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Exploring Green Chemistry: A Practicum Handbook for 11th Grade Science Students

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Abstract—The development of this practicum handbook aims to determine the validity of green chemistry-based chemistry practicum handbooks and to determine the practicality of green chemistry-based chemistry practicum handbooks. Research with the title "Development of a Green Chemistry-Based Chemistry Practicum handbook for 11th Grade Science Students." With the Research and Development (R&D) approach, the researcher has finished. The research was conducted at State Senior High School (SMAN) 2 Sungai Tarab, This research was conducted using the 4D model, namely (define, design, development, and disseminate), but researchers only carried out up to the development stage. At the feasibility stage, the green chemistry-based chemistry practicum handbook based on the validation results obtained 87.46%, with a very valid category. 2. At the practicality stage based on the student response questionnaire, the results were 85.41%, with a very practical category.

Keywords—Guidance, green chemistry, defining, designing, developing, and disseminating.
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1. Introduction

Education is a learning process, knowledge, skills and habits of a group of people that are passed from one generation to the next through teaching, training and research. When viewed, the purpose of education is to develop abilities and shape personalities in order to become better (Suriansyah, 2011). Education can be obtained at school. School education has a very important role in improving students' understanding of learning materials. In delivering educational material at school, of course, there is a process that students must go through. Students must carry out the learning process and interact with the teacher.

Teaching materials are one of the determinants of learning success. Teaching materials are a set of materials that are arranged systematically so as to create an environment or atmosphere that allows students to learn. Teaching materials have a function to facilitate teachers in carrying out learning. When viewed from the types of teaching materials used in schools there are several kinds such as modules, student worksheets and practicum handbooks (Ika Lestari, 2013).

When viewed from the teaching materials used, especially for chemistry learning subjects, the learning process is not only carried out in the classroom but also carried out in the laboratory. Of course, the teaching materials used at school are those used in the classroom and those used in the laboratory. Not all schools can provide teaching materials for the learning process in the laboratory. This case has occurred in several schools such as SMAN 7 Semarang, which stated that the learning process in the laboratory could not be carried out because there was no practicum handbook so that the learning process was only carried out in the classroom (Siska, 2019). This also happened at SMAN 2 Batul school where the teaching materials used during the learning process in the laboratory were hand outs in the form of paper sheets made by the teacher himself and did not use practicum handbooks (Rayuni, 2016).

The above conditions are not much different from the place of observation that researchers conducted at SMAN 2 Sungai Tarab. Researchers have conducted observations on May 22, 2022 and conducted interviews with Mrs. Ferawaty, S.Pd. In the interview process, the researcher asked several things about learning media, teaching materials, learning methods, learning strategies used, and infrastructure in the classroom. When viewed from the learning media used by teachers, namely power points that are already interesting. The teaching materials used are textbooks.

Based on this condition, a solution is needed to solve the problems faced at the school, namely by developing a practicum handbook. The practicum handbook is a guideline for practicum implementation which contains procedures for preparation, implementation of data analysis and reporting. With the existence of a practicum handbook can be a source of learning support during practicum, students know how to work to do practicum and can increase student interest in practicum activities so that students can better understand the material compared to school textbooks that contain procedures for the process of doing practicum and testing student understanding.

The practicum handbook that researchers will develop based on solving these problems is based on Green Chemistry. Green chemistry practicum handbook is a practicum handbook using chemical techniques and methods to reduce or eliminate the use of product base materials, by-products, solvents, reagents, which are harmful to human health and environmental problems. Green Chemistry-based practicum handbooks aim to prevent pollution or reduce the use or production of hazardous materials.

2. Method

The research method that researchers use is development research or also called Research and Development (R&D), which is a learning system design model that can be applied to make and develop products (Sugiyono, 2018). In this case the product that the researcher produces is a Green Chemistry-Based Chemistry Practicum handbook for 11th Grade ScienceStudents.

3. Results and Discussion

Research with the title " Exploring Green Chemistry: A Practicum Handbook for 11th Grade Science Students ." With the Reasech and Developemt (R&D) approach has been completed by researchers. The research was conducted at SMAN 2 Sungai Tarab, this research was conducted using the 4D model, namely (define, design, development, and disseminate), but the researchers only carried out until the develoment stage. For each activity will be explained in the sub chapter below.

3.1. Define Stage.

The define stage is carried out to find out an overview of the conditions and problems found in schools and find solutions, the needs of students, and learning objectives. The define stage includes several stages, namely: needs analysis, material analysis, teaching material analysis and learning objectives analysis.

3.1.1. Needs Analysis

At this stage the researchers conducted interviews with chemistry teachers and students at SMAN 2 Sungai Tarab. The interview was conducted with Mrs. Ferawaty, S.Pd.

3.1.1.1. Interview with chemistry educator of 11th Grade

At this stage, an analysis of the chemistry learning process was carried out with chemistry educators. In conducting interviews, there were several questions that researchers asked related to learning tools that would be prepared by educators before entering the classroom, including models, approaches, methods, teaching materials, media, and learning facilities and infrastructure. Educators said that chemistry learning at school had been carried out in accordance with the demands of the curriculum used at school. One example is that educators have used a discovery learning model with student centered learning and the method used is discussion. The learning model used by educators in delivering the material is good. This is because before the educator teaches the material to be delivered, the educator first prepares a learning model that is in accordance with the material to be delivered. The learning model is prepared by educators as a guide in conducting learning that is systematically arranged to achieve learning objectives. Based on interviews with chemistry teachers, it was found that the problem in the learning process in the laboratory was due to the limitations of chemical tools and materials. Due to the limitations of chemical tools and materials, the learning process in the laboratory is not carried out and learning is carried out in a class where the material is only explained by the teacher. So that students do not understand the material conveyed by the teacher.

3.1.1.2 Learner Interview

Learner analysis was conducted by conducting interviews with 11th Grade Science students at SMAN 2 Sungai Tarab. During interviews with students, researchers also asked questions related to learning media, learning facilities and infrastructure, learning models, and teaching materials used during chemistry learning.

Some students said that the learning models, learning methods, and learning media used by educators when learning chemistry were good enough. Because educators have used models, learning methods that vary when learning chemistry. However, some students said that they did not understand the practicum process because there was no book for the practicum handbook used so that the practicum and material were poorly understood by students.

3.1.1.3. Analysis of Learning Materials

At this stage the researchers analyzed the material contained in the syllabus of chemistry 11th Grade Science even semester. Based on the contents of the syllabus, there are several learning materials in 11th Grade Science even semester, namely: (1) Acid-base properties in everyday life; (2) Salt hydrolysis; (3) Properties of colloids; (4) Properties of buffer solutions; (5) Acid-base titration.

3.1.1.4. Analyzing The Teaching Materials used by The Teacher

At SMAN 2 Sungai Tarab, the teaching material used is a package book entitled "Chemistry for SMA/MA 11th Grade" with the publisher Erlangga. This teaching material is used by teachers during the learning process in the classroom and also in the laboratory. The teaching materials in the form of package books contain a lot of material that teachers can convey during the learning process in the classroom, but the lack of methods or instructions during the learning process in the laboratory makes it difficult for students to carry out learning in the laboratory.

3.1.1.5. Determination of learning objectives

Determination of learning objectives is based on Basic Competencies (KD) and Indicators. Based on the results of the

formulation of Core Competencies (KI) in the syllabus, a product is produced in the form of a Green Chemistry-Based Chemistry Practicum handbook for 11th Grade Science Students. The purpose of producing this product is to facilitate the teacher in the learning process in the laboratory and also make it easier for students and teachers in using tools and materials during chemistry practicum.

3.2. Design Stage (Planning Stage)

The design stage (planning stage) aims to deliver a prototype of learning devices where this stage includes the planning stage and the implementation stage. This Green Cemistry-Based Chemistry Practicum handbook for 11th Grade Science Students is designed and developed based on the material in the syllabus.

3.3. Develop Stage (Development)

At this stage of development, the practicum handbook and research instruments that have been designed are then validated by the validator. After being validated by the validator, the practicality test was then carried out in one class.

Table1. Validation results of the validation test sheet for the Green Chemistry-Based Chemistry practicum handbook for 11th Grade Science Students

No	Validator Assessment	Validator			Amount	Max. Score	%	Validity
		1	2	3				
1	Questionnaire format	3	4	4	11	12	91.66	very valid
2	Language used	6	8	7	21	24	87.50	very valid
3	Questionnaire questions	11	12	11	34	36	94.44	very valid
	Total	**20**	**24**	**22**	**66**	**72**	**91.66**	**very valid**

In the table it can be seen that the format, language and questionnaire items get a very valid score with an average of 91.66%, so the validation sheet is suitable for use. After carrying out the validity of the practicum handbook validation sheet, the validation of the green chemistry-based chemistry practicum handbook for 11th Grade Science students can be seen in full in the appendix. In general, the results of the validation of the practicum handbook can be seen in table 1.

Table 2. Analysis of the results of the Green Chemistry-Based Chemistry practicum handbook validation sheet for 11th Grade Science students

No	Validator Assessment	Validator			Amount	Max. Score	%	Validity
		1	2	3				
1	Didactic Requirements	18	22	22	62	72	86.11	Very Valid
2	Construct Requirements	36	36	37	109	120	90.83	Very Valid
3	Technical Requirements	13	12	14	39	48	81.25	Very Valid
4	Green chemistry model	6	8	8	22	24	91.66	Very Valid
	Total	**73**	**78**	**81**	**232**	**264**	**87,46**	**Very Valid**

The table 2 shows that the results of the validation of the green chemistry-based chemistry practicum handbook for 11th Grade Science overall this practicum handbook is categorized as very valid with an average percentage of 87.46%. Thus this practicum handbook is in accordance with the syllabus and learning objectives that already refer to the 2013 curriculum, the writing and appearance of the practicum handbook is interesting. This practicum handbook is based on green chemistry. The language of the practicum handbook is communicative and the physical form of the magazine is attractive and as desired.

Table 3. Analysis of the validation results of the validation sheet for the practicality of the Green Chemistry-Based Chemistry practicum appointment 11th Grade Science

No	Validator Assessment	Validator			Amount	Max. Score	%	Validity
		1	2	3				
1	Questionnaire format	3	4	3	10	12	83,33	Very valid
2	Language used	6	8	6	20	24	83,33	Very valid
3	Questionnaire questions	11	12	9	32	36	88,88	Very valid
	Total	**20**	**24**	**18**	**62**	**72**	**86,11**	**Very valid**

Tab In Table 3 it can be seen that the format, language and statement items of the questionnaire get a very valid score with an average of 86.11%, so the questionnaire for students' responses is suitable for use. Furthermore, to find out the teacher's response to the implementation using a green chemistry-based chemistry practicum handbook at SMAN 2 Sungai Tarab. The results of the validation of the practicality sheet can be seen in the appendix. In general, the analysis of the results of the teacher's practicality sheet can be seen in table 4.

Table 4. Analysis of the validation results of the validation sheet for the practicality of the Green Chemistry-Based Chemistry practicum appointment 11th grade science by the teacher.

No	Validator Assessment	Validator			Amount	Max. Score	%	Validity
		1	2	3				
1	Questionnaire format	3	4	4	11	12	91.66	Very valid
2	Bahasa yang digunakan	6	8	7	21	24	87.50	Very valid
3	Questionnaire questions	11	12	11	34	36	94.44	Very valid
	Total	**20**	**24**	**22**	**66**	**72**	**91.66**	**Very valid**

In table 4. it can be said that the questionnaire format, the language used, and the questionnaire items have been categorized as very valid, with the average obtained being 91.66%. It can be stated that the anget is feasible to use.

Table 5. Analysis of Practicality Test Results by Students

No	Assessment Aspect	Total	Max. Score	%	Practicality
1	Ease of Use	512	576	88,88	Very Practical
2	Learning time efficiency	158	192	82,29	Very Practical
3	Benefits obtained	490	576	85,07	Very Practical
	Total	**1160**	**1344**	**85,41**	**Very Practical**

By the data analysis of the students' response questionnaire, it can be seen that the percentage obtained is 85.41% with a very practical category. The first aspect of determining the quality of learning products is validity (Haviz, 2013: 33). Product validity is carried out with certain steps. Product validation is an activity carried out by presenting several experts or experts who have experience to assess the new product designed. The link in this development is two experts in the field of media and material. Each expert is asked to assess the product design, so that its weaknesses and strengths are known (Purnama, 2016: 24). The purpose of the validity test is to evaluate the chemistry practicum handbook that has been developed. The validity stage of the chemistry practicum handbook is carried out so that the green chemistry-based chemistry practicum handbook developed can be known for its feasibility based on the validator's assessment. The validity of the practicum handbook can be seen from the results of the review and validation results from the validator.

Based on the validation of the Biology Magazine Based on Contextual Learning has been validated by 3 validators, namely 2 lecturers and 1 person with a biology teacher at school, declared valid with a presentation of 87.46%. This is in accordance with the validity assessment criteria put forward by Riduwan (2010), that the validity value with a range of 81%-100% is declared a validity value with very valid criteria. This means that the green chemistry-based chemistry practicum handbook 11th Grade Science is in accordance with the criteria that have been included in the validation sheet which includes aspects, namely didactic aspects which include 6 assessment points with an average validity of 86.11%, aspects of construct requirements which include 10 assessment points with an average validity of 90.83%, aspects of technical requirements which include 4 assessment points with an average validity of 82.25%, and aspects of green chemistry-based chemistry practicum handbooks which include 2 assessment points with an average of 91.66%.

Based on the results of validation by validators and improvements after revision, the green chemistry-based chemistry practicum handbook product is considered very valid by validators with an average percentage of 87.46% and can be used for the learning process. The feasibility of practicum handbooks used in learning has fulfilled the four conditions assessed. These requirements include didactic requirements, construction requirements and technical requirements (Aini, et al, 2019: 68). The first requirement is the didactic requirement which obtained a presentation value of 86.11% with a very valid category. This can be seen from the learning material contained in the practicum handbook referring to the 2013 curriculum, this practicum handbook can help students become more active and independent in learning. this practicum handbook can emphasize the process of expressing opinions. this practicum handbook can be used for individual and group learning. this practicum handbook is in accordance with the characteristics of students and with the practicum handbook making the learning process more effective.

The second requirement is the construct requirement which obtained a value with a presentation of 86.11% with a very valid category. This can be seen from the practicum handbook has a clear identity (cover, title, and material), has an introduction, has rules and regulations when in the laboratory, has an introduction to laboratory equipment and its functions, has symbols of hazardous materials, has 12 principles of green chemistry. This practicum handbook has a clear and simple sentence structure, uses appropriate language and is easy to understand and uses good and correct Indonesian language rules. for aspects of the green chemistry model obtained a percentage of 91.66% with a very valid category which means that this practicum handbook already has material that is in accordance with the green chemistry learning model, namely by using materials and tools effectively and efficiently and minimizing the formation of waste or waste from practicum.

So overall, the practicum handbook that the researchers developed can be said to be very valid because it received an assessment from the validator of 87.46%. Based on the assessment given by the validator, all the requirements of the practicum handbook have been declared very valid both from the didactic requirements, construct requirements, technical requirements and the green chemistry model.

4. Conclusion

Based on the results of the data analysis of green chemistry-based chemistry practicum handbooks that the authors have done up to the practicality stage, it is concluded that at the feasibility stage of green chemistry-based chemistry practicum handbooks based on validation results obtained 87.46%, with a very valid category. At the practicality stage based on the student response questionnaire, the results were 85.41%, with a very practical category.

5. Recommendations

For the next research so that more material can be practiced and preferably chemistry labor in schools is even better.

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