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The Development of Teaching Aids with Green Chemistry as A Learning Media for Thermochemical Materials

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Abstract

This development research aims to: (1) Develop simple thermochemical teaching aids (2) Practical activities with the concept of green chemistry that were environmentally friendly and safe to use (3) Obtain teacher responses to thermochemical teaching aids with green chemistry as an alternative to the limited pre-practicum facilities. The development model used in this research was the 4-D model by Thiagarajan, Semmel, and Semmel which had been modified from four stages to three stages, namely: (1) Define (2) Design and (3) Development. The stages carried out include (1) preliminary studies (2) product development and (3) product testing. The results of the preliminary study indicated that the development of teaching aids as a substitute for practicum activities was needed due to the limited existing facilities and infrastructure. Also, because thermochemical material had a high level of understanding and the abstractness of the concept, it was necessary to carry out practicum activities. The use and development of calorimetry props was an alternative in the implementation of thermochemical material practicum activities and by utilizing waste, it was possible to present simple calorimetry props that were environmentally friendly and safe to use. The results of product development in the form of props obtained the validity of the material with the results of 0.89 and the validity of the media with the results of 0.90, therefore the validation results of the props were categorized as valid. The practicality of the teaching aids was Green chemistry 88%, the result shows that the teaching aids developed were very practical so that these props were suitable for practicum. While the results of the teacher's response to the teaching aids with an overall average of 3.75 (maximum score of 4), based on these results indicate that the overall response of students to the teaching aids was very good.

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INTRODUCTION

Chemistry is the science of understanding and engineering matter, in the sense of turning a material into another. Engineering can be done by an expert by understanding chemistry, namely knowing the composition, structure, and properties of matter (Purba, 2012). Chemistry includes chemical knowledge in the form of facts, theories, principles, and laws based on scientific findings and scientific work. Chemistry is a study of natural sciences that is mostly discussed about chemical reactions that contain interactions between atoms so that it tends to be abstract (Kean & Middlecamp, 2010). This leads to many concepts that students find difficult to understand. The ability to apply chemical concepts is very important for students to have. This is in line with research conducted by Kaur (2010), that the benefits of understanding the application of a concept can improve the purpose of learning, namely connecting subject matter problems with real-world problems. Therefore, it takes the right means/media to teach the concept of chemistry. One of the most appropriate ways to teach the concept of time is by practicum.

There are constraints on the implementation of a practicum activity due to inadequate facilities and pre-facilities to carry out practicum activities in schools. Some experimental activities cannot be carried out because practicum tools have never been made before and the purchase price of tools is relatively expensive (Hofstein & Naaman, 2007). One of the efforts to keep practicum activities carried out can be done by developing simple practicum props. Props are tools in the learning process so that the concept taught is easy to understand by students (Widiyatmoko & Nurmasitah, 2013). The use of props is very appropriately applied in chemistry learning because in general chemistry has a high concept validity. With the use of props, it is expected that abstract concepts can be more easily understood by students (Arifin, 2003).

One of the simple props media that can be used in the practicum of learning the chemistry of thermochemical materials by using calorimetry props derived from waste materials. Thermochemical are materials considered difficult by students (Nurfidianty et al. 2015). The availability of this tool is usually only small in schools, making it difficult for teachers to practice. Therefore, in this study researchers want to create props that can be used to replace calorimetry tools with simple tools, easy in a can, and environmentally friendly, and safe to use by practice. In line with this, the concept of Green chemistry is one of the solutions. The use of Props based on Green Chemistry aims to ensure that students have discipline and concern for the environment, especially in handling chemicals, shaping behavior to participate in environmental maintenance (Arifin, 2009).

Based on the description, researchers intend to develop props loaded with Green chemistry as a medium of chemical learning of thermochemical materials so that it is expected to make learning more meaningful according to scientific approach and the use of Green chemistry that is environmentally friendly.

METHOD

The research design used in this research is R&D (Research and Development). The development model used is a modified 4-D model as suggested by Thiagarajan et al. (1974), which consists of define, design, development, and disseminate. This research was done modification of the 4-D model, namely simplification from four stages to three stages, namely define, design, and development.

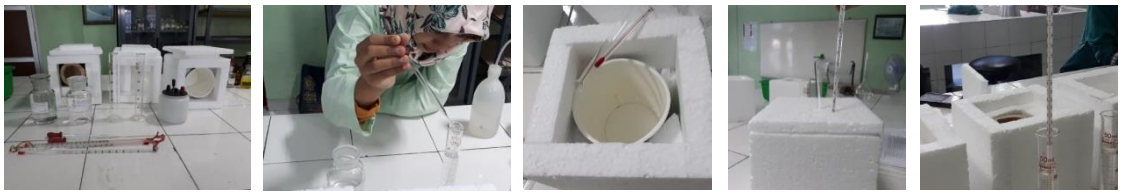
Define activities are carried out by researchers to define and define the requirements needed in the development of props, which include Front end analysis, Learner analysis, Task analysis, Concept analysis, Specifying instructional objectives. The Design aims to design calorimetry props that can be used in the learning process, with the stages of Construction Criterion-Referenced Test, Media Selection, Format Selection, Initial design. The Development is a stage that is done by testing materials and media (props), then test results are used for revision so that the props can be used and adjusted to the needs.

RESULT AND DISCUSSION

Results of Props Development

Props developed was calorimetry charged Green Chemistry made from waste / used materials. Utilization of instant noodle Styrofoam cup, plastic bottle, and bamboo as one of the simple alternative tools that could be used in thermochemical practicum as a substitute for calorimetry.

The development of props is presented in Figure 1.



(a) *(b)* *(c)* *(d)* *(e)*

(a) Set of calorimetry props (b) Measurement of HCL and NaOH concentration (c) Props that have been given solution (d) Temperature measurement of HCL solution and NaOH (e) Props trial.

Figure 1. Green Chemistry-laden Set of Props

Prop Feasibility Testing

The development of Green Chemistry charged calorimetry props then tested their accuracy value using calorimeters commonly used in practicum. Practicum determined the change of enthalpy reaction by using volume variation. It was done to find out if a slight volume change in temperature was still visible. The volume variations used are 25mL, 50ml, and 100mL. The results obtained that with the amount of volume 25ml was still detected temperature changes very well. It was matched by one of the principles of Green Chemistry, namely prevention to minimize the formation of waste. The results of the tests at this stage are presented in Table 1.

Table 1. Props Testing Results

Tool	Simple Calorimetry	Calorimetry (Sterofoam)	Calorimetry (Bamboo)	Calorimetry (Plastic)
Initial solution temperature (NaOH)	31	31	31	31
Initial solution temperature (HCL)	31	31	31	31
Final temperature of the mixture	35	35.5	36	35.5
q Reaction	- 3.344 kJ/mol	- 3.762 kJ/mol	- 4.180 kJ/mol	- 3.762 kJ/mol

The test results of the props stated that the tool could measure the exact temperature detected. Practicum results have an error rate percentage value of 0.52%. in addition, this Green Chemistry-charged calorimeter prop was worth using for thermochemical practicum.

Prop Validation Results

The Green chemistry charged calorimeter used in this study had been validated by 3 validators. Validation was carried out by 3 expert experts (2 lecturers in Walisongo Semarang and 1 chemistry teacher at Nusa Bhakti Senior High School). The validator provides advice for improvement the calorimetry developed. The advice given by the validator then used as a reference for the development of props. The data from the validation of props containing Green Chemistry was presented in Table 2, Table 3, and Table 4.

Table 2. Green Chemistry Props Material Validation Results

No	Components	Validator Score			Mean	Validity Value	Criteria
		1	2	3			
1	Conformity with the concept of calorimetry	4	4	4	4	1	Valid
2	Performance Tools	4	4	4	4	2	Valid
3	Relation to learning materials	4	3	3	3.33	3	Valid
4	Educational Value	3	3	4	3.33	4	Valid
	Average Number					0.89	Valid

The results of the expert validation assessment of Green chemistry calorimetry received a valid assessment, with an average validity value of 0.89. Therefore, the practicality of Green Chemistry props could be used in learning

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Table 3. Green Chemistry Props Media Validation Results

No	Components	Validator Score			Mean	Validity Value	Criteria
		1	2	3			
1	Durability Tools	3	4	3	3.33	0.78	Valid
2	Tool Accuracy	4	3	4	3.67	0.89	Valid
3	Tool Efficiency	4	4	4	4	1	Valid
4	Usage Security	4	4	4	4	1	Valid
5	Aesthetic	3	3	4	3.33	0.78	Valid
6	Completeness Tools	4	4	4	4	1	Valid
7	Kit Box	4	4	3	3.67	0.89	Valid
	Average Number					0.90	Valid

The expert validation assessment component of the green chemistry calorimeter got a valid assessment, with an average validity value of 0.90. Therefore, the practicality of Green Chemistry props could be used in learning.

Table 4. Greem Chemistry Props Media Validation Results

No	Components	Validator Score			Mean	Validity Value	Criteria
		1	2	3			
1	Acces	3	4	3	3.33	83%	Practical
2	Coast	4	3	4	3.67	92%	Practical
3	Technology	4	4	4	4	100%	Practical
4	Care	3	3	3	3	75%	Practical
5	Facilities	3	3	4	3.33	83%	Practical
6	Organization	4	4	4	4	100%	Practical
7	Tools	4	4	4	4	80%	Practical
8	Novelty	4	4	3	3.67	92%	Practical
	Average Number					88%	Practical

The results of the practical validation assessment of props had an excellent level of practicality with an average practicality value of 88%. Therefore, props loaded with Green chemistry can be used in learning.

Results of the teacher's response to teaching aids

The results of the teacher response data analysis showed that out of 20 teachers, 15 teachers or 75% of 20 teachers gave excellent responses to the teaching materials developed, 5 teachers or 25% of 20 teachers gave good responses. If converted into positive and negative criteria, then the data showed that 100% of the teachers responded positively to the teaching aids Green Chemistry developed. The complete results of the student response questionnaire could be seen in Figure 4.

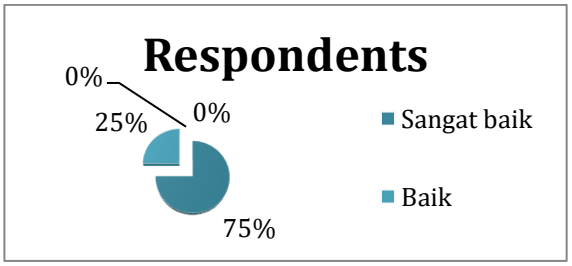

Figure 4. Results of the theacer's response to teaching aids

Figure 4 showed that overall teacher at the implementation stage gave an excellent response to the use of green chemistry charged props with an average score of 36,38 out of a total score of 40. If converted into positive and negative criteria, then the data showed that 100% of teachers gave a positive response to Green chemistry charged props developed. Based on these results showed that overall, the teacher's response to green chemistry charged props was excellent.

The data from this observation showed the initial condition of the learning process, especially regarding the practicum that took place in schools. The preliminary research was conducted through observation in interviews with chemistry teachers of Nusa Bakti High School Semarang related to the learning of chemical practicum. Preliminary research was conducted to obtain information about practicum that had been done in the learning process, problems faced by teachers in chemical practicum.

Thermochemical material practicum activities had been carried out in several schools but were still limited to observation and proof of concepts or principles that had been studied. This was due to inadequate facilities and pre-facilities and fewer supportive facilities to carry out practicum activities in, beside kat the chemical learning process used by teachers were still in the conventional context, plus the demands of a dense curriculum causing teachers only delivering materials, in addition the material that should be delivered with practicum activities was still much unrealized.

Thermochemical practicum usually uses a tool called Calorimeter The availability of tools was limited that teachers found it difficult to perform practicum activities, therefore it was necessary to create props that could be used as replacing the calorimeter tool with a simple tool. Tools that are easy to get and related with the concept of Green Chemistry so that students have discipline

and concern for the environment, especially in handling chemicals, forming behavior to participate in environmental maintenance.

CONCLUSION

Props developed was calorimetry charged Green chemistry made from waste / used materials. Utilization of instant noodle sterofoam cup, plastic bottle, and bamboo as one of the simple alternative tools that could be used in thermochemical practicum as a substution for calorimeter.

A simple calorimeter prop developed using 3 principles of Green chemistry. The first was prevention to minimize the formation of waste. The second was the use of renewable feedstocks that the researchers developed using wasted from used goods that can be recycled. The last principle was interantly safer chemistry for accident prevention, the props were used because it was safe for students. Aspects of Green Chemistry were minimizing hazardous substances, use of reaction catalysts and chemical processes, the use of non-toxic reagents, the use of renewable resources, increased atomic efficiency, the use of environmentally friendly and re-recycling solvents. Green chemistry aimd to develop chemical processes and chemical products that were environmentally friendly and in accordance with sustainable development

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