemistry practicum. This study aims to explore and analyze the science process skills of the second semester students of Chemistry Education Study Program, Sanata Dharma University, which focused for chemistry grade 12 in water electrolysis using straws and mini test tubes as physical chemistry's experiment and formation reaction of silver mirror uses vial bottle and mirror media as experiment of organic chemistry. The results show that students' science process skills which includes observation skills with good average score, prediction skills with good enough average score, skills in interpreting data with good average scores, and communication skills with good average score for two kind of experiments conducted. In general, students were enthusiastic in carrying out the two SSC experiments. The students also evaluate the experiments to be able to help develop and improve their soft skills in chemistry learning.

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INTRODUCTION

Chemistry is indeed inseparable from experimental activities. This activity is one of the efforts that can be done to bring closer and attract our interest in chemistry and the surrounding environment. Through experiments, we learn a lot in terms of verifying and proving every chemical phenomenon that we can encounter in life.

In the high school chemistry syllabus in 2013 Curriculum, a number of topics can present practicum as a fun learning method for students. The majority of students like practicum because practicum can open up their better insight into chemistry and its application in life. In this case, practicum is considered to be able to build conceptual understanding of the nature of chemistry that is close to life (Arends, 1990). Experiments activities train students' critical thinking in learning, solving problems, and easier to understand the material in depth (Arif, 2016). Furthermore, practicum in chemistry is also considered capable of developing student process skills because it can provide direct experience for students, so students better understand the importance of the role of practicum in chemistry (Simanjuntak, 2017). Chemistry learning including practicum must integrate the scientific process that occurs in it (scientific method), how to solve problems, concepts, obtain information, and chemistry in life (Susilowati & Hastuti, 2013), so that the skills to be observed in practicum can be measured and achieved.

Research by Ratmini (2017) reveals that the implementation of chemistry practicum in high school is influenced by a number of supporting factors such as lab tools and materials, readiness of teachers and students to carry out practicum, availability of chemical laboratory assistants who can assist in practicum, and sufficient time allocation for practicum.

For chemistry teachers, practicum can be considered as a means to verify things that want to be known further or help students try to explore and discover something new from an experimental design. Through these two methods, practicum can be packed well and always memorable.

Practicum that should have been implemented in high school is not necessarily able to be done by the local chemistry teacher because of limited facilities and costs for purchasing tools and materials needed in practicum. Most equipments and chemicals have high prices, so practicums cannot be implemented, or they may be implemented but not optimal. In fact, chemistry learning with practical methods is needed to understand the chemical phenomena that exist and to link theoretical and practical concepts to build a balance between students' cognitive, psychomotor and affective dimensions.

One solution that can be offered in this case is a Small Scale Chemistry (SSC) practicum, a minimalist practicum concept that seeks to be able to present a simple, interesting, and pleasant chemistry lab. Bradley (1999) & Huang (2007) explain that small scale chemistry is now being adapted and used as a solution to overcome practical activities in schools. Simple equipments and materials, even from the environment can be developed into efficient practicum kits for lab work. This practicum kit is what we can call as one of the appropriate technologies that are innovative and can be developed again as needed while paying attention to the principles of green chemistry, especially those related to the use of reagents and product efficiency. This is what makes small-scale chemistry practicum kits become the main attraction to teach us to use objects around us to be processed into useful items and become learning media that amaze students. This is in accordance with what was conveyed by Zidny et al (2017) which states that making a simple kit for the needs of chemistry labs helps to understand the material for students.

For example, a small scale chemical kit developed by Haryati & Onggo (2016) turns out to be a more efficient media for learning chemical reactions. Furthermore, Redhana & Merta (2017) in their research stated that the green chemistry-based practicum method was more effectively implemented because it was easily obtained from the surrounding

environment and was more environmentally friendly.

Efforts in developing small scale chemistry practicum kits can be carried out from various academic staffs. Chemistry Education Study Program of Sanata Dharma University, Yogyakarta strive to train students through small scale chemistry labs, which someday they will apply in high school when they become chemistry teachers. Burmeister et al (2012) propose that there are at least four types of models that can be used to integrate sustainable development in chemistry education, namely adopting the principles of green chemistry into chemistry education practicums, adding sustainable strategies as chemical education content, using controversial sustainable issues to socio-science issues, and chemistry education as part of school development. Considering these four models, the importance of small scale chemistry practicums is a matter that must be instilled in our students, given the target of continuing to develop sustainable chemical concepts.

In conducting this small scale chemistry practicum, students at the Sanata Dharma University, chemistry education study program, Yogyakarta Indonesia rated their process skills as important experimental skills in science learning such as chemistry. Anggraeini & Hidayah (2016) emphasizes that in chemistry learning, students are not only required to master chemical knowledge as a product, but are able to master products, attitudes, and processes, so that students' science process skills can develop.

This study aims to investigate the science process skills of students in small scale chemistry labs focused on water electrolysis material and silver mirror formation. The benefits that can be obtained from this research are lecturers can analyze the science process skills of students through small scale chemistry practicum which is certainly presented uniquely and students can get the experience of conducting small scale chemical experiments as innovative and creative new insights in fostering a spirit of learning and experimenting with interesting and fun chemistry.

METHODS

The method of this research is descriptive quantitative-qualitative (Creswell, 2012). The subjects of this study were 35 students of Chemistry Education Study Program, Sanata Dharma University, Yogyakarta who participated in two types of small scale chemistry practicum entitled water electrolysis and silver mirror formation in July 2018 and January 2019. The instruments used in this study were student process skills assessment sheets , student response questionnaires in assessing small scale chemistry practicum and posttest chemical process and practicum skills. The final results of each instrument are analyzed qualitatively and quantitatively. The Rasch model is also used to analyze the final results of filling out all research instruments. Sumintono & Widhiarso (2015) stated that Rasch is comprehensive so that it can analyze items up to instruments.

RESULTS AND DISCUSSION

Result and discussion should be presented in the same part, clearly and briefly. Discussion part should contain the benefit of research result, not repeat result part. Result and discussion part can be written in the same part to avoid extensive quotation.

Science process skills are skills that focus on the learning process that aims to develop understanding of concepts (Yang & Heh, 2007). Thus, students will be more focused in understanding the contents being taught. Ozgelen (2012) emphasizes that science process skills are the ability to carry out and direct action in science learning such as chemistry to produce concepts, theories, principles, laws, and facts. For this reason, the role of students as subjects who are active in chemistry classes should not be ignored and must continue to develop students' potential in learning. Furthermore, Gultepe (2013) and Ramig (2012) explain that science process skills include the skill of observing, summarizing, identifying, predicting, giving hypotheses, interpreting data, investigating, and communicating. In this study, measuring the chemistry science process skills of students is only limited to the skill of observing, predicting,

interpreting, and communicating. It should be noted that science process skills in learning are not just about demanding basic scientific abilities, but also related to the characteristics of the science (Hikmah et al., 2018). In this case, students are required to understand the basic and important concepts of chemical material that will be carried out in practicum, so that they can optimize chemical science process skills.

Analysis Students' Science Process Skills in Water Electrolysis Experiments

Electrolysis is an electrochemical cell that is studied by high school students grade 12 in first semester. Practicum using inverted U pipe media to observe chemical phenomena in the cathode and anode is quite often done in a number of schools that are able to present the visualization of electrolysis results. Tesfamariam et al (2014) suggested that small scale chemistry practicum on the topic of electrolysis can improve understanding of students' chemical concepts, the process is fast, easy, and enjoyable.

In July 2018, a small scale chemistry practicum entitled electrolysis was carried out using sodium sulfate solution as an intermediary to show the decomposition reaction of water into hydrogen gas and oxygen. The Brom Thymol Blue (BTB) indicator is dropped into sodium sulfate solution until the solution becomes orange. This practicum uses transparent straw media (two pieces) 0.6 cm diameter to hold sodium sulfate solution which has been pressed by a BTB indicator, then the two straws that stand stable on the wells plate are pierced with a needle and supplied with electricity from the battery. The results of the analysis of students' science process skills are as follows:

1. As many as 91.42% of students have good observation skills in observing discoloration of sodium sulphate solutions which are BTB penetrated in two different straws. The results of the Rasch analysis with Cronbach Alpha values of 0.94 indicate that the reliability of the instrument for assessing student process skills is very good.
2. As many as 82.85% of students are able to predict quite well the color changes of the blue solution occur at the cathode as hydrogen gas and the color of the yellow solution that occurs the anode as oxygen gas. The results of the Rasch analysis with the Cronbach Alpha value of 0.76 indicate that the reliability of the instrument for assessing student process skills is good.
3. A total of 85.71% of students are classified as good in interpreting data. Students are able to discuss the two gases at each electrode based on the change in color of the solution on the two straws, test the hydrogen gas and oxygen in the straw using fire, and determine the ratio of the volume of solution in both straws as the mole ratio of the two gases. The results of the Rasch analysis with the Cronbach Alpha value of 0.80 indicate that the instrument reliability assessment of student process skills is good.
4. As many as 80% of students have good communication skills. This can be seen from how to explain the procedure, convey the findings, and discuss the results of the experiment. The results of the Rasch analysis with the Cronbach Alpha value of 0.75 indicate that the instrument reliability assessment of students' science process skills is good.

In addition, students were also asked to assess their personal performance during the implementation of this practicum by filling out the student response questionnaire in assessing small-scale process skills and chemistry practicum. In general, students were very interested, although there were difficulties in turning over straws during a water electrolysis practice with straw media, but students were good at observing, predicting experimental results through color changes, presenting a discussion based on data that students could easily distinguish between hydrogen and oxygen gas based on the color of the solution in the straw and the height of the volume of the solution in the straw. Students also believe their communication is already good and hope that it will be better in improving the concept of electrolysis for other solutions besides sodium sulfate. This is in line with the research of Kamata & Seiko (2013) who also conducted a water electrolysis experiment and told us that this experiment was easy, inexpensive, visually interesting, and the observation process was fast, so that this practicum received positive responses from students.

Meanwhile in the posttest, students worked on 4 essay questions related to the reason for using sodium sulfate, the fact of the gas ratio formed in both straws, the electrolysis reaction that occurred, and the nature of the solution in the two straws. The posttest results show that students are good and able to answer all four questions. The Rasch analysis result of 0.83 shows that person reliability is good. Item number 1 about selecting sodium sulfate solution as a test solution is a difficult question for students.

In January 2019, small scale chemistry experiment on the topic of electrolysis of water were carried out using plastic cups and small test tubes. Two holes are made at the bottom of the plastic cup and cover with tacks. Plastic cups filled with distilled water, then put two test tubes containing sodium sulfate solution. Both test tubes are inserted in reverse and made facing the tacks. From the outside of the glass, a 9 volt battery is supplied and observed changes occur. In contrast to the previous one, this experiment did not use indicators. The electrolysis practice that is done this time really sharpens students' thinking skills to find something new. In this case, Ergul (2011) reveals that practicum based on discovery can develop cognitive abilities, especially in critical and creative thinking, scientific attitude, and of course science process skills. These three components become an important part of SSC electrolysis practicum. The finding activity is an important aspect in improving students' science process skills (Pratono et al., 2018), so that this needs to be conveyed to students to continue to develop their own potential in chemical lab work.

The results of students' science process skills analysis are as follows:

1. A total of 85.71% of students have good observation skills in observing the height of the volume of the solution in both test tubes. Students can also observe the emergence of colorless gases in this experiment. The results of the Rasch analysis with the Cronbach Alpha value of 0.78 indicate that the reliability of the instrument for assessing student process skills is good.
2. A total of 82.85% of students were able to predict quite well the difference in gas produced in both test tubes. The results of the Rasch analysis with the Cronbach Alpha value of 0.77 indicate that the instrument reliability assessment of student process skills is classified as good.
3. As many as 82.85% of students are classified as good in conducting data interpretation. Students are able to discuss the two gases at each electrode based on the height of the solution volume as a comparison of the moles of hydrogen and oxygen gas produced during electrolysis. The results of the Rasch analysis with the Cronbach Alpha value of 0.77 indicate that the instrument reliability assessment of student process skills is classified as good.
4. As many as 80% of students have good communication skills. This can be seen from the method of explaining the procedure, conveying the new findings without acid base indicators, and discussing the results of experiments on the gas produced. The results of the Rasch analysis with the Cronbach Alpha value of 0.75 indicate that the instrument reliability assessment of students' science process skills is good.

In addition, students were also asked to assess their personal performance during the implementation of this practicum by filling out the student response questionnaire in assessing small scale process skills and chemistry practicum. In general, students are very interested because using plastic cups is an effort to reduce plastic waste which has been utilized and mini test tubes as a solution to the application of chemical principles to green. The process of assembling tools for electrolysis takes quite a long time, but students include both observing, predicting experimental results through the height of the volume of the solution in a test tube, and presenting a discussion based on data that students can distinguish the presence of hydrogen gas and oxygen without acid base indicators. In this context, students succeed in finding and exploring new things through investigations in chemical labs. According to Wulanningsih et al (2012), investigations conducted on discovery activities/inquiry into new things can trigger

and practice science process skills to be even better. Students also assess their communication as good because students have clearly obtained unique data and findings to communicate.

Meanwhile in the posttest, students worked on 4 essay questions related to the reason for using salt in this experiment, identification of the gas formed, the ratio of gases formed in the two test tubes, and the electrolysis reaction that occurred. The posttest results show that students are good and able to answer all four questions. The Rasch analysis result of 0.8 indicates that person reliability is good. Item number 1 about selecting sodium sulfate solution as a test solution is a difficult question for students.

Analysis Students' Science Process Skills in Silver Mirror Experiment

Silver mirror is part of an organic reaction that is studied by second semester of high school 12 grade students. Practicum using test tube media and reacting samples containing aldehyde / ketone with Tollens reagents are often done in senior high school. This reaction is a qualitative test to distinguish functional groups of aldehydes and ketones. Supasorn et al (2014) state that the aldehyde and ketone test is an organic reaction that can be packaged in small scale chemistry and further developed in guided inquiry-based learning. Zakaria et al (2012) emphasize that small scale chemistry for organic chemistry labs can be more effective because the quantity of reagents can be reduced 10 times, so the quality of learning increases.

In July 2018, a small scale chemistry practicum was conducted to form a silver mirror using bottle and mirror media, so that at the end of the experiment two products were obtained, namely silver bottles and silver mirrors.

In making silver bottles, the media used is a small transparent vial bottle, which is filled in a row with $AgNO_3$ solution, NH_4OH solution, KOH solution, and glucose solution. The mixture in the vial bottle is heated to form silver deposits.

The results of the analysis of students' process skills are as follows:

1. As many as 94.28% of students have good observation skills in observing discoloration from light brown deposits, clear solutions, gray solutions, to the formation of silver deposits. The results of the Rasch analysis with Cronbach Alpha value of 0.96 indicate that the reliability of the instrument for assessing student process skills is very good.
2. A total of 85.71% of students were able to predict quite well the color changes that occur in each addition of the solution into the vial bottle. Students are quite good and fluent in predicting the color of the solution, but the final results of silver bottle formation are not all perfect according to student predictions. The results of the Rasch analysis with the Cronbach Alpha value of 0.80 indicate that the instrument reliability assessment of student process skills is good.
3. A total of 88.57% of students were classified as good in conducting data interpretation. Students are able to discuss understanding each reaction, starting from the formation of Ag_2O deposits, deposits that dissolve again and form complexes with excess ammonium hydroxide solution, until Tollens reagents are formed and the vial bottle heating process is carried out. All of these stages produce different colors so students are able to discuss them well. The results of the Rasch analysis with the Cronbach Alpha value of 0.85 indicate that the instrument reliability assessment of student process skills is good.
4. 85.71% of students have good communication skills. This can be seen from the method of explaining the silver formation procedure in stages, conveying the findings about the silver lining the vial bottle, and discussing from the experimental results that silver coating on the bottle could be different during the experiment. The results of the Rasch analysis with the Cronbach Alpha value of 0.80 indicate that the instrument reliability assessment of students' science process skills is good.

In addition, students were also asked to assess their personal performance during the implementation of this practicum by filling out the student response questionnaire in assessing small-scale process skills and chemical practicum. In general, students are very interested, although not all students in the group obtain perfect silver coating results on

vial bottles. Students also consider their communication to be quite good and hope that they will be better at making silver bottles.

Meanwhile in the posttest, students worked on 4 essay questions related to changes in vial bottles after the experiment, chemical reactions that occurred, the role of glucose in this experiment, and substances that could form silver mirrors. The posttest results show that students are good and able to answer all four questions. The Rasch analysis result of 0.8 indicates that person reliability is good.

In making silver mirrors, the media used is a two sided mirror, which is filled in a row with $AgNO_3$ solution, NH_4OH solution, KOH solution, and glucose solution. The mixture in the petri dish is then shaken slowly, then added hot distilled water into it until a silver precipitate is formed.

The results of the analysis of student process skills are as follows:

1. 88.57% of students have good observation skills in observing color changes in petri dishes until silver deposits are formed. The results of the Rasch analysis with the Cronbach Alpha value of 0.85 indicate that the reliability of the instrument for assessing student process skills is very good.
2. A total of 85.71% of students were able to predict quite well the color changes that occur in each addition of the solution into the vial bottle. Students are quite good and fluent in predicting the color of the solution, but the final result of forming a silver mirror is not completely coated on the mirror according to student predictions. Students predict that the results will be better than silver bottles. The results of the Rasch analysis with the Cronbach Alpha value of 0.80 indicate that the instrument reliability assessment of student process skills is good.
3. A total of 88.57% of students were classified as good in conducting data interpretation. Students are able to discuss understanding each reaction, starting from the formation of Ag2O deposits, deposits that dissolve again and form complexes with excess ammonium hydroxide solution, to form Tollens reagents and pouring hot distilled water into a petri dish containing Tollens reagent mixture and glucose solution. All of these stages can be discussed by students. The results of the Rasch analysis with the Cronbach Alpha value of 0.85 indicate that the instrument reliability assessment of student process skills is good.
4. 85.71% of students have good communication skills. This can be seen from the method of explaining the silver formation procedure in stages using mirror media, conveying the findings about silver coating the two-sided mirror, and discussing from the experimental results that silver coating on a two-sided mirror can be different during the experiment. The results of the Rasch analysis with the Cronbach Alpha value of 0.80 indicate that the instrument reliability assessment of students' science process skills is good.

In addition, students were also asked to assess their personal performance during the implementation of this practicum by filling out the student response questionnaire in assessing small-scale process skills and chemical practicum. In general, students are very interested because the silver mirror produced can be used as an innovative product by students, although not all students in the group get the perfect silver coating on the mirror. Arifin (2015) emphasizes that each part of science process skills influences students' understanding and makes it easy to answer questions. Through the basic concept of the reaction of silver mirror formation in the context of small-scale chemistry, students are required to produce silver mirrors with vial and mirror bottles. Furthermore, Hanson (2014) states that small-scale chemistry in the topic of organic practicum can be easy to follow and fun. Students also consider their communication to be quite good and hope that they will be better at making silver mirrors. Hanson (2014) states that small-scale chemistry in the topic of organic practicum can be easy to follow and fun.

Meanwhile in the posttest, students worked on 4 essay questions related to changes to the silver mirror bottle after the experiment, chemical reactions that occur in the mirror, the role of glucose in this experiment, and substances that can form a silver mirror. The posttest results show that students are good and able to answer all four questions. The Rasch analysis result of 0.8 indicates that person reliability is good.

Subamia et al (2017) stated that small scale chemistry practicums are easy and safe to apply, ready to use at any time, without risk, easily prepared, and do not produce hazardous waste. Referring to this statement and relating it to the two experiments that have been carried out, all components in assessing chemical science process skills for small scale chemistry practicums can be measured faster and better than conventional labs. Students can understand practicum material well and quickly. In addition, experiments on the process of forming a silver mirror with vial bottles and mirrors can run fast, while the unique electrolysis process with plastic cups and plastic tubes can quickly take place and attract the attention of students. The small scale chemical practicum module used in the experiment directs students to discover new things and emphasizes the importance of chemical science process skills that are measured during small scale chemistry practicum. This is in accordance with inquiry-based practicum modules that contribute to developing students' critical thinking skills and process process skills (Paulo & Cruz, 2015).

In the future, the two SSC experiments in this research can be carried out and further tested for their effectiveness in chemical practicum learning in high school. Chemistry teachers need to develop the ability to improve science process skills in small scale chemistry experiments. Teachers play an important role in improving students' science process skills through mature planning and organizing (Amnah et al., 2017), so that small scale chemical practicums can be designed to be interesting and memorable for students.

Aydin & Cakiroglu (2017) emphasize that experience in learning is obtained by maximizing the knowledge of chemistry in life. Through this experience, various materials and tools in the surrounding environment can often be used for small scale chemistry experiments.

CONCLUSION

Based on the discussion that has been done, it can be concluded that the small scale chemistry for electrolysis practicum uses straws, plastic cups, and test tubes, the average process skills of students in terms of observing, interpreting, and communicating are good, while predictability is quite good. Students like to take part in this experiment even though there are difficulties with the procedure. Meanwhile, the silver mirror experiment using vial bottle and mirror attracted the attention of students. The average process skills of students in terms of observing, interpreting, and communicating are good, while the predictive ability is quite good. Students were happy to take part in this experiment and they concluded that the silver coating process on vial bottle / mirror could be different for each group.

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