

Validity of a Chemistry Laboratory Manual Based on Green Chemistry Principle for High School Students Grade X in the Odd Semester

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Abstract- This study aims to determine the validity of the Chemistry laboratory manual for high school students grade X in an odd semester which is appropriate according to experts. The chemistry laboratory manual developed applies the principle of green chemistry in each of the experiments. The principles of green chemistry that are applied are the first principle (waste prevention), the third principle (chemical synthesis which is less dangerous), the 4th principle (designing safer chemicals), the 5th principle (safer solvents and auxiliaries), and the 12th principle (chemicals which is inherently safer for accident prevention). This research is part of research and development research with a 4-D development model. This research was only carried out to the stage of content validation and construct validation by experts.

Keyword- Chemistry Laboratory Manual, Green Chemistry, Content Validation, Construct Validation.

I. INTRODUCTION

Environmental sustainability has become a very important issue today given the increasingly unsettling environmental conditions. Responding to this, the Ministry of Primary and Secondary Education has issued regulation no 54 in 2013 concerning about standards of primary and secondary education graduates who must have responsible behavior in their effective interactions with the community and also the environment. This regulation is set with the hope that the young generation of Indonesia will have a high sense of concern for the environment so that they can play an active role in participating overcome environmental

problems that occur both locally and globally (Wahyuningsih, 2017). The efforts to realize these expectations can not be separated from the learning process that was more environment approach. Practically, the Green Chemistry approach can be used as a foothold as a learning approach that is more environmentally learning process.

Green chemistry is an active learning approach that is student-centered in teaching chemistry in an environmentally friendly way. According to green chemistry is a useful approach to raising awareness and teaching sophisticated problem-solving skills through chemistry. Green chemistry or sustainable chemistry is interdisciplinary and involves

environmental exploration. Therefore, it can function as an approach to facilitate integrative and interdisciplinary learning experiences where students use critical thinking and communication skills to overcome complex environmental problems due to waste and chemical processes (Haack et al, 2005). While green chemistry covers human health and the environment, it is guided by 12 principles of very specific chemical practices (Anastas and Wagner, 1998). Through the application and expansion of 12 principles, green chemistry can contribute to sustainable development (Wardencki et al., 2005).

Laboratory activities are considered to be the right target to introduce the concept of green chemistry because the activities in the laboratory about chemistry practicum can produce hazardous waste if its use is not monitored and controlled properly (Wahyuni, 2017). The way to do this is by applying some Green Chemistry principles that suitable for each practicum title that will be done. That way, students will know that the work done by them is based on Green Chemistry using non-hazardous materials, a safe process and does not produce waste that endangers the environment and health.

Laboratory activities in science learning aim at teaching laboratory skills; helping to acquire and develop concepts, and develop social skills (Hodson in Pullaila, 2007), this is in line with the aim of learning chemistry as part of the curriculum those are the development of chemical literacy, introducing chemistry to high school students so that they have an adequate foundation and are interested in studying chemistry, developing scientific thinking skills and growing awareness of moral responsibility regarding the use of chemical processes and products (Noh, 1997; Ling, 1997; Tongwen, 1997).

Based on the results of preliminary observations obtained information that chemistry practicum in high school has not applied the principles of green chemistry and there is no laboratory manual based on green chemistry as a guide during the activities laboratory. This opportunity is the basic need analysis for the development of green chemistry-based chemistry lab guides for grade X students in an odd semester. Also this laboratory manual will be developed into a tool or media to introduce the Green Chemistry approach so that it needs to develop a chemistry laboratory manual based on Green Chemistry for high school students grade X in the odd semester that is feasible to be implemented to students.

The purpose of the study is to assess the content and construct validity of the chemistry laboratory manual based

on green chemistry principle, so the laboratory manual that was developed are appropriate for students to use.

II. RESEARCH METHOD

The aim of this research is to produce a valid chemistry laboratory manual that was based on green chemistry principle. The method is Research and Development (R & D) using 4D instructional design model developed by Thiagarajan, Semmel & Semmel (1974). The model consists of 4 phases called Define, Design, Develop, dan Disseminate. The research was limited to validity tests by experts.

Define is a phase to set and define learning prerequisites. It begins with analysis of core competencies, basic competencies, and learning materials based on the content standard of curriculum 2013. This phase consists of five main steps named (1) front-end analysis, (2) students analysis, (3) task analysis, (4) concept analysis, and (5) learning goals formulation.

Design is a phase to define skills, formulate the goals, and determine the sequence of learning and small scale test that can be implemented. The focus of this phase is to design the chemistry laboratory manual that is based on green chemistry principle. The steps of this phase includes: a) understanding basic competencies and specifying the indicators and learning goals that students must achieve for grade X in the odd semester, b) determining concepts, c) designing chemistry laboratory manual, d) choosing appropriate format for the chemistry laboratory manual.

Develop is a phase to develop draft of the laboratory manual. This phase consists of two stages named validity and practicality testings. Validity testing in this research was done by giving validity questionnaire to experts (3 chemistry lecturers, 2 chemistry teachers). The evaluation on validity testing were on the content validation and construct validation. The result was used to revise the product for further practically and effectiveness testing of the laboratory manual developed.

The instruments used to collect data in this research were validity questionnaires and the chemistry laboratory manual itself. To determine the content validity were analysed with Content Validation Index (CVI). Lynn's criteria to judge content validity are $I-CVI=1,00$ with 3 to 5 experts and a minimum $I-CVI$ of 0,78 for 6 to 10 experts and it would have an $S-CVI/Ave$ of 0,90 or higher. For construct validation data were analysed with Kappa Cohen formula.

Table 1. Decision category based on Kappa moment (k)

Interval	Category
0,81 – 1,00	Very high
0,61 – 0,80	High
0,41 – 0,60	Middle
0,21 – 0,40	Low
0,01 – 0,20	Very low
<0,00	Invalid

III. RESULTS AND DISCUSSION

A. Define

At this stage, a literature study, interviews with teachers, and analysis of Core Competence and Basic Competence of chemistry lesson for grade X in the odd semester 2013 curriculum were conducted. The results of the interviews with the teacher were that chemistry laboratory activities in high school were not based on green chemistry principles and chemistry laboratory manual based on Green Chemistry is also doesn't available. Therefore we need a chemical laboratory manual that includes several experiments on grade X chemicals even using chemicals and safe tools.

By using chemistry laboratory manual, students can carry out chemical practicum activities safely because the tools and materials that were used are harmless and easily found and used in everyday life, in addition in the laboratory manual, work schemes are also presented in the form of drawings so as to facilitate students in the trial implementation and can minimize accidents at work, minimize waste that can pollute the environment. This chemical laboratory manual also contains information about using laboratory tools and laboratory techniques that can use for senior high school students grade X in the odd semester.

From the analysis of Core Competence and Basic Competence of chemistry lessons for high school grade X in the odd semester, it was found that there were at least 4 practicums to do. the topic of the experiment was the scientific method, the role of chemistry in life, ionic compounds and covalent compounds, and molecular interactions.

B. Design

The define phase was followed by the design of chemistry laboratory manual. A chemistry laboratory manual was consist of 2 introduction and laboratory activities part. In the introduction part concludes: 1) Introduction of green chemistry, 2) Laboratory Safety, 3) Introduction of tools and

chemical, 4) Hazard symbol, 5) Safety equipment, 6) Scientific method, 7) Laboratory technique, 8) Making and dilute solution. While in the laboratory activities part concludes 4 laboratory activities.

A green chemistry-based laboratory manual is designed to provide solutions to the constraints of practicum implementation. For the time constraints of inadequate practicum, this laboratory manual presents a work scheme in the form of drawings so the students can more quickly and easily conduct experiments.

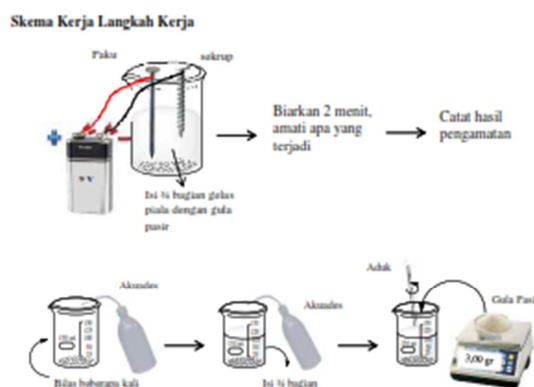


Figure 1. Drawing Shceme Work Step

With the work steps in the form of a drawing scheme, students no longer ask their teacher or coworkers what stages of work they will be doing and what laboratory equipment should be used.

The principles of green chemistry used in each Experiment are also displayed and explained in detail.



Figure 2. Green Chemistry Principle.

In this laboratory manual work safety are also displayed in each experiment, so students know and can apply them so that practicum activities take place safely and accidents at work can be avoided.

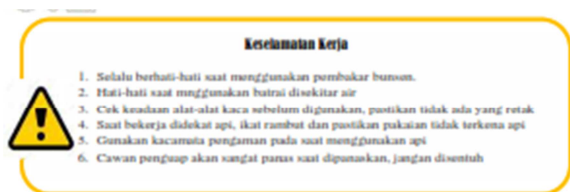


Figure 3. Work Safety

C. Development

1. Validation of questionnaire to experts

Validity explains how well the collected data covers the actual area of investigation (Ghauri and Gronhaug, 2005). Validity basically means “measure what is intended to be measured” (Field, 2005).

Based on the validity test of content and construct validity questionnaire using the instrument validity assessment sheet the results obtained in figure 4 and 5 as follows:

Validity of content validity questionnaire

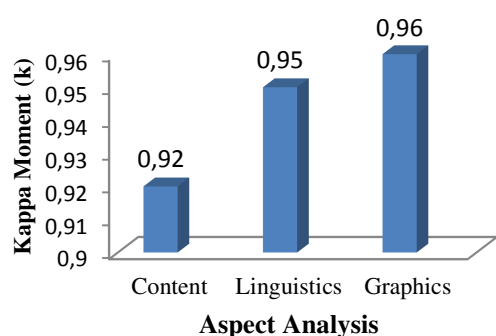


Figure 4. Analysis per aspect on validity level from validators

The result of the questionnaire validity was very high, it means that questionnaire can be used to validation of the laboratory manual

Validity of construct validity questionnaire

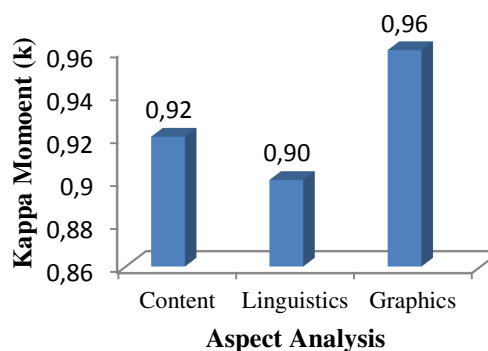


Figure 5. Analysis per aspect on validity level from validators

2. Validation of Chemistry Laboratory Manual based on green chemistry

a) Content Validation

Content validity is defined as “the degree to which items in an instrument reflect the content universe to which the instrument will be generalized” (Straub, Boudreau et al. 2004). Here are the result of content validation of chemical laboratory manual based on green chemistry by 5 experts

Table 2. Content Validation Index For Introduction and Laboratory activities

Criteria	S-CVI/Ave		S-CVI/UA	
	Intro ducti on	Labo rator y Activ ities	Intro ducti on	Labo rator y Activ ities
content compatibility with the curriculum	1,00	1,00	1,00	1,00
The correctness of the contents of the chemical scientific content	1,00	1,00	1,00	1,00

Table 3. Conten Validation Index For Green Chemistry Principle application in laboratory activities

Green Chemistry Principle	S-CVI/Ave	S-CVI/UA
Waste Prevention	1,00	1,00
Less Hazardous Chemical Synthesis	1,00	1,00
Designing Safer Chemical	1,00	1,00
Safer Solvent and Auxiliaries	1,00	1,00
Inherently Safer Chemistry for Accident Prevention	1,00	1,00

From the result the value of CVI for all aspect is 1,00, that means the content in the chemistry laboratory manual based on green chemistry was valid and can be used to the next analysis.

b) Construct Validation

Here are the result of construct validation of chemical laboratory manual based on green chemisrty by 5 experts.

Table 4. Kappa moment for content aspect

Aspect Analysis	Kappa Moment	Category
Compatibility with curriculum 2013	0,89	Very High
theory accuracy	0,89	Very High
theory update	0,85	Very High

Table 5. Kappa moment for Linguistics Aspect

Aspect Analysis	Kappa Moment	Category
Suitability of the language used with the development of students	0,92	Very High
the readability of the contents of the laboratory manual	0,88	Very High

the influence of language used to motivate students	0,83	Very High
the correctness of the language used	0,9	Very High
the correctness of the language used	0,85	Very High
the use of terms and symbols in the laboratory manual	0,83	Very High

Table 6. Kappa moment for Presentation Aspect

Aspect Analysis	Kappa Moment	Category
presentment technique	0,88	very high
supporting the theory presentment	0,85	very high
presentation of information and experiments	0,82	very high
completeness of presentation	0,85	very high

Table 7. Kappa moment for Graphics Aspect

Aspect Analysis	Kappa Moment	Category
the size of the laboratory manual	0,98	Very High
Cover design of the laboratory manual	0,82	Very High
Content Design of the laboratory manual	0,83	Very High

As a whole, chemical laboratory manual based on green chemistry had an average Kappa moment of 0.87 indicating very high degree of validity. A product is said to be valid if it can create a condition that fulfills the content and construct of the determined one.

IV. CONCLUSION

Based on the results of research and data analysis done, it can be concluded that The chemistry laboratory manual based on green chemistry for high school students grade X in

the odd semester had very high degree of validity and can be used to the next step of analysis.

REFERENCES

- [1] Anastas, P.T. and J.C. Warner. (1998). Green Chemistry: Theory and Practice. 1st Edn., Oxford University Press, USA., ISBN: 978-19-850698-0, pp: 152.
- [2] Field, A. P. 2005. Discovering Statistics Using SPSS, Sage Publications Inc.
- [3] Haack, J., J.E. Hutchison, M.M. Kirchhoff and I.J. Levy.(2005). Going green: Lecture assignments and lab experiences for the college curriculum. *J.Chem. Educ.*, 82: 974-978. DOI:10.1021/ed082p974
- [4] Ling, L.M. (1997). Chemical Education in Hongkong in Y.Takeuchi M.M. Ito (Eds).Chemical Education in Asia-Pasific. Tokyo: The Chemical Society Of Japan
- [5] Noh, T., Han, I., Woo, K. W. & Kang, S. (1997). Chemical education in Korea. In Y. Takeuchi & M. M. Ito (Eds.), Chemical education in Asia-Pacific. Tokyo: The Chemical Society of Japan.
- [6] Pullailla, A., Redjeki, S., & Rusdiana, D. (2007)."Guided Inquiry Learning Model to Improve the Mastery of Concepts and Creative Thinking Skills of High School Students on Temperature and Heat Material". *Journal of Natural Sciences*. 1 (3), 287295.
- [7] Thiagarajan, Sivasailam., Dorothy Semmel and Melvyn Semmel. (1974). Instructional Development for Training Teacher of Exceptional Children: A Sourcebook. Indiana University
- [8] Tongwen, H., Wending, L., Yogxing, W. (1997). In Y.Takeuchi M.M. Ito (Eds).Chemical Education in Asia-Pasific. Tokyo: The Chemical Society Of Japan
- [9] Wahyuningsih, A. S. (2017). Pengembangan Modul Praktikum Kimia Dasar. *Jurnal Pena Sains*, 43-51.
- [10] Wardencki, W., J. Curylo and J. Namiesnik. (2005). Green chemistry-current and future issues. *Polish J. Environ. Stud.*, 14: 389-395.