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Teaching Solar System Topic through Predict-Observe-Explain-Apply (POEA) Strategy: A Path to Students' Conceptual Change

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Abstract: The misconception of the Solar System topic is still found in students so that it becomes one of the obstacles in the learning process. The purpose of this study is to analyze the effectiveness of the implementation of Predict-Observe-Explain-Apply (POEA) learning to change the junior high school students' conception in the Solar System topic. Quasi-experimental research with the non-equivalent control group design was conducted in one of the private junior high schools in Bandung city. Samples were selected based on the test of the average significance of the pretest score of the population. Furthermore, 30 students of the experimental class and 32 students of control class were selected. The research instrument, which consisted of 15 four-tier diagnostic test questions about Solar System were used to collect data before and after treatment. The tests were analyzed quantitatively by using the Mann-Whitney statistical test to determine the significance of the difference in the acceptable conception changes (Acceptable Change) of students in the experimental class with changes in the conception of students in the control class. The results of the research show that the implementation of POEA learning is significantly more effective than POE learning in changing the conception of Solar System topic. The findings of this study can be an alternative for junior high school teachers in planning learning about the Solar System, especially in an effort to change students' misconception about the Solar System.

INTRODUCTION

POE (Predict, Observe, Explain) learning developed by Gunstone & Whit in 1981 has long been known to diagnose students' understanding (Samsudin, Suhandi, Rusdiana, Kaniawati, & Coştu, 2017). This learning consists of three hierarchical stages that must be passed by students. The first stage is the stage of predict where the students make predictions related to a given problem. The second stage is the stage of observing where the students make observations on demonstrations/experiments related to the problem. The last stage is the stage of explaining where the students provide an explanation regarding the findings of the observation and the differences with the predictions (Abdullah, Nayan, & Hussin, 2017; Ayvaci, 2013; Kala, Yaman, & Ayas, 2013; Karamustafaoğlu & Mamlok-Naaman, 2015; Ning Tyas, 2013).

Besides being able to diagnose student understanding, POE learning can also be applied to help students in changing the initial misconception into a correct one (Ayvaci, 2013; Cinici & Demir, 2015; Klangmanee & Sumranwanich, 2011). In addition, POE learning is more effective than traditional

learning both in increasing students' understanding of concepts and changing students' conceptions (Ayvaci, 2013; Hilario, 2015; Karamustafaoğlu & Mamlok-Naaman, 2015; Kibirige, Osodo, & Tlala, 2014). This is because POE learning fulfills four conditions of conceptual change approach initiated by Posner (Syuhendri, 2017). On the predict stage, students are given some of the problems to be discussed in the group. Then the results of the discussion, which is the student's prediction are given to the teacher. The teacher then probes the results of the discussion from the student. This is intended to create cognitive conflict and diagnose student thinking. In addition, the interaction of students and teachers regarding the results of the discussion can help students review what has been discussed and reconsider their ideas. At the observing stage, the teacher conducts demonstrations or experiments. At this stage, it is acceptable that students can find discrepancies between what they think and what actually happened. In these two stages, the students are acceptable to feel dissatisfied with the knowledge they have. At the explain stage, after the students realize that there is a discrepancy between the results of the prediction and the results of observation, the teacher can begin the learning, convey the material in the syllabus, and at the right time, explain why a particular concept was correct so that new concepts can be accepted by the students clearly (intelligibility) and reasonably (plausibility). Furthermore, the new concept could provide new opportunities for the students to think, learn, and solve other problems (fruitfulness) (Luthfiani, Sinaga, & Samsudin, 2018; Syuhendri, 2017).

The level of success (fruitfulness) that students have in applying the POE strategy is actually biased to be measured. This is due to the absence of an advanced step after the explain stage. Therefore, Syuhendri develops POEA learning by adding the apply stage as a step to strengthen the fourth condition of the Posner. At the applying stage, students are asked to apply new concepts by resolving new problems given by the teacher so that teachers and students can measure whether the new concept has been understood by students or not (Cinici & Demir, 2015; Coştu, Ayas, & Niaz, 2012; Syuhendri, 2017).

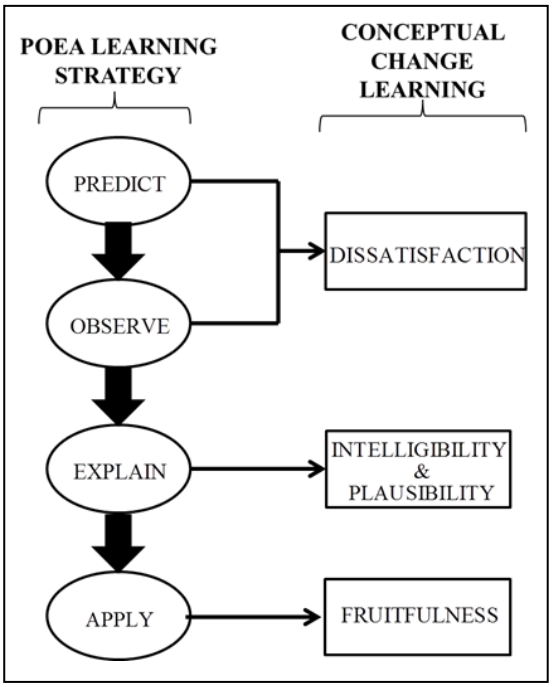


Figure 1. The Relationship between POEA Learning and Conceptual Change Learning Approach.

Topic about the Solar System is important material in science because this topic is the basic material that must be understood by students before understanding other astronomical topic. Many studies focusing on this topic reveal the existence of students' misconceptions in this material such as research from Trumper (Trumper, 2006), Sadler (Sadler et al., 2010), Liliawati & Ramalis (Liliawati & Ramalis, 2009), and Kanli (Kanli, 2015). Among the many misconceptions in this topic of the Solar System here are some of the most common cases: (1) There are many stars in the Solar System; (2) Day and night occur because the Earth rotates around the

Sun; (3) The Sun revolves around the Earth; (4) Earth is nearer the Sun in summer; (5) Seasons occur because the Earth revolves around the Sun; (6) The lunar phase occurs because the Moon moves towards the shadow of the Earth, and (7) The lunar phase during the solar eclipse is the full Moon.

In this article, the focus of research is to change students' conceptions in the Solar System topic. The change in student conceptions is indicated by the change in the conceptual categories of students into a better conception category. The concepts that form the basis of the Solar System topic are in accordance with the 2013 Curriculum Revisions that was applied when the research was conducted. The focuses of the research were the Solar System, stars, planets, the rotation of the Earth, the revolution of the Earth, the Moon, and the eclipse. In addition, the purpose of this study was to identify changes in students' conception profiles in Solar System topic and to obtain information about the effectiveness of the implementation of POEA learning to change the conception of junior high school students in Solar System topic.

METHOD

The research method used in this study was quasi-experimental of quantitative research. The research design used in this study was a non-equivalent control group design. Non-equivalent control group design is a research design consisting of two research classes, namely the experimental class and the control class. In the classes, there were three stages that were conducted, namely the pretest (O_1), the treatment (X), and the post-test (O_2). The treatment in this study was the implementation of the Predict-Observe-Explain-Apply (POEA) learning, which was applied to the experimental class (X_1) and POE learning applied to the control class (X_2). This difference was intended to create comparable datas between classes so that the results of the study can be more realistic and accountable. At the pretest and posttest, the students as the research sample were given a test instruments in the form of questions to measure the effectiveness of the implementation of the demonstration method with POEA learning in facilitating changes in student conceptions. The research test instrument consisted of 15 four-tier diagnostic test questions which included the concept of the Solar System, stars, planets, the rotation of the Earth, the revolution of the Earth, the Moon and eclipses.

Table 1. Non-equivalent Control Group Research Design

Classes	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_2
Control	O_1	X_1	O_2

The population of this study was seventh grade students of junior high school (SMP) in the city while the sample of this study were two seventh grade classes of the population chosen as the experimental class and the control class. The sampling technique used was the non-probability purposive sampling type of purposive sampling by testing the significance of the average score of the pre-test between the two classes which became the experimental class and the control class based on the Mann-Whitney test (see equation (1) to equation (4)). The following are the results of the significance tests of the classes in the population.

Table 2. Statistical Test Results in Determining the Experimental Class and Control Class

$\bar{x}$	Significance of the two classes	$z_{critical}$	z_{table}	*P*
$\bar{x}_A = 32{,}89$	A and B	0,61		0,54
$\bar{x}_B = 33{,}33$	A and C	0,14	1,96	0,89
$\bar{x}_C = 30{,}57$	B and C	0,63		0,53

The data is enunciated as no difference if the absolute value of $z_{critical}$ is

smaller than the absolute value of z_{table} (Nachar, 2008). Because the value of z_{table} was 1.96, it was greater than the calculated value of the two classes, then it can be concluded that class A, class B, and class C had the same average. So, the determination of the class to be taken into consideration was based on the average score of the pure pretest $(\bar{x})$. The class that became the experimental class was class A (N = 30), and the class that became the control class was class C (N = 32).

The test instrument was made in four-tier diagnostic test format to analyze the changes in students' conceptions. The instrument consisted of 15 four-tier questions (with details: the first level is a multiple choice question, the third level is the reason for the answer to the first level, and the second and fourth levels are the levels of confidence in answering one level before (Caleon & Subramaniam, 2010; Gurel, 2015). Figure 2 is an example of a four-tier diagnostic test.

In addition to the four-tier diagnostic test questions, students were also given a set of student worksheets in each meeting as a representation of the POEA learning stages. Here is an example of the POEA student worksheets.

5.1 The followings are the characteristics of some planets in the Solar System.

Planets	Mass (X the Mass of Earth)	Distance to the Sun (Km)
a	17. 2	4.5 Billion
b	317. 6	778.5 Million
c	0. 81	108 Million
d	0. 06	57.9 Million

Based on the data, the planet that will takes the longest time to revolve around the Sun is?
A. a B. b C. c D. d

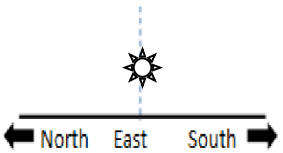
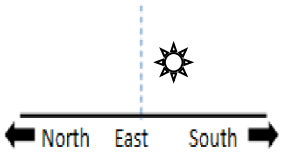
5.2 Your level of confidence toward question No. 5.1 is?
A. Confident B. Unconfident

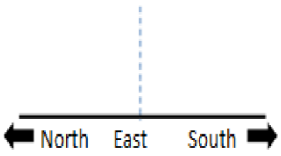
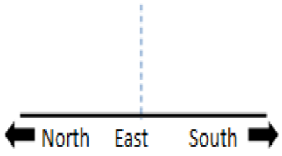
5.3 Your reason for question No. 5.1
A. The bigger the mass, the longer it will take revolve around the Sun.
B. The bigger the mass, the faster it will revolve around the Sun.
C. The farther the distance, the longer it will take to revolve around the Sun
D. The farther the distance, the faster it will revolve around the Sun
E. Other reason.....

5.4 Your level of confidence toward question No. 5.3 is?
A. Confident B. Unconfident

Figure 2. The Example Problems of Four-Tier Diagnostic Test for Planet Concepts

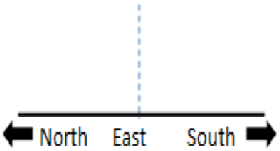
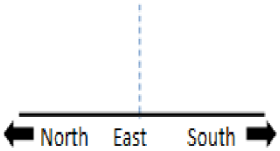
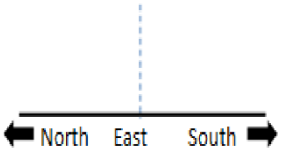
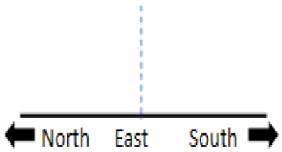
PREDICT
Observe the Sun' position in Bandung as shown in the following illustration. Based on the existing data in your task, predict the position of sunrise for other times by sketching it in the provided table.

March 19, 2018	May 19, 2018
	

July 19, 2018	September 19, 2018
	

OBSERVE

Explore and observe the state of the sky shown in the Stellarium. Set the time and place in the Stellarium according to the time and place at the prediction stage. Sketch your observations in the following table!

March 19, 2018	May 19, 2018
	
July 19, 2018	**September 19, 2018**
	

EXPLAIN

Explain your findings of the position of the sunrise in the sky that you have drawn on the Observe Stage! Is there a difference at any given time? Discuss the answers with your group and write down your conclusions about the phenomenon!

……
……
…… ……...

APPLY

Two researchers were researching apparent motion of the Sun in the sky by observing shadows formed from a stick within a year. The study was conducted in two different places, namely Medina (21.45 ° N) and Moscow (55.60 ° N). the researchers in Medina found that the stick did not form shadows at all in the middle of the day of June 19, 2017, and June 26, 2017, while researchers in Moscow never found the same phenomenon. Why does this happen?

……
……
……

Figure 3. The Example of POEA Student Worksheet

From the results of pretest and posttest, the types of students' conception were known. The types of student's conception and the technique of giving a score were determined based on the analysis of the combination of students' answers as shown in Table 3 (Samsudin et al., 2017).

Table 3. The Combination Profile of Students' Answers for Determination of Conception Category

Categories	Score	Symbol	Tier-1	Tier-2	Tier-3	Tier-4
Understanding (U)	2	■	1	1	1	1

Categories	Score	Symbol	Tier-1	Tier-2	Tier-3	Tier-4
Partial Understanding (PU)	1		1	1	1	0
			1	0	1	1
			1	0	1	0
			1	1	0	1
			1	1	0	0
			1	0	0	1
			1	0	0	0
			0	1	1	1
			0	1	1	0
			0	0	1	1
			0	0	1	0
Misconception (M)	0		0	1	0	1
No Understanding (NU)	0		0	1	0	0
			0	0	0	0
			0	0	0	1
Un-coded (UC)	0		The category is given if the students do not answer one or more questions.			

Changes in students 'conceptions were analyzed by comparing students' conceptions at the pretest and the posttest. The types of changes in the students' conceptions are shown in Table 4. The acceptable conception (acceptable change, abbreviated as A) consists of three types, namely the complementary (CP), Revision (R), and Construction (CT). The conception can also experience a declining category (not acceptable change, abbreviated as NA) which is then called the negative change or disorientation (D). In addition to the possibility of conception changes, the possibility of no change can also occur. This type of possible change in conception is called static (0).

Table 4. Types of Changes in Students' Conception Adapted from Lappi (2013) and Samsudin, et al. (2017)

No.	Type of Change Conception of	Rules of Determination Type of Change Conception		Qualitative Description
		Pretest	Posttest	
1	Complementation (CP)	PU	U	Acceptable Change (A)
2	Revision (R)	M	U	Acceptable Change (A)
		M	PU	
3	Construction (CT)	NU	U	Acceptable Change (A)
		NU	PU	
		UC	U	
		UC	PU	
4	Static Type I (St-1)	U	U	No Change (NC)
		PU	PU	
5	Static Type II (St-2)	M	M	No Change (NC)
		NU	NU	
		UC	UC	
6	Disorientation (D)	U	M	Unacceptable Change (NA)
		…	…	
		UC	M	
		UC	NU	

Description: U: Mastering concepts, PU: Mastering some concepts, M: Misconceptions, NU: Not mastering concepts, and UC: Uncategorized.

To analyze the effectiveness of the implementation of the learning, the data on acceptable conception changes (A) in the experimental class and the control class became the data which the significance of the differences is tested

statistically. The statistical test used was the Mann-Whitney test. This was done based on the fact that the distribution of data in all research classes was not normal. The following is the null hypothesis (H_o) and working hypothesis (H_a) as the basis for testing the effectiveness of the implementation of POEA learning:

H_o: "There is no difference in the students' conception changes between the class that was taught using POEA learning compared with the class that was taught using POE learning on the Solar System topic."

H_a: "There are changes in the students' conception between the class that was taught using POEA learning compared with the class that was taught using POE learning on the Solar System topic."

There was two formula used for testing, namely formula (1) and formula (2).

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \quad (1)$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2 \quad (2)$$

With n_1 as the number of samples in the experimental class, n_2 as the number of samples in the control class, R_1 as the number of ranks in the experimental class, and R_2 as the number of ranks in the control class. Those formulae were used to determine the smallest value of U which was then referred to as $U_{critical}$. Because the sample size of the two classes was more than 20, the Mann-Whitney test must use the normal distribution curve z formula approach. The formula is as follows (Nachar, 2008).

$$z = \frac{U - \left(\frac{n_1 n_2}{2}\right)}{\sigma_U} \quad (3)$$

With z as the value of $z_{critical}$, U is the value of $U_{critical}$, and σ_U is the standard deviation of the U to fill the formula (4).

$$\sigma_U = \sqrt{\frac{n_1 n_2 (N+1)}{12}} \quad (4)$$

Where N is $n_1 + n_2$. In order to test the hypothesis, the calculated z value can be compared with the z_{table} value (with $\alpha = 0,05$). The null hypothesis is rejected if the absolute value of $z_{critical}$ is greater or equal to the absolute value of z_{table}. The significance value p can be determined by looking at the area under the normal distribution curve of the calculated z value (Krzywinski & Altman, 2013). For the one-tailed test, if the value of p is smaller than the margin of error $(\alpha = 0,05)$, then the data difference is enunciated to be significant (Sham & Purcell, 2014).

RESULT AND DISCUSSION

Changes in the Students' Conception

The results of code-based pretest and posttest of some students' answers are shown in Table 5.

Table 5. Students' Conception Category Based on the results of Pretest and Posttest

Item Code	Understanding (U)		Partial Understanding (PU)		Misconception (M)		No Understanding (NU)	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Q1	SE1; SE2; SE5	SE2; SE3; SE5	-	SE1; SE4	SE3; SE4	-	-	-
Q2	-	SE2; SE3; SE5	SE1; SE2; SE3	SE1; SE4	SE5	-	-	;
Q3	SE2	SE1; SE2;	SE5	SE3; SE4	SE1	-	SE3;	-

Item Code	Understanding (U)		Partial Understanding (PU)		Misconception (M)		No Understanding (NU)	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Q4	SE5	SE5 SE2; SE4; SE5	SE2; SE4	-	-	SE1; SE3	SE4 SE3	-
Q5	-	SE1; SE2 SE3; SE5	SE5	SE4	SE1; SE3; SE4	-	SE2	-
Q6	-	SE3; SE5	SE1; SE3; SE5	SE1	SE2; SE4	-	-	SE2; SE4
Q7	-	SE1; SE2 SE3; SE5	SE1; SE2 SE3; SE5	-	SE4	SE4	-	-
Q8	SE3	SE1; SE3	SE1; SE4	SE4	-	SE2	SE2; SE5	SE5
Q9	-	SE3; SE5	SE3; SE5	SE1; SE2	SE1; SE2; SE4	-	-	SE4
Q10	-	SE3; SE5	SE1; SE5	SE1;	SE3; SE4	SE2	SE2	-
Q11	-	SE1; SE3	SE1; SE3 SE4; SE5	SE2; SE4; SE5	-	-	SE2	-
Q12	-	SE5	SE2; SE3; SE5	SE1; SE2 SE3; SE4	SE4	-	-	-
Q13	SE5	SE1; SE3; SE5	SE3; SE4	SE2	-	-	SE2	SE4
Q14	SE5	SE2; SE4; SE5	SE2; SE3; SE4	SE1; SE3	-	-	-	-
Q15	SE5	SE1; SE2; SE5	-	SE4	SE4	SE3	SE2; SE3	-

Description: Q1, Q2 ... is a code that represents the concept of a particular Solar System and SE1, SE2 ... is the students' code.

Table 5 is the distribution of the conception of several students in the experimental class. The pre-test group is the group before the POEA learning was applied and the posttest group is group after POEA learning was applied. If the pretest and posttest data are compared, then there are various types of conception changes experienced by students. For example, the numbers of students that belong to the understanding the concept (U) category have increased while the numbers of students that belong to the misconception (M) and "not understanding the concepts" (NU) categories have decreased. Changes in the number of students in each conception category can also be seen in Table 6.

Based on Table 6, the numbers of students that belong to the mastering the concept (U) experienced the highest increase after learning was given. In the experimental class, the numbers of students that belong to the U category increased from 32.9 % to 42.9 %. On the other hand, the number of students that belong to the partial understanding (PU) category had decreased. This occurs because the number of students in the PU category changed their conception category more than the number of students in other categories that changed into PU category as well as students who remain in the PU category.

Table 6. Distribution of Students Based on Their Conceptions in the Experimental Class and Control Class

	Percentage of Students' Conceptions in the Experimental Class (%)					Percentage of Students' Conceptions in the Control Class (%)				
	U	**PU**	**M**	**NU**	**UC**	**U**	**PU**	**M**	**NU**	**UC**
Average Pretest	10,0	38,0	22,4	24,7	4,9	9,4	35,6	21,0	23,1	4,6

	Percentage of Students' Conceptions in the Experimental Class (%)					Percentage of Students' Conceptions in the Control Class (%)				
	U	**PU**	**M**	**NU**	**UC**	**U**	**PU**	**M**	**NU**	**UC**
Average Posttest	42,9	30,7	13,1	12,9	0,4	31,7	40,0	15,8	11,7	0,6
Changes	+32,9	-7,3	-9,3	+22,3	-4,4	-11,8	4,4	-5,2	-11,5	-4,0

Description: U: Understanding; PU: Partial Understanding; M: Misconception; NU: Not Understanding; UC: Un -coded

Table 6 also shows the numbers of students that belong to the M, NU, and UC categories were also decreased. It means that the numbers of students in the PU category change to be better conception category (U) are more than the numbers of students in the PU category who change into worse ones (M, NU, or UC). The same results can be seen in other studies such as Samsudin et al. and Syuhendri (Samsudin et al., 2018, 2017; Syuhendri, 2017).

If the number of conception categories' change percentage between the control class and the experimental class is compared, the change in the number of conception U in the experimental class is greater than in the control class. However, this data cannot conclude the effectiveness of the implementation of POEA learning because this data does not reflect how the conceptions change and what their types are. For this reason, conception data for each student as a result of the pretest and posttest in Table 4 must be compared again to find out the type of change in the student's conception. Table 6 shows the determination of the type of conception of students based on Lappi and Samsudin (Lappi, 2013; Samsudin et al., 2017).

If the conception based on the results of the pretest and posttest is compared, the possibilities for conception changes occur as shown in Table 4. In general, changes in conception are divided into three types as shown in Table 7, namely acceptable changes (A), unacceptable changes (NA), and no change (NC). In type A, the students' conception in the Solar System topic experiences positive changes. These positive changes are the effect of the implementation of POEA learning. In the complementary change type (Cp), the students finally become familiar with the concept. This indicates that POEA learning, in line with other conceptual learning, can improve students' initial conceptions into intact conceptions (Cinici & Demir, 2015). In the revision changes type (R), students who initially experienced misconceptions turned into a better conception. This type of change is also called reconstruction misconception. Cases like SE3 in Q1 and SE5 in Q2 (see Table 5) show that POEA learning can help students overcome their misconceptions so they can understand the concept (Syuhendri, 2017). On the construction changes type (Ct), students who initially did not understand the concept experienced positive conception changes after the implementation of POEA learning, as indicated by SE2 in Q5 and Q15. This indicates that POEA learning can form students' conceptions so that students could have a good understanding of concepts (Coştu et al., 2012; Syuhendri, 2017).

Table 7. Some Examples of Conception Changes based on Student Answers in Table 4

Types of Change Conception		Pre-test	→	Post-test	Examples of Student Conception
Acceptable Change (A)	Complementary (Cp)	PU	→	U	**SE2 in Q2**: "At the pretest, SE2 was sure that the Sun is a star because the Sun is a celestial body that can be seen because it glows. After the

Types of Change Conception		Pre-test	→	Post-test	Examples of Student Conception
					implementation of the POEA learning, SE2conception transformed into intact conception, so SE2 gave the correct answer, both for tier 1 and tier 3. SE2 confidently replied that the Sun is a star because the Sun is a celestial body that can emit their own light.
Acceptable Changes (A)	Revision (R)	M	→	U	**SE3 in Q1**: "SE3 initially experienced a misconception regarding the members of the Solar System. SE3 states that the Canopus star and Sirius star are members of the Solar System because these two stars can be seen in the sky. After the implementation of POEA learning, the concept of SE3 underwent a reconstruction towards a better conception. This is indicated by the SE3 answer at the posttest. SE3 confidently answered that the two stars are not members of the Solar System, because the Solar System consists only of the Sun (one star), planets, and other celestial bodies that surround it."
	Construction (Ct)	NU	→	PU	**SE2 in Q15**:" At pretest, SE2 assumed that all types of Moon phases can cause a total solar eclipse because the entire surface of the Moon can cover the Sun fully. The SE2 indicated that he did not understand the concept of the eclipse because SE2 became Q15 uncertainly. After the implementation of the POEA, the SE concept improved. Although unsure, SE2 stated at the posttest that dead Moon phase can cause a total solar eclipse and the position of the Earth, Moon, and Sun is in a straight line. "
No change (NC)	Static Type-1 (St-I)	PU	→	PU	**SE1 in Q6**: "There was no change in the SE1 conception. At the pretest, SE1 stated that day and night occur because the Earth moves around the Sun as a result of the Earth maintaining its motion from the beginning of formation. This conception does not change during posttest. "
	Static Type-2 (St-II)	NU	→	NU	**SE5 in Q8**:" POEA learning did not influence SE5 on the concept of Q8. SE5 did not understand the concept of annual star pseudo motion because he was uncertain to assume that the stellar annual pseudo motion occurs because of the rotation of the Earth at the pretest and posttest. "
Unacceptabe changes (NA)	Disorientation (Do)	M	→	NU	**SE4 in Q13**: "SE4 believed that Jupiter has a higher constituent density than mars because Jupiter is bigger than mars. The SE4 concept did not experience positive changes even though POEA learning was applied. This is indicated by the SE4's answer at posttest. Although SE4's answer changes, the answer remains wrong by having "not sure" in tier 4. "

Remarks: SE1, SE2... students number 1, 2 ... in the experimental class; Q1, Q2... question code; U: Understanding; PU: Partial Understanding; M: Misconception; NU: Not Understanding; UC: Un-coded

One of the positive conceptual changes, namely the change in students' conceptions into a partial understanding indicates that the students' conceptions have not been intact, such as SE4 case in Q1 and SE3 in Q3. In addition to the

acceptable changes in conception, there are some cases that show unacceptable changes in conception (NA). Changes in this type of conception are marked by changes in students' conceptions into the negative direction (disorientation) and not desired changes as an effect of POEA learning. This indicates that the reconstruction of misconceptions and the construction of correct conceptions in the Solar System topic cannot fully occur in students. Misconception, furthermore, is a conception that has a tendency to be difficult to reconstruct (Kaltakci, 2012) so that the process cannot be conducted in a short duration (Samsudin et al., 2017).

Several other cases show students' conceptions do not change, in the sense that students experience conception consistency. Consistency of conception can be either positive (St-I) or negative (St-II). For the cases of SE1 in Q1, SE5 in Q4, and SE3 in Q8, these students maintain their original conception (U). This can be interpreted that POEA learning can be used as a means to confirm the truth of the concepts possessed by these students. As with the three cases of a positive conception of consistency, the cases of SE4 in Q7 and SE5 in Q8 show a negative conception of consistency. Similar to the case of disorientation conception changes, there is no change in students' misconceptions into the acceptable conception because the conceptions that the students possess are fundamental in their knowledge structure (Samsudin et al., 2017) so that the process cannot be conducted in a short duration.

Furthermore, the profile of the numbers of students based on the type of conception changes experienced as a whole and their comparisons between the experimental class and the control class are presented in Table 8.

Table 8. Student Distribution Based on the Type of Changes of Conception

No. Problem	Acceptable Change (%)		Unacceptable Change (%)		Static [+] (%)		Static [-] (%)	
	Exp.	Con.	Exp.	Con.	Exp.	Con.	Exp.	Con.
Q1	53,33	59,38	13,33	3,13	20,00	18,75	13,33	18,75
Q2	46,67	43,75	20,00	12,50	23,33	31,25	10,00	12,50
Q3	46,67	40,63	13,33	15,63	20,00	46,67	20,00	9,38
Q4	40,00	53,13	13,33	12,50	23,33	15,63	23,33	18,75
Q5	53,33	34,38	20,00	18,75	10,00	53,33	16,67	18,75
Q6	46,67	53,13	20,00	12,50	28,13	30,00	3,33	6,25
Q7	53,33	43,75	13,33	9,38	23,33	28,13	10,00	18,75
Q8	53,33	37,50	10,00	25,00	20,00	28,13	16,67	9,38
Q9	50,00	43,75	10,00	21,88	20,00	21,88	20,00	12,50
Q10	46,67	50,00	16,67	18,75	16,67	18,75	20,00	12,50
Q11	46,67	31,25	10,00	25,00	33,33	31,25	10,00	12,50
Q12	60,00	46,88	13,33	31,25	16,67	15,63	10,00	6,25
Q13	56,67	43,75	10,00	28,13	20,00	21,88	13,33	6,25
Q14	50,00	15,63	13,33	18,75	36,67	34,38	0,00	31,25
Q15	53,33	37,50	13,33	12,50	26,67	28,13	6,67	21,88
Average	**50,44**	**42,29**	**14,00**	**17,71**	**22,67**	**25,63**	**12,89**	**14,38**

Conceptual learning, both POEA and POE can basically change students' conceptions to a better direction. Table 3 shows the numbers of students who mastered the concept in both research classes are increasing and the number of students who experienced misconceptions and do not understand the concept is decreasing. Table 4 shows that the number of students who succeeded in changing their conceptions towards a better ones (A) is more than students who

are disoriented (NA). Other studies such as Klangmanee & Sumranwanich (2011), Kala (2013), Samsudin (2017), and Syuhendri (2017) have also shown that conceptual learning can change students' conceptions and reduce misconceptions that exist within students (Kala et al., 2013; Klangmanee & Sumranwanich, 2011; Samsudin et al., 2017; Syuhendri, 2017). The comparison of the experimental class and the control class shows a difference in the number of each conception categories' average change percentage. The increase in the number of students who mastered the concept (understanding) in the experimental class was higher than in the control class (32.9 % and 22.3 %). Likewise, the decrease in the number of students who do not master the concept and misconceptions in the experimental class was higher than the control class. This data is also supported by the data in the table. The percentage of students who experienced a change in type A in the experimental class is higher than in the control class. However, the data have not shown whether POEA learning is better at changing students' conceptions than POE learning, so the data in Table 8 must be statistically tested.

The Effectiveness of POEA Learning in Changing Students' Conceptions

Statistical tests to measure the effectiveness of the implementation of POEA learning were determined by testing the significance of differences in the number of acceptable conception changes (A) between the experimental class and the control class. Statistical techniques to test the effectiveness was the non-parametric statistical techniques, namely the Mann-Whitney test (Mann-Whitney U-Test). This is because the normality test and homogeneity tests that had been done showed that the data distribution was not normal. Table 9 shows the results of the Mann-Whitney test calculations.

The result obtained is the absolute value of $z_{critical}$ of 2,0002. The value of z_{table} was determined by the margin of error of 0.05 so that the z_{value} is 1, 96.

Table 9. Statistical Test Results Changes in Students' Conception in the Experimental Class and Control Class

Classes	$\bar{x}$	$z_{critical}$	p
Experimental	7.57	2,0002	0.0228
Control	6.34		

The null hypothesis is rejected if the absolute value of $z_{critical}$ is greater or equal to the absolute value of z_{table} (Nachar, 2008). Based on these references, the working hypothesis is accepted, namely the changes in the students' conceptions in the class that applied POEA learning is better than the changes in the students' conceptions in the class that applied POE learning in Solar System topic. It indicates that POEA learning is more effective than the implementation of the POE strategy in changing students' conceptions in the Solar System topic. In addition, the significance value of p obtained is 0.0228. the data differences are said to be significant if the significance value of p is smaller than the margin of error (Sham & Purcell, 2014). Based on these references, it can be enunciated that there is a significant difference between the effectiveness of POEA learning and POE learning. The results of this study are in line with the results of research on POEA learning conducted by Syuhendri (2017).

Modification of POE learning can help students understand the concepts better (Coştu et al., 2012). The addition of the applying stage after the explaining stage has been shown to have an influence on the level of success of students in changing their conceptions. Students can have the opportunity to test new concepts obtained in the previous stage by solving new problems if it is equivalent to the previous problem. The teacher can also have the opportunity to know the extent to

which students understand the concepts that have been given. With this stage, the success of students in understanding concepts and teachers in conveying concepts can be measured more plausible. This stage does not exist in traditional POE learning, so the results of the study show that POEA learning can change students' conceptions better than POE learning.

CONCLUSION

The implementation of POEA learning helps the students to change their conceptions into better conceptions. The acceptable changes are the most common conception changes experienced by students. The understanding the concept (U) becomes the conception category with the highest distribution after POEA learning is applied. In this study, it is also found that the addition of apply to POE learning has a more positive influence on the level of changes in students' conception more than POE learning without this stage. The final result shows that POEA learning is more effective in changing students' conceptions better than POEA learning.

Researchers recommend several things for further research on POEA learning. As previously mentioned, the stage of applying (apply) provides a significant influence on the level of student success in changing their conception. Thus, the Apply stage should be maximized. It aims to open a space for students to continue to hone and deepen their concept. Learning by applying the POEA strategy should be done in three to four hours per meeting (if one meeting hour is equivalent to 40 minutes) so that the stages of the POEA can be carried out optimally and the success of changing students' conceptions into a good conception can be achieved.

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