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Development of Inquiry-Based Chemistry Laboratory Sheet Oriented to Green Chemistry for Improving the Science Process Skills

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Abstract

Science process skills are indispensable for educators in the world of education or in everyday life that includes observing, categorizing, interpreting, forecasting, questioning, formulating hypotheses and communicating. The aim of this research is to develop of inquiry-based chemical practicum green chemistry-oriented for improving the students' science process skills in a colloid material. This research is a type of R & D research with One Group Pretest-posttest Design design applied to test the application of practicum as the product of development. The criteria for the success of this study are valid practicum, increasing KPS and getting a positive response from learners. Research data obtained by observation method, documentation, questionnaire and test. Device validation results obtained valid criteria (3.8 of 4). The results of early practicum KPS were in enough and fewer categories, improved on the final lab in the good and excellent category. The average of cognitive learning outcomes of the broad test classes is 79.20 (> of KKM) and the proportion of classical learning completion is greater than 80% or 24 of the 30 students reach the KKM. Students respond positively to the practicum in the "strongly agree" criteria.

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INTRODUCTION

Learning at various levels of education including SMA / MA, sector is still developing. The learning pattern is still dominated by the paradigm of teacher centered learning (TCL), non-constructivist, not the paradigm of student centered learning (SCL), so that learning becomes less effective and not well constructed. Learning that can empower the potential of learners such as thinking empowerment has not been implemented optimally so that the learning process becomes less meaningful. Learners are more likely to be passive in class in receiving lessons, more silent, listening, recording, memorizing, even learners can feel bored and end up not seriously following the learning process (Priyatmojo, 2010).

The learner-centered learning model has become the focus developed in the learning process in Indonesia through the 2006 Education Unit Level Curriculum (KTSP) and Curriculum 2013 policies. Inquiry learning model is one of learner-centered scientific learning model. Inquiry learning model is a learning model involving learners in the process of data collection and hypothesis testing (Kemediknas, 2013). Inquiry is a stimulating learning, teaching and inviting learners to think critically, analytically and systematically in the various issues that are expressed (Hartono, 2013). Inquiry provides the experience of the participants in order to find the answers independently of the real learners, learners active or involved in learning, learners are given the authority to initiate, design and implement problem solving and trained learners to dare to take decisions (Widodo, 2011). Inquiry emphasizes the learner to find concepts through experiments in the laboratory using scientific steps assisted by practical instruction (Rustaman, 2005). The purpose of science education allows individuals to use scientific process skills, determine the problems around them, observe, analyze, hypothesize, experiment to conclude, generalize, and apply the information they possess with the necessary skills. Scientific process skills (KPS) include the skills of every individual that can be used in daily life by becoming scientific literate and improving the quality of living standards by understanding the nature of science (Aktamis, 2008).

One of the learning methods that can be used to equip the science process skills for learners is the practicum method, because with the practicum learners can develop the basic skills of the experiment. It becomes a means of achieving the orientation of science learning, that is in addition to product-oriented also process-oriented. Rustaman (2005), practicum is the best tool in developing science process skills. Learning by practicum method provides an opportunity for learners to experience themselves or do it yourself. Hofstein (2004) describes laboratory activities in laboratory activities that are cooperative learners in small groups to investigate phenomena with specific instructions and one way to study the environment. Feyzioglu (2009) revealed that the laboratory plays an important role in effective chemical education. Laboratories are essential to understanding abstract chemical concepts. Sesen (2013),activities in the laboratory will be more meaningful if learners are given enough time and opportunities to interact and reflect to initiate discussion. Based on the explanation, it is necessary to practice a practicum that can develop the ability to think and develop the skills of science process learners, one of which is LKS practicum based inquiry.

The implementation of chemical labs in the school laboratory is one way for students to gain a direct understanding of chemistry, but the implementation of chemical labs generally uses hazardous chemicals that will result in waste to the environment that negatively impacts the environment and human health. The problem of waste has become a global problem so as to create an environmentally friendly chemical movement known as Green Chemistry or environmentally friendly chemistry. The term Green Chemistry was first introduced in 1991 by Anastas in a special program issued by the US EPA (Environment Protection Agency) aims to implement Green Chemistry as a developmental

compound in chemical and chemical technology from industry, academia and governance (EPA, 2013). This green chemistry emphasizes the use of materials, processes, or practices that reduce or eliminate the creation of pollutants or waste. Green chemistry provides connections between the subject matter of chemistry and the daily life of learners as well as creating space for learners and teachers to address the environmental problems faced by local and global communities in an ethical way (Karpudewan, 2012). The advantage of applying green chemistry according to Braun (2006) is to provide connections between the materials taught in the classroom and the environment of everyday learner, green chemistry to change the way the view of the learners.

Based on observational data of Chemistry teacher and learners of MAN 1 Semarang, related to chemistry learning are: 1) teachers still apply the TCL model in learning chemistry of Colloid material, so that learners more role as listener and recorder; 2) in chemistry lessons, teachers emphasize more cognitive aspects, while affective and psychomotor aspects of attitudes and problem-solving skills are less emphasized and their science-process skills are less developed; 3) the absence of teaching materials or inquiry tools based on inquiry is green chemistry oriented; 4) in general the learners think that all chemicals are dangerous, they end up lacking the courage to perform work procedures that exist in the manual lab or LKS. Chemical learning is then considered to be related only to difficult formulas and hazardous materials; 5) learners judge that learning chemistry is less interactive and interesting, because of less enjoyable learning strategies.

Based on the description of the above problems, it is deemed necessary to conduct research on the development of chemistry-based inquiry-based chemistry inquiry kit. This research aims to; (1) to know the characteristics of the developed chemical practicum device, 2) to know the validity of the developed chemistry practicum, (3) to know the improvement of the students' science process skill and (4) to know the student's response to the application of the developed chemistry practicum.

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METHODS

The type of this research is R & D is the development of chemistry-based inquiry practicum inquiry-oriented green chemistry. The development procedure uses the Four-D Model (4-D) model development model suggested by Thiagarajan, Semmel and Semmel in Trianto (2013). The 4-D model consists of define, design, develop, and disseminate. In this research, modification of 4-d model is (1) preliminary study that is library study, field study and initial product preparation; (2) model development includes product compilation, product validation, product revision, limited testing and revision of test results; (3) model test includes product test through experiment, final preparation, and product socialization.

Product socialization is not done with consideration of time and consideration that at the stage of development of the model has been generated a valid device. The object of this research is a green chemistry-based inquiry-based self-directed device. The design used in this study is one group of pre-test post-test design (Creswell, 2013), class XI IPA 6 as a class of limited trials and Class XI IPA 7 as a spacious test class. The method used is test and non test method. The test instrument used is a PPP competency test. Non-test instruments include expert validation sheets, questionnaires and observation sheets, the descriptive analysis used.

RESULTS AND DISCUSSION

Designed product development products are syllabus, RPP, practicum tool, student response questionnaire, and questionnaire used to measure student PPP. At this stage of development is done several phases, namely: phase realization / construction, test phase, evaluation and revision. At this stage the researcher performs some validation of research tools to the experts to produce a valid research

tool. Recapitulation of learning device validation results presented in Table 1.

Table 1. Recapitulation of Validation Results of Research Instruments and Instruments

No	Validated instrument	Validator Score 1	2	3	Total score	Number of Items	Average	Criteria
1	Syllabus	35	40	38	113	30	3,8	Valid
2	Lesson plan	78	88	86	252	69	3,7	Valid
3	Laboratory Worksheet	139	138	151	428	24	3,8	Valid
4	Test the science process skills	28	28	31	87	24	3,5	Valid
5	Questionnaire of science process skill	31	29	32	92	24	3,8	Valid
6	Questionnaire response of learners	32	31	29	92	24	3,8	Valid

The average value of the validation result of the instrument by the validator shows that the developed research instrument has very good criteria. Thus, it can be concluded that the research instrument can be used as a data-taking tool in research. Chemical practice device characteristics developed are the use of environmentally friendly chemicals as a substitute for hazardous substances in high school chemistry lab. Environmentally friendly chemicals in question are materials that do not cause negative effects to health and the environment so safe to use, in addition to the advantages of the use of environmentally friendly chemicals is the material is easily obtained in everyday life with a relatively cheaper price. Stage learning with LKS practicum chemistry that is implemented include: (i) orientation and formulating problems, (ii) formulating hypotheses; (iii) organizing learners to design simple experiments; (iv) learners to test hypotheses; (v) learners make conclusions about experiments that have been performed and presented experimental results, (vi) analyzing and evaluating the learning process. The information used to solve the problems in the LKS of chemistry practicum is collected through individual and group activities, here trained students' learning process skills in (1) using tools and materials, (2) proposing hypotheses, (3) observation (Observation), (4) classifying (5) interpreting (6) predicting, (7) asking questions, and (8) communication.

The KPS enhancement of learners is measured by a description test of 10 questions for pre-test and post-test. The results of pre-test data analysis found that all learners in the class of experimental trials were not completely classical with KKM 75. After being given the learning with the tools of the practicum developed, the post-test, the result of post-test analysis found that 24 out of 30 participants educated (80%) reached KKM with average score of learners 79,20. Improving the skills of the students' learning process is done using the normalized average gain (N-gain) formula. The calculation results are presented in Table 2.

Table 2. Results of Pre-test and Post-Test of Process Skills of Science

No	Data	Average Value	High Grade	Low Grade	N-Gain	Criteria N-Gain
1	Pre-test	9,30	34	4	0,77	High
2	Post-test	79,20	85	64		

Table 2 shows an increase in the mastery of science process skills on colloid competence, judging by the mean values of pre-test and post-test of 9.30 and 79.20, respectively. The achievement of N-Gain value of 0.77 includes the high category. This improvement is in line with Rustaman's (2005) statement, stating that inquiry is more emphasizing the learner to find concepts through experiments in the laboratory using scientific steps assisted by practical guidance. The results of research in his research journals explained that laboratory activities can improve the skills of students 'learning process and problem-solving skills of learners and can increase students' interests and attitudes toward science learning. The improvement of the student KPS per-indicator is analyzed from the data of pre-test and post-test scores obtained in extensive trials. Here are seven indicators of the science process skills measured in this study presented in Table 3.

Table 3. Results of Analysis of Process Skills of Science Per Indicator

No	Indicator science process skill	Item number	Average		N-Gain	Criteria
			Pre-test	*Pos-test*		
1	Interpreting	1	7,23	8,40	0,42	Medium
2	Grouping / Classification	2	0,50	9,00	0,89	High
3	Observing	3	1	9,30	0,92	High
4	Forecast / Prediction	4	0,33	8,60	0,86	High
5	Apply the concept	5	0,2	10,53	0,65	Medium
6	Communicate	6	0	12	0,86	High
7	Submitting hypotheses and designing experiments	7	0	11,83	0,79	High

Based on Table 3, it can be seen that there is an increase of score average in each science skill indicator, N-gain obtained shows high achievement level on indicator (2,3,4,6,7) and level of achievement with medium criterion at indicator (1.5). The highest N-Gain science process skill indicator occurs on the observing / observation indicator and the lowest on the interpreting / interpretation indicator. The highest increase in observational indicators is possible because inquiry-based learning on colloid material leads learners to perform work-based activities and observations (labs) in the laboratory so that it requires learners not just following procedures and steps according to worksheets but rather try to design and experiment on their own. The process of observation and processing of data compiled in the form of activity report reports also requires learners to better understand the concepts and discussion in the activities of colloidal material practicum so as to enable learners to understand well how to relate observational data to theories on the discussion of reports that have been compiled.

The result of observation and calculation shows that the psychomotor value of students has increased, it is evident in the activity of the second practicum average value is higher than the first practice. Improvement of psychomotor value of learners on practicum activity can be seen Figure 1.

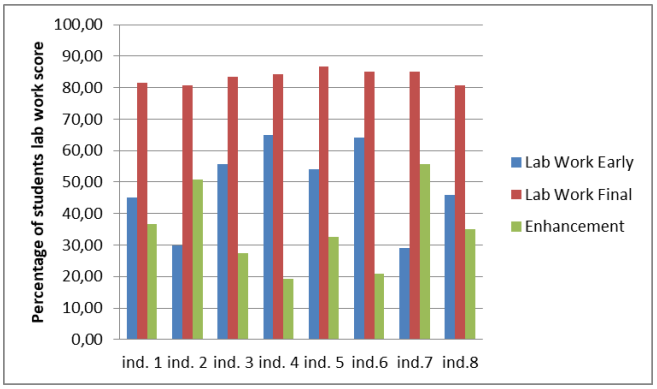

Figure 1. Percentage of Practicum Value

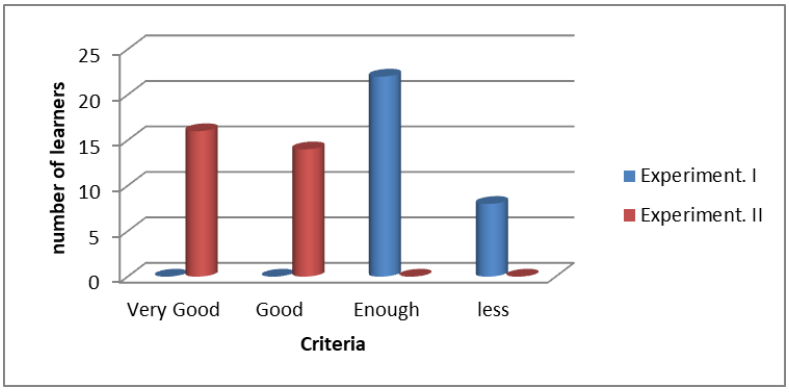

Figure 2. Psychomotor observation results of learners

As shown in Figure 2, the preliminary practicum shows more significant frequencies for sufficient and less categories compared with the final practicum showing more significant frequencies for very good and excellent categories. This indicates that the chemistry-based chemistry-based inquiry kit has a positive impact on the psychomotor development of learners. Bilgin (2009) in his research, explains that teaching materials based on guided inquiry guided in cooperative learning environments can help learners to gain meaningful learning by making the connections between concepts and conceptual discussions help learners to recognize their ideas, share ideas and allow them to develop social interaction. Research conducted by Feyzioglu (2009), shows the results that laboratory activities can improve the skills of students 'learning process and problem solving skills of learners and can increase students' interest and attitudes toward science learning, the laboratory not only strengthens theoretical knowledge, also enables learners to find his own knowledge. Aktamis (2008) in his research shows that learners in learning with science skills training process more successful than learners with conventional learning activities. These results show that science skills training courses improve student achievement and scientific creativity. The result of the respondent's analysis of the practicum device is presented in Figure 3.

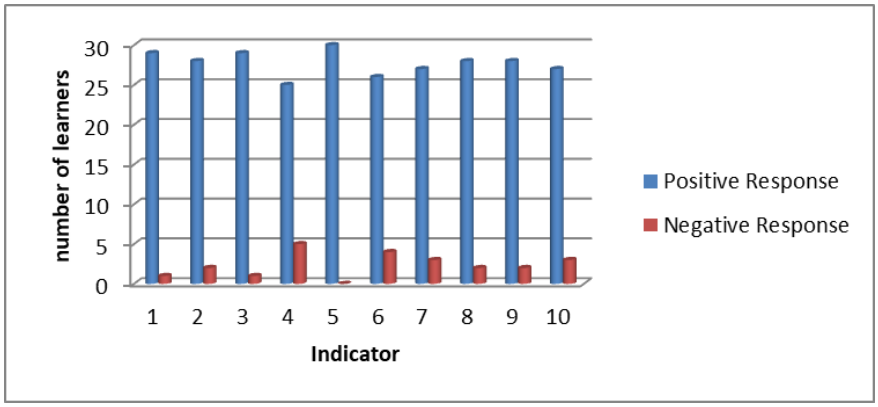

Figure 3. Analysis of Questionnaire Response Extension Learners Test

The results of questionnaire responses generally show that all learners responded positively to the learning with an inquiry tool based on inquiry with green chemistry. This suggests they benefit from the application of inquiry-based labs with green chemistry. They consider this learning interesting and fun and can encourage learners to learn more about colloid competence. Associated with the positive response of learners, the results of the data show as much as 92% of students provide an average positive response to the learning developed. This is caused in the learning process, learners are not only given knowledge of colloidal material from the side of science alone, but taught about keterhubungkaitan with application in everyday life.

Table 4. Recapitulation of Student's Response to Extensive Test Practicum Equipment

Indicator	1	2	3	4	5	6	7	8	9	10	Total
Score	92	92	97	91	96	96	100	98	99	99	960
Positive	29	28	29	25	30	26	27	28	28	27	92%
Negative	1	2	1	5	0	4	3	2	2	3	8%

According to Widodo (2011), inquiry gives real-life experiences of learners, learners active or involved in learning, learners are given the authority to initiate, design and implement problem solving and trained learners to dare to make decisions. Hofstein (2004) explains that practicum activities have the potential to build positive social relationships and attitudes that can support cognitive development. The advantage of applying green chemistry according to Braun (2006) is to provide connections between the materials taught in the classroom and the environment of everyday learner, green chemistry to change the way the view of the learners. In accordance with the opinion of Huba and Freed (2000), students centered learning emphasizes learners to build knowledge through gathering and synthesizing information and integrating it with general skills of inquiry, communication, critical thinking, problem solving, and so on. Learning becomes more fun, making learners want to know more about the material learned.

CONCLUSION

Based on the analysis of research results and discussions related to the development of inquiry tools based on inquiry with green chemistry on colloid material to improve the science process skill of the students showed (1) Inquiry tools based on inquiry of green chemistry related to the developed colloid material reaches the prevalence rate of 3.8 from the score maximally 4 with valid criteria so that the practicum device can be used in the research data retrieval process, (2) application of inquiry tools based on inquiry of green chemistry related

to colloid competence can improve the science process skill learners with obtained 24 of 30 learners (80%) complete study classically with value above KKM 75 with level of achievement 0,74 and mean value 79,20. The results showed that the application of inquiry tools based on inquiry into green chemistry proved effective in improving the students' science process skills in colloidal material, (3) The results obtained 28 out of 30 students (92%) gave a positive response to inquiry tools based on inquiry with green chemistry related to the developed colloidal competence so that the experimental devices based on inquiry are able to be used in the learning process. (4) The characteristics of the chemical practicum devices developed are the use of environmentally friendly chemicals as a substitute for hazardous substances in high school chemistry lab. Environmentally friendly chemicals in question are materials that do not cause negative effects to health and the environment so safe to use, in addition to the advantages of the use of environmentally friendly chemicals is the material is easily obtained in everyday life with a relatively cheaper price.

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