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Elicit-Predict-Confront-Observe-Explain-Reinforce (EPCOER) Learning on Thermochemistry to Reduce Alternative Concept among Students with Different Initial Knowledge

Berlian Enggarani*, Suhadi Ibnu, Aman Santoso
Chemistry Education-Universitas Negeri Malang
Jl. Semarang 5 Malang 65145, Jawa Timur, Indonesia. E-mail: berlianenggarani@gmail.com*

Abstract: This study aimed to reduce the alternative concepts of students with EPCOER learning models and POE learning models on thermochemical material. This study used a test instrument in the form of three tier tests having 98% content validity. Cronbach Alpha reliability coefficient of 0.881 with a very high category. The research was conducted in two research classes at high school. The results showed a decrease in the alternative concepts that students had before learning. There were differences in the alternative concepts of students in the experimental and control classes, which students in experimental class had fewer alternative concepts compared to the student in the control class. The reduction in the alternative concepts of students were showed by the difference of students pretest and posttest scores.

Key Words: EPCOER, initial knowledge, alternative concepts

Abstrak: Penelitian ini bertujuan untuk mereduksi konsep alternatif siswa dengan model pembelajaran EPCOER dan model pembelajaran POE pada materi termokimia. Penelitian ini menggunakan instrumen tes berupa *three tier test* yang memiliki validitas isi 98% dengan kriteria sangat baik dan koefisien reliabilitas *Alpha Cronbach* 0,881 dengan kategori sangat tinggi. Penelitian ini dilakukan pada dua kelas di SMA. Hasil penelitian menunjukkan adanya penurunan konsep alternatif yang dimiliki siswa antara sebelum dan sesudah pembelajaran, di mana hasil penelitian konsep alternatif siswa pada kelas eksperimen dan kelas kontrol menunjukkan ada perbedaan. Hasil reduksi konsep alternatif siswa ditunjukkan oleh beda skor pretes dan postes siswa, di mana skor postes siswa lebih tinggi dari pada postes.

Kata kunci: EPCOER, pengetahuan awal, konsep alternatif

INTRODUCTION

Chemistry is the study of matter and its changes and is one of the important sciences for everyday life. Taber (2009) states that Chemistry has three characteristics, abstract (microscopic) concepts, mathematical (symbolic) concepts, and physical (macroscopic) concepts. Thermochemistry is one topic that has these characteristics. This topic includes the heat energy involved in a chemical reaction. One topic that is considered difficult is its chemical reaction and energy (Ayyildiz & Tarhan, 2012). According to Nahum et al, (2004), students have difficulty in understanding abstract Chemical concepts. Students cannot see energy, heat and enthalpy, so it is difficult for them to understand the concepts involved in thermochemistry and there is great potential for the formation of alternative concepts. Numerous previous studies have shown the existence of alternative concepts on the topic of Thermochemistry. According to Santini (2009), alternative concepts on the topic of Thermochemistry were found in the concept of exothermic reactions, endothermic reactions, the concept of enthalpy change writing signs in thermochemical equations for exothermic reactions and endothermic reactions, concepts of the nature of the formation and decomposition of compounds and the concept of using the formula for determining the magnitude of

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enthalpy change using standard enthalpy formation data. In addition, students cannot distinguish the concepts of heat and temperature (McDermott, 2003; Paik, et al, 2007). Students consider "heat" and "temperature" to have the same meaning and use them interchangeably (Niaz, 2006; Schönborn, et al, 2014; Yalçýnkaya, et al, 2009). Based on the description above, it is required to conduct research on thermochemical topic.

Thermochemistry is an important concept related to other chemical concepts. Hence, if students acquired alternative concepts on thermochemical topics, it is feared that students also acquired alternative concepts on other topics. Alternative concepts are conceptions that are not in accordance with general understanding and are not accepted scientifically (Wenning, 2008). Alternative concepts influence greatly in learning Chemistry. If students acquire new information that is contrary to their alternative concepts, it will be difficult for them to accept new information because they assume that the concept is wrong according to their understanding (Horton, 2007). Continous alternative concept acquired by students distracts the next conception. Learning process cannot eliminate alternative concepts, both alternative concepts and new knowledge will be stored collectively. Effective learning is not to eliminate alternative concepts, but to create situations where new knowledge is more easily invoked from brain memory than alternative concepts that students have (Effendi, 2016). Reducing alternative concepts in students requires reinforcement or affirmation of new knowledge. In addition, to prevent alternative concepts from the beginning, identification is needed on the initial knowledge students have.

Initial knowledge is defined as multidimensional and hierarchical entities that are dynamic and consist of various types of knowledge and skills (Hailikari, dkk, 2008). Early knowledge has long been regarded as the most important factor influencing student learning and achievement. The initial knowledge possessed by students often contains various alternative concepts (Suratno, 2008). Ausubel (2000) suggests that the learning process that ignores students' initial knowledge result in misunderstanding or alternative concepts of students becoming more complex and stable. Special attention from the teacher is needed. During this time, learning process often neglects students' initial knowledge, where teachers should use learning models that involve students' initial knowledge. Early knowledge that is properly organized can improve students' mastery of concepts.

Based on the explanation above, both alternative concepts and initial knowledge are closely related to learning. Conventional learning models are less effective in dealing with students' alternative concepts. Based on previous research, learning to overcome alternative concept constraints is a model that involves cognitive conflict. One way that can be used to reduce alternative concepts is to use learning models that are able to accommodate initial knowledge with cognitive conflict strategies for changing understanding. One learning model is Elicit-Predict-Confront-Observe-Explain-Reinforce (EPCOER). EPCOER is a learning model developed from the predict-observe-explain POE model combined with an ECIRR (elicit-confront-identify-resolve-reinforce). This model consolidate POE and ECIRR in which the identify and resolve stages in the ECIRR model are eliminated, then the elicit, confront, and reinforce stages are combined with the predict, observe, and explain stages. The purpose of the integration of the two learning models is to reduce student alternative concepts.

The stages of the EPCOER learning model are as follows: a) *Elicit*, the teacher will investigate and explore students' alternative concepts through activities that make students think clearly such as asking questions, dialogue, and asking students to observe a phenomenon; b) *Predict* is a process of making assumption about an event or phenomenon. The prediction is based on initial knowledge, experience, or books they have read related to the problem to be solved; c) *Confront* is facing; students are confronted with a phenomenon that aims to provide a contradiction with the statements or predictions of students, thus placing students in a state of cognitive conflict. But, if students do not experience alternative concepts, this stage serves to reinforce the obtained concept; d) *Observe* is a process of making observations and proving whether the prediction given is correct or not; and e) *Explain* is a process of students providing an explanation of the compatibility between the allegations with the observations they have made from the observation stage. Based on the background that has been described, the students' alternative concepts can be reduced by using the EPCOER learning model, because this model allows students to experience cognitive conflict which further alter the alternative concept understood by students.

METHOD

In this article, it is reported that the non-quantitative part of the research employed the mix-method design, which is the part that causes alternative concepts. This study aims to determine and reduce the alternative concepts students have using the EPCOER learning model. In this study there are three variables, the independent variable (learning model), the dependent variable (alternative concept) and the moderator variable (initial knowledge). The sample selection was done by cluster random sampling technique on students of SMAN 2 Malang, obtained by two research classes. The test used was a three-tier test given at the beginning and at the end of learning. Based on these data, the two classes were determined as: 1) one class as an experimental class (N = 32); and 2) one class as a control class (N = 31). To analyze students' alternative concepts, four categories were used which refer to Aslan et al. 2012 (Table 1).

RESULTS

The results of the reduction of alternative concepts of students learning with the EPCOER learning model were analyzed from the pre-test and post-test scores as well as by interviews given to the experimental and control class students. Pretest is intended to measure students' initial knowledge and to see alternative concepts students have before learning thermochemical topic. Recapitulation of students' pretest and posttest data in the experimental and control classes is presented in Table 2.

Table 2 shows the average pretest scores of the experimental class students (33.66) and the control class (39.29). The difference between the two classes is quite significant, 5.63, where it can be seen that the control class has an average initial knowledge higher than the experimental class.

Posttest was intended to find out alternative concepts that students have after learning thermochemical topic. The average posttest score of the experimental class students (80.6) was higher than the control class (73.8). Based on the average post-test results in both classes, it shows that learning with the EPCOER model provides a better impact in learning. Recapitulation of posttest data in the experimental class and the control class can be seen in the foloowing Figure 1.

To further understand the alternative concepts possessed by students of the experimental class and the control class, quantitatively it can be observed from the number of students who answered in each of the categories of understanding in the pretest and posttest. The categories of student understanding are mastering the concept (MK), acquiring alternative concept (KA), assuming (MB) and do not know the concept (TT).

Table 3 shows that in the experimental class, students who understood the concept (MK) increased, while in the control class also increased but were less. Students who acquired alternative cocnept (KA) of the experimental class students increased less than the control class. Students acquiring alternative concepts have increased because previously during the pretest, many students did not know the concept (TT). Where in the experimental class, the percentage did

Table 1. Three Tier Test Answer Category

Tier 1	Tier 2	Tier 3	Kategori
Correct	Correct	Sure	Mastering the concept (MK)
Correct	Incorrect	Sure	Acquiring alternative concept (KA)
Incorrect	Correct	Sure	Acquiring alternative concept (KA)
Incorrect	Incorrect	Sure	Acquiring alternative concept (KA)
Correct	Correct	Unsure	Assuming, no self-assurance (MB)
Correct	Incorrect	Unsure	Do not Know the Concept (TT)
Incorrect	Correct	Unsure	Do not Know the Concept (TT)
Incorrect	Incorrect	Unsure	Do not Know the Concept (TT)

(Arslan, dkk, 2012)

Table 2. Pretest Data Recapitulation (Initial Knowledge)

	Class	Total students	Lowest score	Highest score	Avg
Pretest	Experimental	32	18	58	33,66
	Control	31	20	56	39,29
Postest	Experimental	32	64	93	80,59
	Control	31	50	95	73,77

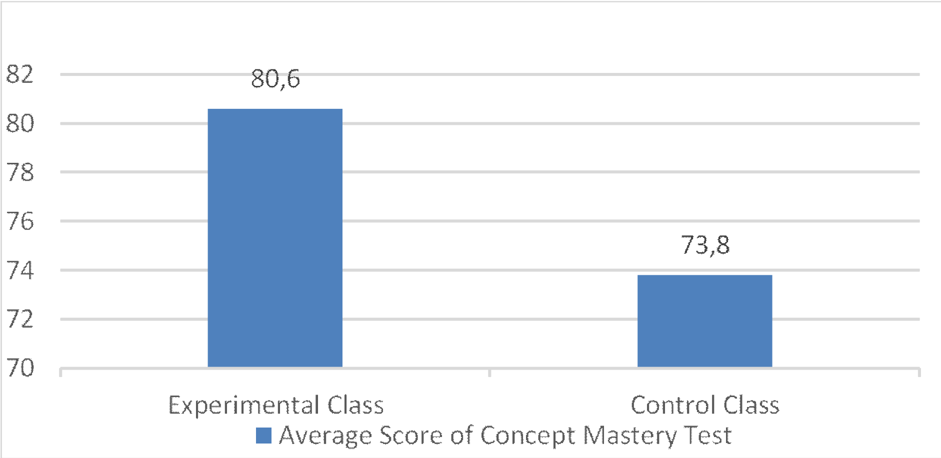

Figure 1. Comparison of Postest Average Score

Table 3. Comparison of Student Understanding Categories between the Experiment and the Control Class

No.	Class	Total Understanding Categories (%)							
		Experiment (EPCOER)				Control (POE)			
		MK	KA	MB	TT	MK	KA	MB	TT
1.	Pretest (x)	329	486	79	1606	180	563	80	1509
2.	Postest (y)	1300	564	97	539	1142	698	45	615
	Margin (y-x)	971	78	18	-1067	962	135	-35	-894

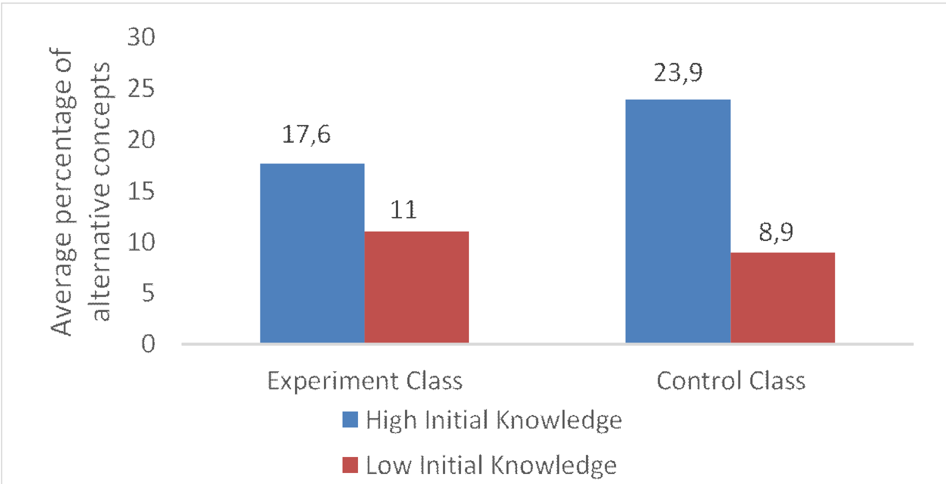

Figure 2. Average Percentage of Alternative Concepts of Students between Groups

not know (TT) the concept of students had a greater decline than in the control class.

The table 3 also shows that the alternative concepts in the experimental class acquired less than the control class. This raises the conjecture that learning with the EPCOER model has an impact in reducing alternative concepts. In addition, it decreased the number of students who did not know the concept after being given treatment.

Differences in alternative concepts can be seen between initial knowledge groups. The following table explains the differences in alternative concepts between students who have high and low initial knowledge in both the experimental and control classes. Recapitulation of posttest data in the experimental class and the control class can be seen in Figure 2.

Figure 2 above shows that students who have high initial knowledge in the control class have higher alternative concepts compared to the experimental class. While students with low initial knowledge in the control class have lower alternative concepts compared to the experimental class. On the average overall, alternative concepts in the experimental class (those learned with the EPCOER model) are lower than the control classes (those learned with the POE model).

DISCUSSION

The results showed that there were a number of alternative concepts in thermochemical topic acquired by students. This alternative concept was found in almost all sub-topics, including energy, understanding thermochemistry, systems and environment, exothermic and endothermic reactions, thermochemical equations, various enthalpies, and determining the value of enthalpy changes. Based on data analysis and interviews with students, the major factors were students' intuitive thinking, students' abilities, preconceptions or initial knowledge, alternative concepts in previous topics, limited understanding of the specific terms and symbols, as well as lack of accuracy and limited understanding of the problems given. This is in accordance with the statement of Fitria (2014), students acquired alternative concept due to preconceptions, abilities, stages of development, interests, ways of thinking, classmates and the alternative concept acquired in the previous lesson. Students' limited understanding about reactants and products, confusion in equating reaction equations, and the inability to explain the chemical structure of a compound should have been understood in the X grade.

Alternative Concepts of Student Groups before Learning with the EPCOER and POE Models

Students were identified to experience alternative concepts before participating in learning. It was indicated from students' pretest answers. Alternative concepts can be a source of student difficulties, hinder the learning process, and lead to poor mastery of concepts. Therefore, Taber (in Tan & Treagust, 2002) suggests the importance of identifying alternative concepts of students to help put back their initial knowledge (preconceptions) into scientifically acceptable concepts. Furthermore, Purtadi and Sari (2009) explained that the importance of identifying alternative concepts in students is to prevent further errors in understanding the upcoming concept and the inability to connect between concepts. If this alternative concept is neglected, it leads to a chain of conceptual er-rors. The Figure 3 and 4 presents a comparison of the percentages of each category of students' understanding of concepts in both classes.

Based on the Figure 3 and 4, most of the 25 items led to alternative concepts. This is because students have not yet acquired a thermochemical topic and did not have prior knowledge about the topic. Furthermore, before learning with the EPCOER and POE models, students experience many alternative concepts at the beginning to middle numbers, where the items are mostly at the level of understanding (C2), application (C3) and there are several levels of analysis (C4).

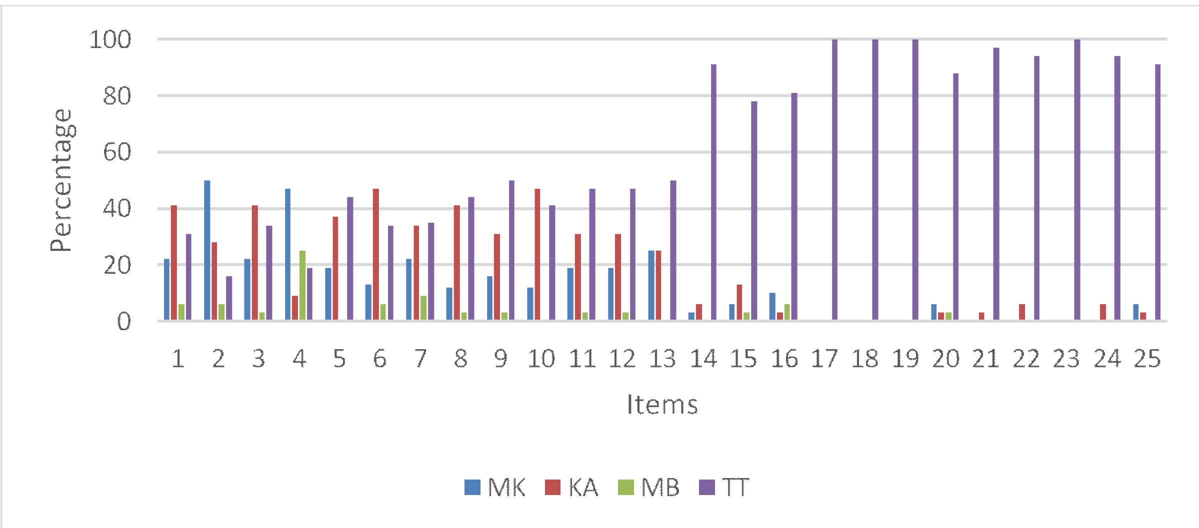

Figure 3. Comparison of Student Alternative Concept Percentage before Learning in Experimental Classes

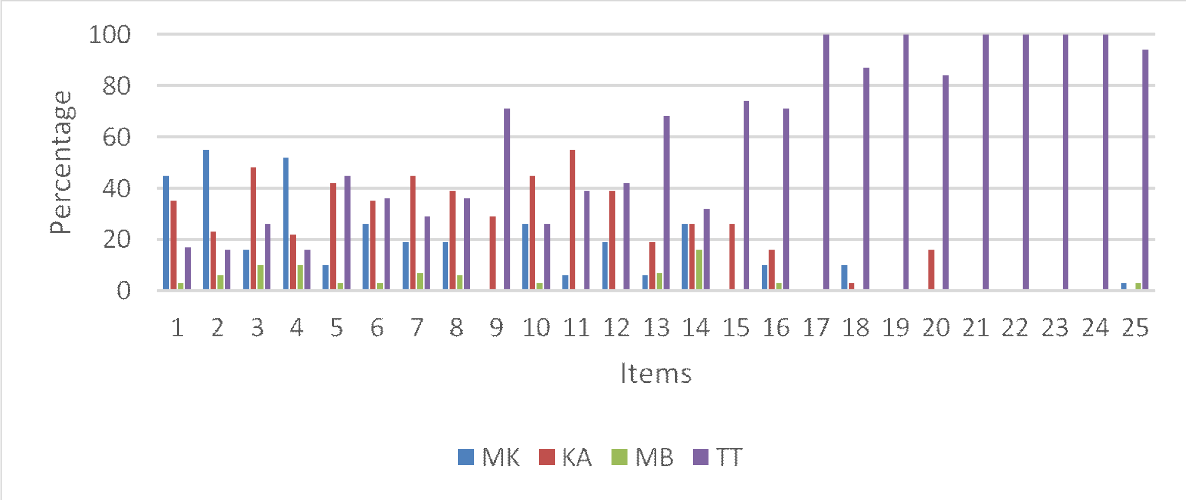

Figure 4. Comparison of Student Alternative Concept Percentage before Learning in Control Classes

This is in accordance with Sugiawati (2013), problems that cause conflict are generally at the cognitive level of C2 (comprehension), C3 (application) and C4 (analysis).

The Figure 3 and 4 shows that the alternative concepts in the experimental and control class were more likely identical. Thus, the capabilities of the two classes are comparable. The alternative concept before learning is mostly due to students answering questions without reasons, but they answered confidently. Thus, according to the category of Arslan, et al, (2012), when students provided right answer, wrong reason, and sure to what they answer, it means that the student experiences an alternative concept. Students acquired the alternative concepts for the following subtopics: 1) energy (heat) and terochemical understanding, 2) energy and enthalpy conservation laws, 3) systems and environment, 4) exothermic and endothermic reactions, 5) thermochemical equations and various changes of enthalpy.

Alternative Concepts of Student Groups after Learning with the EPCOER and POE Models

The results of this study illustrate that all concepts tested still leave students who experience alternative concepts. This is a fairness because not a few experts in the field of education state that preventing the occurrence of alternative concepts in students is difficult. The situation is in accordance with the statement of Barke et al., (2009) that alternative concepts are resistant or difficult to change. Furthermore Ibrahim (2012) states that even though it has been introduced to the correct concept, there is still an opportunity to acquire false conceptions (alternative concepts). The results of this study are also in line with research results from Greenbowe and Meltzer (2003) who still find alternative concepts in the thermochemical concept. The Figure 5 and 6 presents a comparison of the percentages of each category of students' concept understanding in both classes.

Based on the Figure 5 and 6, the 25 items given still lead to alternative concepts, but the percentage of students who acquired alternative concepts has decreased. In the final part of the questions given (starting number 15), it is seen that before learning, almost 100% studentd did not know the concept (TT). But, after the learning, some students comprehended the concept, (MK), acquired alternative concepts (KA) and some of them still did not know concept (TT). Most students in the experimental class acquired alternative concept about the determination of enthalpy change with a cycle diagram sub-topic with a percentage of 48%. Whereas, in the control class, most students acquired alternative concept about the subtopic relationship of enthalpy of standard decomposition and formation enthalpy with a percentage of 71%.

Most students acquired alternative concepts in the cognitive domains C2 and C3 before learning. However, after the learning, most students acquired alternative concepts in the domains of C3 and C4. This is because in these items students are required to master the concept as a whole instead of separating between one concept with another concept. Also, it appears that students in the class taught by the EPCOER model acquired lower alternative concepts com-

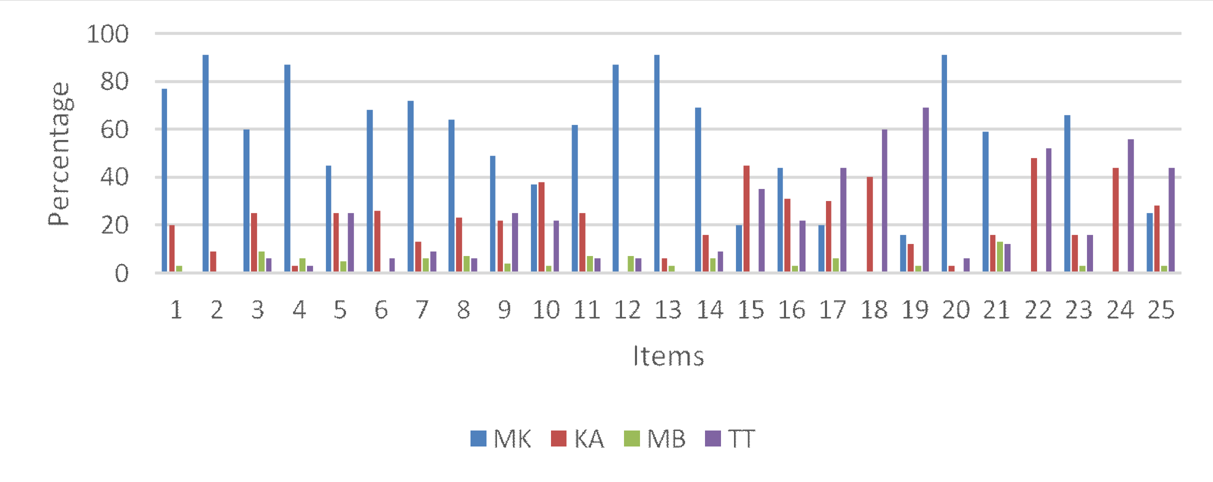

Figure 5. Comparison of Student Alternative Concept Percentage after Learning in Experimental Classes

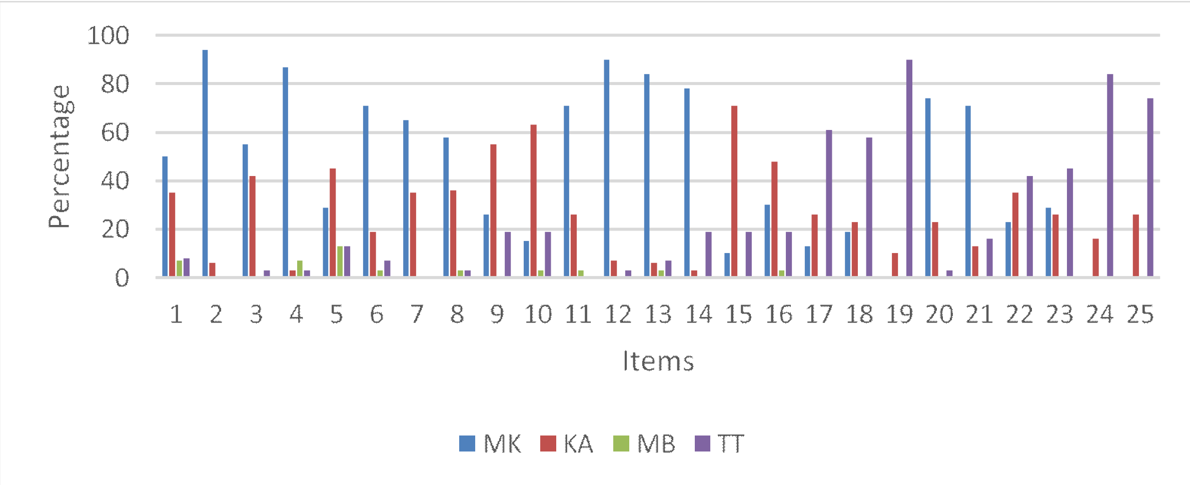

Figure 6. Comparison of Student Alternative Concept Percentage after Learning in Control Classes

pared to students in the class taught by the POE model. The alternative concepts acquired by students after learning are:

1) Energy (heat) and thermochemical understanding. Students assumed that heat and temperature are identical (seen from several student answers). However, only a few students offered such answer, and students in the control class acquired more of these alternative concepts. It was caused by the as-sociation of students with common terms in daily life.

2) The law of conservation of energy and enthalpy. Students assumed energy can be destroyed and created. This alternative concept arose because students' intuitive thinking. In the daily lif, if students initially see an object, then the object no longer exists, they assume that the object is lost. Therefore, students spontaneously assumed that energy is lost without being studied and examined objectively and rationally.

Secondly, students identically consider enthalpy and heat. It was caised by students' cognitive development. Students with operational concrete phase are difficult in understanding and mostly mistakenly comprehending abstract ideas.

3) System and environment. Students were able to define system and environment. However, they did not comprehend what substance and matter which are intended. It was due to the broad generalization concept acquired by students. Students often composed overgeneralization about certain definition (Fitriah, 2015).

4) Exothermic and endothermic reactions. It is the most significant alternative concepts acquired by student in both classess, connecting exothermic and

endothermic reactions in the daily life. Students mostly acquired a reverse understanding of both concepts. Students confused to determine both reactions, in terms of ΔH value sign, heat transfer, as well as rising and falling temperature. Students put lesser attention to understand this concepts. In addition, they tended to memorize only without understanding the concepts. Consequently, when dealing with problems, students are difficult to recall their understanding and most of them have a reverse understanding about both concept.

5) Various changes of enthalpy. Regarding this sub-topic, a) students were confused about the calculation; b) students did not understand thermochemical equation rule, where if certain reaction is reversed, ΔH value sign is also reversed. It is due to the limited ability of students in calculation. In addition, students experienced a delayed process when solving the calculation and did not pay attention to the equation rule. Students might forget the rule or do not know the exact rule of equation. Poor ability of students in understanding the topic leads to alternative concept (Fitriah, 2015).

6) Determining enthalpy change on certain reaction. Regarding this sub-topic, students were difficult in applying correct formula. It is due to students' inferiority when dealing with calculation and formula. Also, students have limited understanding about chemistry language and symbols. Thus, when dealing with formula, students tend to be confused. For instance, $\Delta H = \sum\Delta H_{product} - \sum\Delta H_{reactant}$, students assumed that the value of both $\Delta H_{product}$ and $\Delta H_{reactant}$ are automatically obtained. However, to obtain the value, students should multiply ΔH of product with the coefficient and sum up the entire value of ΔH. The alternative concept obtained by students was due to limited ability in understanding the formula.

Alternative Concepts of Students with High and Low Initial Knowledge in Groups of Students Studying with the EPCOER and POE Models

Chemistry should take into account students' initial knowledge. However, it is not merely correct. If students' initial knowledge are not in accordance with the standardized and acceptable concept, they acquired alternative concept. Alternative concept in students' initial knowledge hinders correct scientific conception. Asusubel (in Fadllan, 2011) reports that if the learning process neglects students' initial knowledge, students' alternative concept would be more complex. The students' preconceptions or initial knowledge of the chemical concepts formed by students are through informal learning in an effort to give meaning to their daily experiences. This initial knowledge is usually obtained by students from parents, friends, previous schools, and experiences in the environment. Early knowledge can have positive and negative effects. Initial knowledge has a positive impact if the knowledge is true and in accordance with scientific knowledge, on the contrary it has a negative impact if it conflicts with new knowledge (Svinicki in Effendi, 2016).

The results of this study indicate that students' high initial knowledge does not always have a smaller alternative concept compared to students who have low initial knowledge. Where it should be, students with high initial knowledge, more easily understand a concept and acquired a few alternative concepts. This is possible because, students did not pay attention when working on pretest questions where the results are a picture of their initial knowledge. For this reason, the researchers do not really know, between students who have high initial knowledge and which students have low initial knowledge. Even in the field, some students who have high initial knowledge are passive in learning. Hence, it can be concluded that between students who have high and low initial knowledge, acquired relatively identical alternative concepts after learning takes place.

In general, groups of students who have high initial knowledge, who learn with the EPCOER model, have a smaller average percentage of alternative concepts compared to groups of students with high initial learning knowledge with the POE model. Conversely, the group of students who have low initial knowledge, who are taught with the POE model have an average percentage of alternative concepts smaller than the group of students with low initial knowledge, who are taught by the EPCOER model. Thus, the EPCOER model is more effective in reducing alternative concepts of students with high initial knowledge, and no more effective in reducing alternative concepts in students who have low initial knowledge. The lack of effectiveness of the EPCOER model in reducing students who have low initial knowledge is due to the low ability of students to understand and apply the lessons learned to new problems.

Basically the alternative concepts acquired by students in both the control class and the experimental class and students with high and low initial knowledge are the same, although there is little difference in certain subtopics. The difference is the percentage of students who experience alternative concepts. In this study, students who studied with the EPCOER model experienced fewer alternative concepts than those who studied with the POE model, although the difference was not significant. So it can be said that the EPCOER model is more effective in reducing alternative concepts in students than the POE model.

CONCLUSION

Based on the results of this study, the EPCOER learning model is more effective in reducing alternative concepts of students who have high initial knowledge, and no more effective in reducing alternative concepts in students who have low initial knowledge. But overall, students who studied with the EPCOER model acquired lesser alternative concepts than students who studied with the POE model, although the difference was not significant. Thus, it can be said that the EPCOER model is more effective in reducing alternative concepts in students than the POE model.

This study only examined the implementation of the EPCOER learning model to reduce alternative concepts, thus other researchers are able to test the application of the EPCOER model to other variables that have not been studied. In addition, future researchers can combine the EPCOER model with a learning media or other techniques to support the effectiveness of the model. This learning model also needs to be applied to other topics that have the same character.

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