The Social Sciences 11 (6): 1028-1034, 2016
ISSN: 1818-5800

The Effectiveness of Scientific Approach Through Predict, Observe, Explain, Elaborate, Write and Evaluate (POE_2WE) Model on the Topic of Kinematics (Rectilinear Motion) at Senior High School

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Abstract: The objectives of this research are to analyze the achievement of the students differences between the students instructed with the scientific approach through Predict, Observe, Explain, Elaborate, Write and Evaluate (POE_2WE) model and those instructed with the conventional model (existing class) and to study the effectiveness of the model on the topic of kinematics (rectilinear motion) at senior high school. The samples of research were the students (Grade 10) of several State Senior High Schools in Ciamis Regency (West Java) and taken randomly. The schools all served as model schools for the implementation of the Indonesian curriculum reform 2013 in academic year 2013/2014 on the topic of kinematics. The data of research were collected through pre-and post-test, questionnaire, observation of the learning process and indepht interview to obtain teachers' responses. The data were analyzed by using thet-test to investigate the normali zed gain differences between two groups. The result of there search shows that the achievement of the students instructed with the scientific approach through POE_2 WE Model is significantly different from the existing class. The difference score between the pre-test and post test of the students instructed with the scientific approach through POE_2WE Model is 42.50 where as the difference score between the pre-test and post test of the students from the existing class is 29.93. The classes instructed with scientific approach through POE_2WE Model have N-gain = 0.8 (high category) and those the existing class have N-gain = 0.5 (mediumcategory). The effectiveness test shows that the score of Sig (2-tailed)is $(0.000)<\alpha(0.05)$. Based on data analysis can be concluded that the scientific approach through POE_2WE Model is more effective than the existing class.

Key words: Scientific approach, POE_2 WE Model, kinematics and senior high school

INTRODUCTION

The main learning problem in formal education now a days is the low student's absorption level which leads to low student's learning achievement (Brunner, 1996; Anderson, 2000; Gagdon and Collay, 2001; Joyce *et al*., 1992). Teacher should innovate the learning process to anticipate such a problem. One of the innovations is the implementation of an innovative learning models that are assumed to be able to improve the quality of the process as well as the learning achievements (Joyce *et al*., 1992; Eggen and Kauchak, 1998; Gagdon and Collay, 2001; Anderson *et al*., 2001; Costu *et al*., 2012). The result of the observations carried out at State Senior High Schools in Ciamis Regency shows that the existing learning models have already included several activity aspects such as class discussion and demonstration but their implementation has not been maximal.

Scientific learning is a learning that adopts scientific steps in building knowledge through scientific method (Gronlund, 1982; Arends, 1996; Slavin, 1995; Harding, 1998). The learning model required is the one that nurtures scientific thinking competence, develops students' sense of inquiry and creative thinking ability (Huinker and Laughlin, 1996; Plomp, 1997; Barton, 1998; Meltzer, 2002). In addition, it must be able to construct the ability to study (Joyce *et al*., 1992; White and Gunstone, 1992; Slavin, 1995) not so much as anaccumulation of knowledge, skills and attitudeas to how those knowledge, skills and attitude are gained by the students (Bruner, 1996; Eggen and Kauchak, 1998; Anderson *et al*., 2001; Yamin, 2012).

Scientific learning does not see the learning achievement as the end result. The learning process is also considered crucial. Thus, scientific learning emphasizes on the process skills. Learning model which is based on the scientific process skill improvement is a

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Table 1: Normalized gain criteria

Value<g>	Criteria
<g≥0.7	High
0,7><g≥0.3	Medium
<g><0.3	Low

learning model which integrates scientific process skills into the presentation of the materials which are integrated in an integrated system (Huinker and Laughlin, 1996; Arends, 1996; Harding, 1998; Anderson, 2000). This model underscores the process of pursuing knowledge rather than transferring knowledge. The students are acknowledged as the subject of learning who needs to be actively involved in the learning process while teacher is merely a facilitator who guides and coordinates the learning activity (Joyce *et al*., 1992; Eggen and Kauchak, 1998; Barton, 1998; Anderson *et al*., 2001). The Indonesian curriculum 2013 recommends that learning in the classroom should be undertaken with a scientific approach which consists of observing, questioning, experimenting, associating and communicating.

Predict, Observe, Explain, Elaborate, Write and Evaluate (POE_2WE) learning model is developed out of POEW (Predict, Observe, Explain, Write) learning model and kynematics (rectilinear motion) learning model with constructivist approach. POE_2WE Model is a learning Model that is developed to find out the students' comprehension of a concept, using constructivist approach (Kearney and Young, 2007; Costu *et al*., 2012; Nana *et al*., 2014). This model constructs knowledge through certain processes. It starts with predicting the solution to a problem, experimenting to prove the prediction then explaining the result of the experiment in oraland written forms. The next step is making examples of the everyday applications followed by writing the results of the discussion and evaluating the students' comprehension in oral and in written forms (Thiagarajan and Semmel, 1974; White and Gunstone, 1992; Slavin, 1995; Young and Chapman, 2010).

MATERIALS AND METHODS

This research used the comparative (Box *et al*., 1978; Slavin, 1995; Bhattacharyaa and Richard, 1997; Young and Chapman, 2010) method with the nonequivalent control group design using two classes, namely: the experimental class and the control group. Pre-and post-tests were given to obtain the class data. The difference between those classes was on the treatment; the experimental class used the scientific learning approach through POE_2WE Model while the control class employed existing class model.

Statistical analysis technique with the independent-sample t-test was also employed to process the data which were the average scores of pre-and post-test, in order to investigate the difference between the experimentalclass and the control class. The statistical analysis used the computer program of SPSS 19. Prior to being calculated using t-test, the homogeneity and normality of the data were tested by using the SPSS Kolmogorov-Smirnov program (Box *et al*., 1978; Bhattacharyya and Richard, 1997).

Normalized gain score: Normalized gain score is an analysis technique toinvestigate theincrease rate of the students learning achievement. According to Meltzer (2002), normalized gain scorecan be calculated with the following equation:

$$< g >= \frac{\text{Post-test score} - \text{Pre-test score}}{\text{M aximum score} - \text{Pre-test score}}$$

Remark: <g> = Normalized gain. Table 1 shows the interpretation of the normalized gain as per to Hake.

RESULTS AND DISCUSSION

Table 2 shows that the pre-tests of the students of both the experimental classand the control class do not show a significant difference ($p>0.05$) meaning that the students of both groups have the equal basic ability. In addition, the post-tests of both the experimental class and thecontrol classshowa significant difference ($p<0.05$). Thus, the result of the students instructed with the scientific approach with POE_2WE Model is significantly different from that of the students instructed with existing class model. The POE_2WE Model is concluded to be effective in improving the students' learning achievement in Kinematics (rectilinear motion) learning at State Senior Secondary School 1 Ciamis, State Senior Secondary School 2 Ciamis, State Senior Secondary School 3 Ciamis and State Senior Secondary School Baregbeg.

To discover their effectiveness, the levels of achievement increase of the pre-and post-test are then calculated using the normalized N-gain formula. The result of the N-gain calculation is presented in Table 3.

Table 3 indicates that the average gain score of the experiment group is 0.8 which is in the high category, meaning that their learning achievement increases significantly. The control class only experiencesthe medium increase.

The pre-and post-test scores data showing a homogeneous and normal distribution is then analyzed by

Table 2: The result of the t-test of the pre-and post-tests of the experimental class and the control class

	Pre-test		Post-test	
Schools of experimental class	t-value	p-value	t-value	p-value
State Senior Secondary School 1, Ciamis	1.157	0.253	13.1490	0.000
State Senior Secondary School 2, Ciamis	2.233	0.077	14.9330	0.000
State Senior Secondary School 3, Ciamis	1.300	0.185	6.2790	0.000
State Senior Secondary School, Baregbeg	3.761	0.079	11.9350	0.000
Experimental group integrated with the control class	2.438	0.056	10.1070	0.000

Table 3: The result of the pre-and post-test achievement increase

Groups	Nameof the School	Gain score	Criteria
Experimental	State Senior Secondary School 1, Ciamis	0.8	High
	State Senior Secondary School 2, Ciamis	0.8	High
	State Senior Secondary School 3, Ciamis	0.7	High
	State Senior Secondary School, Baregbeg	0.7	High
Control	State Senior Secondary School, Cisaga	0.4	Medium

using the paired sample t-test. The t_{count} is -13.923 for the experimental class andis -15.115 for the control class with the probability of 0.000 ($p<0.05$), meaning that both H_0 are rejected. It shows that there is a difference between the students' learning achievement prior to and following the implementation of the POE_2WE Model. The t-test is executed to calculate whether the difference of the learning achievement of those two groups is significant.

There are 120 valid student data in the experiment group and 30 students in the control class. The average scores is 42.50 for the former and 29.93 for latter. The deviation standard of the experimental class is 12.754 and of the control classis 11.399. The average error standard of the experimental class is 1.164 and of the control class is 2.081.

The result of the F-test analyzes the t-test basic assumption that both groups are the same. The hypothesis is that H_0 = both groups have the same variant. The H_1 = the two groups have different variants. If Sig.>α then H_0 will be verified and if Sig.<α then H_0will be rejected. If the score of Sig. (0.627) >α (0.05) then H_0 is accepted. Thus, both groups have the same variant.

The next test uses the assumed equal variant score, but when the calculation of Sig.<α, it uses the data below it . The Hypothesis H_0 = POE_2WE Model does not affect the test score average. The H_1 = POE_2WE Model strongly influences the test score average. If Sig.>α then H_0 is verified. Also, if Sig.>α then H_0 is rejected. Based on Table 5 SPSS calculation because t-count score is high and the value of Sig. (2-tailed) (0.000)<α (0.05) then H_0 is rejected. Thus, POE_2WE Model affects the average test score.

Discussion on the effectiveness of the POE_2WE learning model: As stated by the students, the learning phases on the developed model are easy to follow and to comprehend. The making prediction phase that the students made based on their preliminary abilities can help the students to find the concept by themselves. It is in line with the opinion of (White and Gunstone, 1992; Kearney and Young, 2007; Wah and Treagust, 2004) that students can employ their gained knowledge to illuminate a concept. After making a prediction, the students develop an experiment and then execute it to confirm the truth of the students' prediction.

Therefore, through observation or laboratory activity (practicum), students can find the concept by themselves and through the teacher's guidance they can correct misconception that may occur. This idea is in agreement with the opinion of Gronlund (1982), Eggen and Kauchak (1998), Henningsen and Stein (1997), Gagdon and Collay (2001), Kearney and Young (2007), Nurjanah (2009), Costu *et al.* (2012) that the phases of predict, observe and explain help the students to comprehend the concept through direct observation which is more scientific and that this observation presents the problem explanation. The students can modify the idea in conform to scientific outlook and also gain new knowledge out of discussion and observation. This model can be used to find out the student's understanding on various concepts. The result of the discussion can then be presented before the class (Kearney and Young, 2007; Joyce *et al*., 1992).

Group presentation helps the students to share the ideas and notions which emerge from each group member in the class discussion. Anderson *et al.* (2001) states that discussion is an interactive face-to-face process in which students brainstorm their ideas on the problems in order to solve them, answer questions, enhance their knowledge and comprehension or make decision. The elucidation of the result of the discussion is not only done in words but also in writing so that the students will be able to comprehend the substance and remember it better. Moreover, the students do not merely concludethe result of the discussion but also make a concept map.

According to Slavin (1995) and Plomp (1997) out of the whole process, the students can undergo concept changes, either expanding the ability they have already had or amending their incorrect concept which is not concordant with the scientists' concept.

Criteria show that the increase of the students' learning achievement is in the medium category. It confirms that the application of POE_2WE learning model which are brought impacts on the students' learning achievement increase. The research result shows that the increase of the experimental class is higher than that of the control class, meaning that the implementation of POE_2WE learning model in the experimental class results in the higher achievement increase than that of the control class (Huinker and Laughlin, 1996; Henningsen and Stein, 1997; Joyce *et al*., 1992).

The developed POE_2WE learning model can train the students' critical thinking ability. As also stated by Meltzer (2002) Kearney and Young (2007), Nana *et al*., 2014) in his research which maintains that the improvement of the concept mastery and critical thinking ability of the students who got POE_2WE learning model is significantly better than that of the students who got conventional learning model. It is caused by the fact that in the previous model, the students were asked to do their own try out before they did their experiment or laboratory activity.

The students' critical thinking ability is not only sharpened on the making of the prediction but also during the experiment design activity. Other than the addition of elaboration phase in the form of concept application in day to day living, there is also the evaluation phase to test the students' concept comprehension. In the development of the model before the students conclude the discussion result in writing, they are asked to create a concept map of each meeting based on the topic under the discussion (Gronlund, 1982; Huinker and Laughlin, 1996; Eggen and Kauchak, 1998; Henningsen and Stein, 1997; Gagdon and Collay, 2001; Meltzer, 2002). The mapping of the concept in learning makes it easier for the students to connect related ideas or concepts and help them to construct integrated understanding. Jonassen and Pannen (2005) states that the concept map is a technique to describe the compositionand connection between ideas or conceptsin one's brain.

After being analyzed, the result of the study is then undergone prerequisite test prior to the advanced test. The result of the pre-and post-test analysis is then analyzed by using the paired sample t-test. The result of the calculation repudiates H_0. It shows that there is a difference of the students' learning achievement prior to and following the application of the learning model. Similar case happens to the experimental class which also shows a difference of the students' learning achievement prior to and following the application of the POE_2WE learning model. The result of the analyses of the cognitive sphere concludes that the students' cognitive learning achievement increases (Wah and Treagust, 2004; White and Gunstone, 1992; Nana *et al*., 2014).

This learning achievement improvement is in concordance with the research that was undertaken by Raminah. Bruner (1996), Arends (1996), Barton (1998), Anderson (2000) and Kearney and Young (2007) research demonstrates that the model being used can improve the students' learning achievements, since the students are able to implement the knowledge they have gained in explaining a concept. The students' experience are obtained after they undergo the observe phase. In this phase, the students test their previously gotten prediction. The end result of the observe phase is then discussed by the students so that the students get direct knowledge based on their own experience.

The obtained result shows that the difference of the cognitive learning achievement prior to and following the treatment of the experimental classis higher than the difference of the learning achievement of the control class. It is caused by the fact that in the experimental class, the students are not only executing real practicum experiment but also being able to do observation. Through this interactive experience, the students are able to auto-correct whether their experiment and practicum design are correct or notand also synchronize their prediction with the gained result even before they get the teacher's explanation or confirmation (Kearney and Young, 2007; Nana *et al*., 2014). This POE_2WE learning model can pique the students' interest to learn kinematics (rectilinear motion) and avoid boring and monotonous learning environment.

The potency of POE_2WE learning model development: The POE_2WE learning model helps students to presume or predict, put forward ideas, design experiment, execute experiment discuss the results of the experiment and observation, write the result of the experiment using their own language so that they can comprehend the concept and the topic of linear motion better (Nana *et al*., 2014) The POE_2WE learning modelis constructivist in nature and oriented to nature of science, namely the three dimensions of scientific learning (as the product, process and means to develop scientific attitude).

Table 4: The learning activities of the POE_2WE learning model (Nana *et al*., 2014)

Phases	Teacher activities	Students activities
Predict	Deliver the learning objectives	Pay attention and listen to teacher's explanation
	Present the question to the students	Predict the answer to the teacher's questions
	Distribute the student's working sheets	Read and observe the questions in the form of pictures in student's working sheet
	Make an inventory of the predictions and reasons	Discuss the result of their predictions
	that are submitted by the students	Ask the teacher on the steps, starting from the basic up to the hypothesis
Observe	Encourage the students to work in groups	Make groups
	Supervise the experiments that are conducted by the students	Conduct the experiments
		Gather the data on the result of the experiments
		Conduct group discussion
		Conclude the experiment results
		Analyze the data on the result of the experiment
Explain	Encourage the students to explain their experiment results	Express their opinion on the experiment results
	Ask the students to present their experiment results	Express their opinion on new ideas based on the experiment results
	Clarify the students' experiment results	Respond to other groups' presentations
	Explain new concept/definition	Accept new concept from the teacher
Elaborate	Give problem that is associated with the concept application	Apply the new concept in new situation or everyday living
	Encourage the students to apply the new concept	
	in new situation	
Write	Give a chance for the students to take notes	Write down the results of the teacher's explanation and group discussion
Evaluate	Ask questions for assessment process	Answer questions based on the data
	Assess the students' knowledge	Demonstrate their ability in concept mastery
	Provide feedbacks to the students answers	

Through POE_2WE Model, students are able think critically to presume and predict the solution to the problem given by the teacher. A textbook is distributed beforehand to add to students' knowledge and insight in predicting. Through preliminary prediction, the students are encouraged to think based on their preliminary knowledge (Kearney and Young, 2007; Costu *et al*., 2012; Nana *et al*., 2014).

The students are trained to think critically to create their own experiment design. Through observation, the students are encouraged to observe directly by executing the experiment. The executed experiment plays role in concept strengthening, since through direct observation, the learning gains deeper meaning. This model helps the students to communicate the result of the discussion in written as well as in spoken form. This will in turn facilitate the student in understanding and remembering the topics better (Keraney and Young, 2007; Nana *et al*., 2014). Moreover, the students are asked to make a concept map related to the executed practicum based on the topic under the discussion. The concept map facilitates the students to connect related concepts.

After the students do the class presentation and discussion, the teacher gives affirmation on the submitted answers. The explanation which is connected with the topic under the discussion, namely linear motion is not only performed orally to facilitate the students understanding as well as pique the students' interest and avoid tedious learning material delivery (Kearney and Young, 2007; Nana *et al*., 2014).

Likewise, the application of POE_2WE Model allows the students to get direct experience of the scientific work on the linear motion concept. Other than the improvement of the students' cognitive learning achievement, their psychomotor and affective learning achievements are also improved, since they get used to the application of POE_2WE learning model in kinematics (rectilinear motion) learning (Kearney and Young, 2007; Nana *et al*., 2014).

The advantages of the learning process using scientific approach through POE_2WE Model are among others, lay on several phases. In predict phase, the teacher presents the problem in the form of picture in the given students' working sheets, in observe phase the students execute the experiment and in explain phase the students present the result of their group discussion, which is then responded by other groups. Other development is that when the teacher gives explanation or confirmation on a concept which is not exactly correct yet, the teacher uses video to facilitate the students' understanding. Before the write phase, elaborate phase is added in the form of daily application of the linear motion. In write phase the students make not only conclusion of the practicum result but also concept map and practicum report. The conclusion on the POE_2WE Model is the evaluate phase, in the form of a test to measure the students' level of concept mastery (Kearney and Young, 2007; Nana *et al*., 2014).

The syntax and learning activities of the POE_2WE learning model: From the merging of the phases of POEW learning model and Kinematics (rectilinear motion) learning model using constructivist approach a detailed phases of POE_2WE learning model can be constructed as follows (Table 4).

Predict: In predict phase, the students make a prediction or initial presumption on a certain problem. The problem can be found beforehand in the forms of teacher's questions and pictures on linear motion found in student's working sheet or textbook. This phase of predicting the answers in POEW Model is identical to the engagement phase in constructivist approach. Teacher poses questions that can encourage the students to predict or make temporary answers to certain problems (Nana *et al*., 2014).

Observe: Observe phase is executed to prove the prediction that is posed by the students. The students are invited to perform experiment related to the problems or issues in question. After the students observe, they test the correctness of their temporary answers. The observation phase in POEW Model is identical to the exploration phase in constructivist approach (Nana *et al*., 2014).

Explain: In explain phase, the students explains their experiment results. The students' explanation is performed in group discussion which is followed by class discussion in which each group presents their group discussion result before the class. If the prediction that is posed by the students is verified in the experiment, the teacher guides the students tosummarize and he also gives explanation to corroborate the experiment results. If the students' prediction is not verifiedin the experiment, the teacher helps the students to seek the explanation on why their prediction and presumption are incorrect. The explanation phase in POEW Model is identical to the explanation phase in constructivist approach (Nana *et al*., 2014).

Elaborate: In elaborate phase, the students make examples or apply the concept in everyday living. The elaboration phase is taken from constructivist approach. The teacher encourages the students to apply the new concept in new situation with the purpose of making the students comprehend the taught concept better. This phase is a development of constructivist approach (Nana *et al*., 2014).

Write: Write phase means that the students communicate in written form; reflecting knowledge and ideas that they have. Masingilia and Wisniowska in Ansari (2012) state that writing can help the students to express their knowledge and ideas. Students write the result of the discussion and answer questions that are posed in their working sheet. Furthermore, in this phase students make a conclusion and report out of the experiment results. This phase is the development of the TTW (Think Talk Write) Model.

Evaluate: Evaluate phase is the evaluation of the students' knowledge, skills and thinking process change. In this phase, the students are evaluated on their knowledge of linear motion topic. The evaluation is held in written as well as in spoken forms. This phase is the development of the integration of two models: constructivist approach and POEW Model (Kearney and Young, 2007; Nana *et al*., 2014).

CONCLUSION

There is a significant difference between the students instructed with the scientific approach through POE_2WE learning model and those instructed with theexisting class model. The average N-gain score of the experiment class is 0.8 which is classified as the high category while the N-gain score of the control class is 0.5 which is classified asthe medium category. The effectiveness test using the statistic t-test results in $p<0.05$, meaning that POE_2WE Model is more effective than the existing class model.

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