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POE_2WE Model as an Alternative for Learning Physics in Industrial Revolution 4.0 Era

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Abstract: This study aims to know and analyze POE_2WE as alternative model for learning physics in industrial revolution 4.0 era. The method deployed library research by finding out various data sources. Industrial revolution 4.0 begins in 2018, symbolized by cyber-physical system. Henceforward, various industries have begun utilizing virtual system, in terms of human, machine, data connectivity, known as Internet of Things (loT). However, some preparations related to appropriate learning methods and models are needed to face industrial revolution 4.0. POE_2WE Model is reflected as students interact and communicate in making prediction, designing experiment, conducting experiment, discussing questions in student worksheet and questioning-answering in group presentation. Students are trained to work together in their group, to respect and to receive student weaknesses and strengths one another. The use of internet is really recommended in learning process of collaborative classes. Internet is one of learning media that ease and widen information access and availability. The implementation of POE_2WE model in learning process is by giving students assignment to make a report for their practical work. Students are allowed to search as much as information from the internet in compiling their reports. Besides, teachers also become easy in accessing information on compiling learning material.

***Keywords**: industrial revolution 4.0 era, POE_2WE model*

INTRODUCTION

Indonesia, now, has evenly applied the 2013 curriculum in all schools under Ministry of Education and Culture. This is due to its aim in strengthening learning process and authentic assessment to achieve cognitive, affective, and psychomotoric competences. Strengthening learning process is conducted through the scientific approach, which encourages students to be more able to observe, to ask, to attempt/ to obtain data, to negotiate/to think, and to communicate.

POE_2WE (Prediction, Observation, Explanation, Elaboration, Write and Evaluation) Model is a scientific model developed by Nana (2014) appropriate with this curriculum especially in learning science, especially physics. The empirical fact related to learning science problem shows the need on developing science learning models and methods that can embrace three aspects as proposed by Bloom. This model can help students to develop a number of scienticic skills or works as well as scientific attitudes is the scientific method. By using this method, students can identify problems, arrange hypothesis, predict hypothesis consequences, do experiment to test hypothesis, and formulate a general law simply organized from hypothesis, prediction and experiment. Moreover, teachers also can investigate cognitive, psycomotoric and affective ones.

Moreover, 2018 becomes the beginning of industrial revolution 4.0. Industrial revolution 4.0 deals with digital-based informational society associated to information-based technologies, techonological activities, network logic, flexible technologies, and integrated system. As a consequence, societies including educational society must be aware to this revolution. This

societies are supposed to have some skills, including the ability (1) to master technology and media; (2) to do the effective communication; (3) to have critical thinking; (4) to solve problems; and (5) to do collaborations.

Since POE_2WE Model is applicable for the 2013 curriculum and the industrial revolution 4.0 cannot be avoided, the collaboration is required. This can be done by digitalize POE_2WE Model. All activities in POE_2WE Model in terms of Prediction, Observation, Explanation, Elaboration, Write and Evaluation are supplemented with the internet. Hence, students will be easier in finding the information related to their practical work. Besides, their digital literacy skills are also developed. Moreover, teachers are also facilitated in compiling learning materials and developing learning media-based digital.

Therefore, this paper gives a new insight on POE_2WE Model in the industrial revolution 4.0, or so-called digitalized POE_2WE Model. This upgraded model fulfills both 2013 curriculum and industrial revolution 4.0 demands.

METHOD

This study deployed the literacy method (library research) by investigating various literatures related to the application of POE_2WE model and revolution 4.0 era learning (Anwar, 2004; Arifin, 2011; Harding, 1998; Henningsen & Stein, 1997; Huinker & Laughlin, 1996; Juniati, 2009; Kearney, 2004; Kearney & Young, 2007; Nana, 2014; Nana, Sajidan, Akhyar, & Rochsatiningsih, 2014; Purwaningsih & Pujianto, 2009; Rahayu, Widodo, & Sudirman, 2013; Silverus, 1991; Supriyati, 2012; Tan & Goh, 2008; Trianto, 2010; Young & Chapman, 2010; Yuwono, 2006).

RESULTS AND DISCUSSION

Learning Method in Facing Industrial Revolution 4.0

After passing through three stages of industrial evolution, 2018 is the initial period for the industrial revolution 4.0, symbolized by the cyber-physical system. Various industries now begin to acess the virtual world, in terms of human, mechine and data connectivities or known as *Internet of Things* (loT). To face the industrial revolution 4.0, needs preparation, including the appropriate learning method.

Improvement of human resource

There are many things that need to be changed for developing a country. It also applies to Indonesia, since Indonesia is facing the industrial revolution 4.0 era with the high level of rivalry. These changes include the improvement of human resource. It can be conducted by changing learning method, with reference to the three following ways. The first is to change young generation character and mindset. The second is to take account on the important role of schools in exploring and developing young generation talents. The third is to develop educational institution ability in changing learning model appropriate to the current era.

The role of government in changing learning method

Government certainly has a truly important role in changing learning method. Facility appropriate to children needs is important to be provided by the government. This can be done

by providing a reliable technology. Besides, the meaning of corruption, collution and nepotism (*KKN*) requires to be changed into communication, collaboration and networking to build Indonesian young generations better. By providing various facilities appropriate to current needs and demands, young generations are expected to be ready in facing various challenges in this industrial revolution 4.0 era. Considering a dynamic condition of technology, an extraordinary ability to adapt current condition is necessary. Indonesian young generations are also expected to have ability in competing other countries and to have Indonesian values.

Proposing education 4.0

Education 4.0 is a general term for describing various ways in intergrating the cyber technology, physically and non physically, in learning process. This concept is also a step forward from education 3.0, which more includes neurology, cognitive psychology, and educational technology using the digital technology and web-based mobile. The education 3.0 is the third phase of industrial revolution. The beginning of 1970 is considered as the initial period of the emergence of industrial revolution 3.0, signified by the use of electronic and information technology for the production automatization. The debut of third generation industrial revolution is also signified by the emergence of the first programed logic control (PLC), namely modem 084-969.

This computer-based automatization system makes industrial mechines not controlled by human. As a result, the industrial production cost gets cheeper. Besides, the computer begins to be used in education. The education 3.0 era, as proposed by the Head of Information and Technology Vocation Association of Electoronic and Information School, Institut Technologi Bandung, Dr. Armein Z.R. Langi, is an opportunity to study, owned by anyone with a high desire on knowledge and high "metabolism" capacity as well. However, the education 4.0 is further. The education 4.0 is a response on the need of industrial revolution 4.0, in which human and mechine are equalized to gain solutions, to solve many problmes, and to find some new innovation probabilities that can be utilized for improving the life of modern human.

Information and communication technology for learning in industrial revolution 4.0 era

To face the industrial revolution 4.0 era, education that can build creative, innovative, and competitive generations is necessary. It is conducted by optimizing the use of technology as a means of education, expected to produce outputs with the ability in abreast of time or changing the world better. Indoensia also necessarily improves graduate quality adjusted to work challenges and digital technology demands. This is the perfect time to leave learning process that prioritize memorization or finding an only one true answer. Besides, learning method has also to be shifted into the visionaire thingking process, including strengthening the ability to think creatively and innovatively. This is needed to face various technology and sciece development.

Curriculum revision by adding five competences

The Minister of Education and Cultrure, Muhadjar Effendy, considers that there is a need to revise educational aspects in curriculum by adding five competences. These are fundamental for competing other countries in the industrial revolution 4.0 era. These are (1) critical thinking ability; (2) creativity and innovative ability; (3) good communication ability and skill; (4) cooperation ability; and (5) high self-confidence.

In addition, educational and cultural actors have to be ready to adapt various development to face the industrial revolution 4.0 era. Consequently, school reformation, capacity improvement, teacher professionalism, dynamic curriculum, reliable facilities, up-to-date learning technology are also necessary. By using the appropriate learning method, young generations of Indonesia are expected to be ready and confidence in dealing with challenges and changes due to the industrial revolution 4.0.

Scientific Learning Approach

Scientific learning is a learning adopting scientific stages in building knowledge through the scientific method. Learning model needed is the one enabling to culture the scientific thinking and to develop sense of inquiry as well as creative thinking ability (De Vito, 1989). Besides, it is also needed to produce the ability to study (Joyce & Weil, 1996), indicating that students notice not only what they get i.e. knowledge, skill, and attitude, but also, more importantly, how to get it (Semiawan, 1998; Zamroni, 2000).

Scientific learning is not only considered learning result as an output, but also accouts learning process. Consequently, it reinforces the process to acquire a current skill. Learning model based on the improvement of science process skill is a learning model integrating science process skill into the system of material display integratively (Beyer, 1991). This model emphasizes the process of finding knowledge rather than knowledge transer. Students are served as learning subject that are required to be actively involved in learning process. Meanwhile, teachers are only facilitators who guide and coordinate learning activities.

Science process skill-based learning model potentially constructs students' life basic competences through the development of science process skill, scientific attitude, and knowlege construction process, step by step. The science process skill generally is a basic competence to study (basic learning tools), that is a skill functioning to build a fundamental on each individual for developing him/herself (Chain & Evan, 1990).

Regarding the physics characteristic as part of natural science, physics learning should reflect scientific attitudes, scientific thinking, and scientific work skill competences. Learning activities are conducted through the processes of observing, asking, trying/obtaining data, associating/thinking, and communicating.

(1) Observing activity aims to interconnect learning with factual situation context faced in daily life. The process of observing fact or phenomenon includes finding information, seeing, listening, and reading.
(2) Asking activity is conducted as one process to build students' knowledge in terms of concept, principle, procedure, law and theory, as well as metacognitive thinking. It aims to stimulate students to have great critical, logical and systematical thinking skill. It is conducted through discussion and group work. Group discussion practice gives a freedom space to express idea/opinion by own language, including indigenous language.
(3) Trying or obtaining data activity is beneficial to improve students' curiosity in strengthening conceot and principle/procedure understanding by obtaining data, developing creativity, and improving scientific work skill. This activity includes planning, designing, and conducting experiment, as well as obtaining, displaying, and processing data. The utilization of learning source including computation and automatization mechines is highly recommended in this activity.
(4) Associating activity aims to build scientific thinking and attitude abilities. The data obtained are classified, processed and revealed into specific relationships. This activity can be designed by teachers through situational engineering in a certain activity so that students can do activities in terms of analyzing, agglomerating, catergorizing,

concluding and predicting/estimizing data by utilizing discussion or practical worksheets. The result of trying and associating activities enable students to have higher order thinking skills, even metacognitive thinking.

(5) Communicating activity is a facility to present the result of conceptualization in terms of spoken text, written text, picture/sketch, diagram, or graphic. It is conducted to encourage students to be able to communicate their knowledge, skill and its application, as well as their creativity through presentation, report, and/or performance.

New challenges of life dynamism are increasingly complex. They demand learning activities that not only repeat expected facts and phenomena but also reach new unexpected situations. As supported by the development of technology and art, learning is expected to encourage student thinking ability in unexpected situations. To continuesly stimulate students' creativity and curiosity, learning activities are conducted by the following steps.

(1) Learning activities provide or stimulate students to observe facts or phenomena directly and/or reconstructed so that they seach information, read, see, and listen these facts/phenomena.
(2) Learning activities facilitate students for discussion and question-answer in finding concepts, principles, laws, and theories.
(3) Learning activities encourage students to actively do an experiment.
(4) Learning activities maximize the technology usage in processing the data, developing thinking, and predicting phenomena.
(5) Learning activities give creativity freedom and challenge in communicating attitude, knowledge and skill through presentation and/or performance with applying it in new expected and unexpected situations.

The essence of learning science, as suggested by (Pusat Kurikulum, 2007), is a learning that stimulate students' thinking skill including four main elements: 1) attitude: curiosity about things, natural phenomena, human beings, and cause-effect relationship presenting new problems that can be solved through the right procedure; 2) process: the procedure of problem solving through scientific method; 3) product: in terms of facts, principles, theories, and laws; and 4) application: the application of scientific method and natural science subject concept in daily life. The application of these elements is supposed to construct students with the ability to solve problems with using scientific method and to imitate the way how scientists work in finding new facts in learning process of natural science subject.

TPACK theory

Technological Pedagogical Content Knowledge (TPACK) is a knowledge of how to facilitate learning for students from certain contents through paedagogical and technological approach (Mishra & Koehler, 2006). Ordinary teachers only speak, good teachers explain, superior teachers demonstrate, and great teachers can give inspirations. Since teachers can inspire their students, this country will have young generation who can accelerate the civilization of Indonesia (Harris & Hofer, 2011)

At this time, personal computers are mostly used in the classroom in many countries. However, teachers who use information and communication technology (ICT) need to be investigated further. It is indicated that teachers frequently use ICT for their information transmission rather than learning media (Mishra & Koehler, 2006). This usage results in the stress on how teachers integrate ICT in learning process. TPACK is considered as a framework that potentially can give a new direction to teachers in solving problems related to integrating ICT in teaching and learning process in the classroom.

There are seven variables affecting TPACK (Evrim Baran dkk, 2011), namely (1) Technological Knowledge (TK), the knowledge about how to operate computer and software relevantly; (2) Pedagogical Knowledge (PK), an abilty in organizing learning process; (3) Content Knowledge (CK), a material of knowledge subjet such as language, mathematic, natural science, etc.; (4) Technological Content Knowledge (TCK), the knowledge about how content can be investigated or delegated by technology i.e. using a simulation that is educative and dialogic; (6) Evaluation of learning result; and (7) Students' development to actualize their various potentials (Cox & Graham, 2009). Its implication is simple. If there is a teacher who does not understand students, cannot explain learning materials well, is not able to give evaluation on what has been taught, and cannot develop students' potential, this teacher has no sufficient pedagogic competence (Harris & Hofer, 2011).

Those relationships are illustretaed in the following figure.

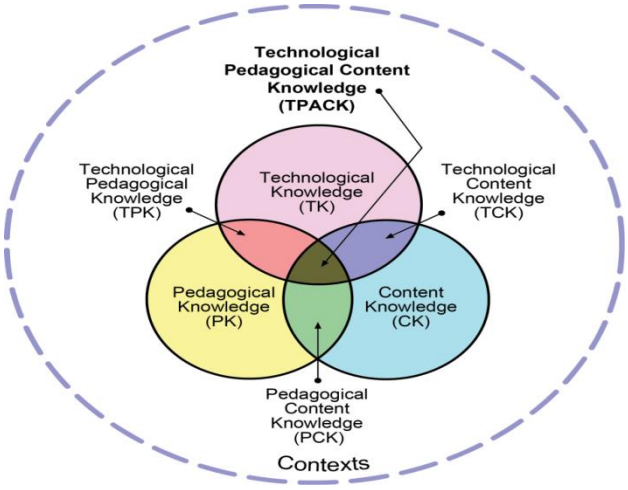

Figure 1. TPACK – Technological Pedagocial Content Knowledge (Mishra, P., & Koehler, M. J. 2008).

The relation between TPACk and POE_2WE is on learning process with POE_2WE model. After students make prediction and answer Student Worksheet, they do observation by an experiment. They do group discussion, to explain what is discussed in the expereiment. Consequently, technology in finding material from internet is needed obtain some references for the experiment.

Definition and Syntax of POE_2WE Model

Learning model of *Prediction, Observation, Explanation, Elaboration, Write,* and *Evaluation* (POE_2WE) is developed from POEW model and learning physics model with Contructivist Approach. POE_2WE model is a learning model developed to know student understanding on a concept with contructivistapproach. This model constructs knowledge with orderly process in terms of prediction solutions, conducting experiment to prove prediction, explaining experimental results in spoken or written texts, making an example of its application in daily life, recording discussion results and making an evaluation about students understanding in orally and textually.

POE_2WE model possibly serves students as learning subjects. Students are active in finding a concept through direct observation or experiment, not through memorizing textbook or teacher explanation. This model enables students to be active in learning process, gives students opportunities to construct their knowledge, to communicate their idea, and to record their

discussion result, so students more master and understand the concept that simultaneously affects the improvement of student achievement. This is in line with (Permatasari, 2011:1) who stated that this model allows students to have those opportunites and makes them easier to master the concept taught.

The combination of learning phases of POEW and learning physic model with Constructivist Approach is explained through learning phases of POE_2WE model as follows.

a) *Prediction:* Prediction phase facilitates students to make initial predication on a problem. The problem found is from statements and pictures about straight movement provided in Student Worksheet before students make predictions. To make the answers in the *prediction* phase in POEW model, is identical to the *engangement* phase in the constructivist approach. Teachers ask questions that stimulate students to make predictions or temporary answers of a problem.
b) *Observation:* Observation phase aims to prove predictions made by students. Students are encouraged to do an experiment related to the problem found. After that, students observe what happens, and students then text the validity of temporary predictions. The observation phase in POEW model is identical to the exploration phase in the constructivist approach.
c) *Explanation:* Explanation phase refers to students who give explanation about the experiment result. The explanation for students is conducted through group discussion, and each group then present their discussion result in front of the class. If the prediction happens in the experiement, teachers guide students to make summary and give explanation to reinforce the experiment result. Conversly, if student predictions do not happen in the experiment, teachers help students to find the explanation why their predictions are not right. The explanation phase is identical to explanation phase in the constructivist approach.
d) *Elaboration:* Elaboration phase deals with students who make an example or apply the concept in daily life. It is adapted from constructivist approach. In this phase, teachers encourage students to apply a new concept in a new situation, so they more understand the concept. This phase is the development of elaboration phase in the constructivist approach.
e) *Write:* Write phase is to do written communication, reflecting student knowledge and ideas. According to (Yamin & Ansari, 2012) suggested that writing can help students to express their knowledge and ideas. Students write discussion results and answer questions in Student Worksheet. Besides, they make the conclusion and report from the experiment result. This phase is the development of *TTW* model.
f) *Evaluation:* Evaluation phase is an evaluation on student knowledge, skills, and thinking process changes. In this phase, students are evaluated in terms of straight movement material orally and textually. This phase is a development of the constructivist approach.

The combination of POEW model and constructivist approach is explained in the following tables.

Table 1. Developmental Syntax of POE_2WE Model

No.	POEW Syntax (Samosir, 2010)	Syntax of learning model with constructivist approach (Duffy & Jonassen, 1992)	POE_2WE Model (Nana et al., 2014)
1.	(Prediction) is to make prediction.	(*Engagement*) is to make questions to recognize student initial knowledge.	(*Prediction)* is to make prediction. It is the prediction phase in POEW model that is identical to the engangement phase in the constuctivist approach.
2.	(*Observation*) is to make research, observation.	(*Exploration*) is to test prediction by conducting and recording the observation result.	(*Observation*) is to conduct the observation. It is the observation phase in POEW that is identical to the exploration phase in the constructivist approach.
3.	(*Explanation*) is to give explanation.	(*Explantion*) is to explain a	(*Explanation*) is to explain the experiment

No.	POEW Syntax (Samosir, 2010)	Syntax of learning model with constructivist approach (Duffy & Jonassen, 1992)	POE_2WE Model (Nana et al., 2014)
		conceot by their own language.	result. It is the explanation phase in POEW that is identical to the constructivist approach.
4.	*(Write)* is to give conclusion.	(*Elaboration*) is to apply a concept in daily life.	(*Elaboration*) is to apply the concept in daily life. It is the development of the constructivist approach.
5.		(*Evaluation*) is to evaluate student knowledge, skills, and thinking process changes.	(*Write*) is to write discussion results. It is the development od POEW model.
6.			(*Evaluation*) is to evaluate the effectiveness of previous phases. It is the development of the constructivist approach.

The table above shows that POE_2WE Model has been developed from two previous models. This model is almost similar to POEW since all POEW phases are adapted in POE_2WE model. However, *elaboration* (between *explanation* and *write* phases) and *evaluation* (in the last phase) are added as adapted from Duffy & Jonassen (1992). Hence, it is implied that POE_2WE Model perfects the POEW model.

Table 2. Learning Activities with POE_2WE Model

Phases	Teacher Activities	Student Activities
Prediction	- Explaining learning goals - Asking questions to students - Inventarizing predictions and reasons expressed by students	- Listening to teacher explanations - Predicting answsers of questions asked by teachers - Discussing prediction results.
Observation	- Encouraging students to work in group - Giving Student Worksheets - Monitoring experimental activities conducted by students	- Building a group - Conducting an experiment - Obtaining the data of experiment results - Conducting group discussion - Concluding experiment results
Explanation	- Encouraging students to explain experiment results. - Encouraging students to present their experiment results. - Clarifying experiment results. - Explaining new concepts/definitions.	- Expressing student opinions about experiment results. - Expressing their opinions about new ideas - Responding other presentations. - Accepting new concepts from teachers.
Elaboration	- Giving problems related to the application of the concept. - Encouraging students to apply a new concept in a new situation.	- Applying a new concept in a new situation or daily life.
Write	- Giving students opportunity to write explanation results.	- Writing explanation results from teachers and group discussion.
Evaluation	- Asking question for assessing the process. - Assessing student knowledge. - Giving feedback on student answers.	- Answering questions based on the data. - Demonstrating abilities in mastering the concept.

Table 2 shows that each phase relates to teaching and learning activities in terms of teacher and student activities. These activities are developed as a guideline in teaching and learning process. Moreover, this also will optimize student practical work result.

CONCLUSION

As a learning model, POE_2WE Model is good in optimizing student practical work result. The utilization of internet in POE_2WE learning process proves that is POE_2WE Model is applicable for teaching and learning physics in the Industrial Revolution 4.0 era.

SUGGESTION

Since the internet is used in collobaration with POE_2WE Model, it is suggested that it can be used to develop learning material and media applied in POE_2WE Model.

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