

2018 The development of learning material

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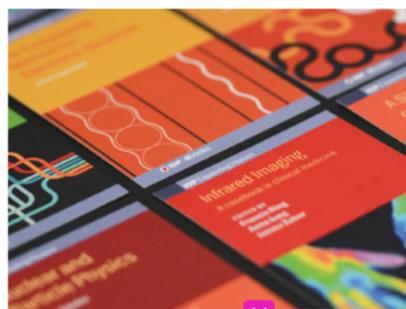
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6 The development of learning material using learning cycle 5E model based stem to improve students' learning outcomes in Thermochemistry

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20 **Abstract.** The objective of this study is describing the feasibility of Learnig Cycle 5E STE (21 science, Technology, Engineering, and Mathematics) based learning material (15) which is appropriate to improve students' learning achievement in Thermochemistry. The study design used 4-D models and one group pretest-posttest design to obtain the information about the improvement of sudents' learning outcomes. The subject was learning cycle 5E based STE (2) learning materials which the data were collected from 30 students of Science class at 11th Grade. The techniques used in this study were validation, observation, test, (9) and questionnaire. Some result attain: (1) all the learning materials contents were valid, (2) the practicality and the effectiveness of all the learning materials contents were classified as good. The conclusion of this study based on those three condition, the Learnig Cycle 5E based STEM learning materials is appropriate to improve students' learning outcomes in studying Thermochemistry.

12 1. Introduction

Education plays an important role in preparing qualified human resources as the next generation of the nation. A good quality of education will create quality human resources as well so the government has some rules for educational institutions in organizing all activities.

Now days, Indonesia is implementing Curriculum 2013. One of the requirements of education according to the curriculum of 2013 is it should be able to support the improvement of student learning outcomes in three domains; those are cognitive, affective, and psychomotor skills. In order to achieve these objectives, the learning activity in the educational unit is must be interactive, inspirative, fun, challenging, motivating, and provide sufficient space for initiative, creativity, physical-psychological talk (5), and able to get the students to have 21st century skills.

Learning involves acquiring and modifying knowledge, skills, strategies, beliefs, attitudes, and behaviors. People learn cognitive, linguistic, motor, and social skills, and these can take many forms [6]. Learning materials are required in every learning activity such as Student Book and Worksheet. Learning materials must have the criteria of validity (content and construct validity), practicality, and effectiveness [7].

The new learning process according to the curriculum of 2013 along with the completeness of learning tools is expected to improve student learning outcomes in three aspects namely knowledge, attitude and skills namn facts in the field showed the opposite results, especially in SMA Muhammadiyah 3 Surabaya where the students' average of 50.6 under the school's standard score that is 80. The result of the chemistry teacher interviews stated that the lowest student learning outcomes in 11th grader is Thermochemistry. It is found some of reason the problem accuses such low understanding of Hess law and Enthalpy concept, confusion understanding bond and its energy and confusion

distinguish between kinetic energy and bond energy among atoms moreover when it comes to energy of a reaction [8]. Some students tend to lose their prior concept such as heat, enthalpy, and bond energy after doing more mathematical problem in the chapter [9]. It shows that they do not get the multidisciplinary study such mathematics and physics involved in studying Thermochemistry so the application in engineering and technology field [10].

Based on the problem stated above, it is necessary to provide learning activity which bring multidisciplinary to improve and help them construct their own concept understanding. One of learning model which is corresponded to constructivist theory is Learning Cycle 5E [3] and learning designed using the STEM approach or can be said Learning By Design (LBD) has a positive and significant effect on students' cognitive learning outcomes compared to learning that only flows without any discouragement there in such as traditional learning or Teacher center learning [3]. The STEM approach itself is a combination of four disciplines (science, technology, engineering and math) as well as which can be incorporated into the model or applied as a curriculum unit. [1] The Learning Cycle 5E learning model with the STEM approach fits in the Thermochemical material because the material characteristics of the Thermochemistry are abstract and are a tiered concept from a simple to a higher concept and demands mathematical ability of students; often students are less aware of the importance of thermochemistry in life. The five phases of Learning Cycle 5E and the STEM approach makes learning inter disciplines can benefits to their learning [4] and gives student opportunities to get 21st century skills such as problem solving, analysis, adaptability, communication and self-management.

2. Research Method

This study used 4D model and one group pretest-posttest design. The data was attain at Science class consist of 30 students at 11th grade at Muhammadiyah High School 3 Surabaya Year 2017-2018

- Validation. This technique is used to determine validity by the expert consisting of the Lesson Plans, Student Textbook, work Sheet, and Knowledge Test.
- Questionnaire. This technique is used to measure students' opinions or responses learning materials . This questionnaire covers the legibility of Student Textbook, student worksheet, and students' responses to learning.
- Observation. This technique aims to collect research data on the implementation of Lesson Plans, student activities, observation of attitudes, skills, obstacles encountered during the learning process.
- Concept mastering tests. The test of concept mastery is conducted through pretest and posttest in accordance with learning objectives and indicators listed in the Lesson Plans. This is to determine the effect of learning on improving the mastery of student concepts.

3. Result and Discussion

3.1 Validation

Learning materials developed using the 4D model are then validated by three validators as experts. Learning tools in this research are lesson plan, student textbook, worksheet, and concept mastery test. Based on the validation result, the four learning materials are valid with the result score presented in Table 1

Tabel 1. Validation score.

No.	Learning Materials	Average Score	Category
1.	Lesson Plan	3.6	Very Valid
2.	Worksheet	3.62	Very Valid
3.	Students Textbook	3.61	Very Valid
4.	Mastery Concept Test	3.77	Very Valid

Thus, the device is suitable for use in the learning process in the subject matter of thermochemistry

3.2 Learning Implementation

Learning implementation is observed to determine the application of learning model using observation sheet which is filled by three observers during the learning, as many as three meetings. The percentage score of learning implementation can be seen in

Table 2. Learning implementation.

Meeting	Aspect		Learning Implementation (%)
	Lesson plan	Done	
1	20	20	100
2	20	20	100
3	20	20	100

The observation of the implementation of the lesson plan shows that the teacher has done all learning steps (syntax) well.

3.3 Students' activity

Observation of 28 dents learning activities during the learning process as many as 3 times meeting by three observers can be seen in Figure 1.

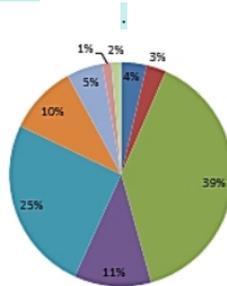
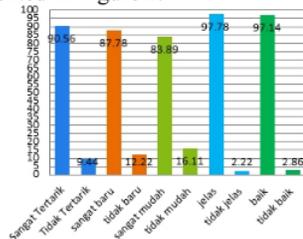


Figure 1. Students activity.

Figure 1 shows the percentage of students' activities, some of which dominate by 39% reading textbooks, 25% of discussion and questioning, 11% doing experiments and irrelevant behavior only 2%. This shows that learning using Learning Cycle 5 E based on STEM is Student Center learning whereas students' irrelevant behavior is caused by some students not yet familiar with new learning model.

3.4 Students Response

After three meetings have been done, students are asked to fill out a student response questionnaire to find out the students response to Learning Cycle 5 E learning. The result of students' response is presented in Figure 2.



Description:
 Opinion 1: Student's attraction to the learning component
 Opinion 2: The renewal of the learning component
 Opinion 3: Students' ease in understanding the learning component
 Opinion 4: Clarity of how to teach teachers in guiding students during KBM
 Opinion 5: How teachers use learning
 Opinion 6: Student ease in answering items
 Opinion 7: Students interest to follow the learning model

Figure 2. Student response to learning.

The overall average value of student responses to the learning model of 91.40% so categorized the response of students is positive (over 81%). Positive student response results can be concluded that students receive well all the components in supporting the improvement of student learning outcomes.

3.5 Mastery Concept Test

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Result of students' mastery concept shown in the Table 3

Table 3. Learning outcomes completion.

Students	Pre			Post			n-Gain	category
	Score	Description	Category	Score	Description	Category		
1	27	Failed	D	87	P	B	0.82	High
2	27	Failed	D	86	P	B	0.81	High
3	26	Failed	D	70	Failed	D	0.59	Midle
4	40	Failed	D	76	Failed	D	0.60	Midle
5	22	Failed	D	87	P	B	0.83	High
6	32	Failed	D	92	P	A	0.88	High
7	29	Failed	D	88	P	B	0.83	High
8	31	Failed	D	86	P	B	0.80	High
9	20	Failed	D	80	Failed	C	0.75	High
10	20	Failed	D	80	P	C	0.75	High
11	21	Failed	D	89	P	B	0.86	High
12	45	Failed	D	74	Failed	D	0.53	Midle
13	30	Failed	D	83	P	C	0.76	High
14	25	Failed	D	70	Failed	D	0.57	Midle
15	25	Failed	D	90	P	B	0.87	High
16	27	Failed	D	83	P	C	0.77	High
17	27	Failed	D	91	P	A	0.88	High
18	33	Failed	D	95	P	A	0.93	High
19	20	Failed	D	73	Failed	D	0.66	Midle
20	20	Failed	D	94	P	A	0.93	High
21	21	Failed	D	93	P	A	0.91	High
22	24	Failed	D	83	P	C	0.78	High
23	26	Failed	D	91	P	A	0.88	High
24	32	Failed	D	88	P	B	0.82	High
25	23	Failed	D	68	Failed	D	0.71	High
26	32	Failed	D	77	Failed	D	0.66	Midle
27	35	Failed	D	90	P	B	0.85	High
28	15	Failed	D	72	Failed	D	0.67	High
29	25	Failed	D	87	P	B	0.83	High
30	25	Failed	D	81	P	C	0.75	High

P: Passed

First, all students did not pass the pretest but at the time of posttest 23 students passed the test. Student completeness in learning reaches 19.33% with high n-gain score.

Based on pretest and posttest results, it can be concluded that learning 5E learning cycle model with STEM approach can improve students' concept mastery of the material presented by the teacher, as indicated by the gain-score on all students who follow the learning process with the average 0.80 or high category.

Learning 5E learning cycle model with STEM approach is effective to improve students' concept mastery, because the learning stages experienced by students are in accordance with the students' cognitive development that is formal operational stage; a stage where the students can already think abstractly/symbolically and solve the problem through experiment [3]. Learning 5E learning cycle

model with STEM approach has five stages (engagement, exploration, explanation, elaboration, and evaluation) with four disciplines of Science Mathematics technology and Engineering applied in it.

Engagement stage is the first stage where students are given apperception and motivation in the form of phenomena close to everyday life. Ausubel states that meaningful learning is a process in which new information is linked to the knowledge structures that a learned person already possesses. This is supported by Thorndike in his theory that the relationship between stimulus and response will be good if there is readiness in the individual. The intended stimulus is the material that will be studied by the students, so that if students do not have readiness to accept the material taught, then the students will not be able to follow the learning well.

The next stage is the exploration stage. This stage is an important stage because at this stage students begin to learn the material. Vygotsky introduced a learning theory called social learning theory. Vygotsky states that knowledge is shaped by the students as a result of the students' own thoughts and activities through language. [6] The learning process takes place when students struggle with problems that are within their means, which is better known as the zone of proximal development. This is the developmental level of ability is slightly above the area of a person's developmental abilities when learning. Vygotsky also introduces the term scaffolding in the learning process, which is providing assistance to students during the early developmental phase which is subtracted little by little and gives students full opportunity to take full responsibility. This is the basis for the researchers to divide the students into heterogeneous learning groups, which means that within the study group each student has a variety of abilities. It is intended that students who have more ability to provide assistance to friends of his group who find it difficult to understand the concept.

This stage provides an opportunity for students to make the most of their senses in interacting with the environment through activities such as experimenting, analyzing, discussing natural phenomena, observing natural phenomena or social behavior, and so on. Students are asked to make predictions, develop hypotheses, design experiments, collect data, draw conclusions, etc. with not only doing or studying with science students' concepts can also utilize the disciplines of technology and mathematics to achieve the goals of this phase.

The next stage is explanation, giving students the opportunity to meet the questions intended to train students to analyze the results of the experiments as well as the questions given by the teacher on the phenomena that the students have observed. Activities in this phase aims to complement, refine and develop the concepts obtained by students. Students are required to explain the concepts being studied in their own sentences. In this phase students find the terms of the concepts studied. Piaget argues that there are two important processes that occur in the development and growth of cognitive children, namely assimilation and accommodation. Assimilation is the process of adjusting or matching new information to what is already known. When an individual receives new information or experience then the information will be modified to fit the cognitive structure he or she has. Accommodations are a process by which a child prepares and rebuilds or modifies what has been known, so that the new information can be better adapted. [6] By asking students to submit their observations there is a stage of exploration will get of assimilation and accommodation in learning activities, students built concepts will be stronger. With the acquisition of this stronger concept, it is expected that students can use new concept to solve problems in everyday life.

The next stage in Learning Cycle 5E with STEM approach, is the Elaboration stage. This stage provides students the opportunity to utilize the concepts they have accomplished to solve other problems. This stage also provides an opportunity for students to trace their psychomotor aspects by utilizing engineering disciplines students are able to create a product or procedure that can be useful to solve the problems around it. Other disciplines that can support this phase are the disciplines of mathematics and technology. Students need to understand the basic principles of the product or procedure that they make in accordance with current technology and have accuracy values that suit their needs. In this study when students try to make products or procedures, students must first understand the concept of science that has been obtained, then students create products or procedures by utilizing technology and take into account the accuracy or accuracy using mathematical skills useful for life

The last stage of Learning Cycle 5E model with STEM approach that very important to do, is the evaluation stage. The acceptance of information learned by students from short-term memory to term memory requires support or things that can help the storage process into long-term memory to organize the information received into its long-term memory. Thorndike put forward a law called the Law of Exercise. This law states that the stimulus relationship with the response will be strong if followed by the exercise, and this relationship will be weakened if not used or terminated. Based on the law, it is very important for the teacher to give the students the opportunity to retrain the concept that he got through the exercise, so it will strengthen the stimulus relationship provided by the teacher with the student response. The teacher-training exercises aim to strengthen students' self-conceptual understanding, through the exercises they will often recall the concepts they learn so that they can be stored in long-term memory where the knowledge is stored in a permanent to be called again later, if you want to use [5] In addition to providing practice questions, this stage also encourages students to conclude the learning that has been done.

Improvement of Learning Outcomes is an indicator that can be used as a reference whether the learning materials was developed is effective to see the improvement of student learning outcomes, which in this case is an increase in mastery of the concept. Students are given tests before and afterward. Student learning outcomes are increase significantly which is expressed by Normalized Gain score (N-gain). The number of students who have a high n-Gain score are 9 students and one students have failed.

Increasing of students learning outcomes with student activity are closely related. The dominant student activity gives an explanation that learning cycle 5E model with STEM approach is student center and positive student response to learning shows that the learning model is suitable to be implemented in class. The new learning model and the conducive atmosphere created during the lessons make it possible to improve student learning outcomes.

4. Conclusion

The research, showed the mastery of concepts students is improved so that it can be concluded that the Learning Cycle 5E with STEM approach is effective to improve the mastery of students' concepts in Thermochemistry

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