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How to teach physics using information and communication technologymedia?: a review to propose newidea of learning models

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Abstract: *The aim of this study was to proposenew idea of learning model to teach physics using ICT (information and communication technology)media. The research method used is the literature review. The results show that there were many ICT-based applications to build the concept of physics and visualize abstract equations into concrete concepts. The teacher's creativity is needed in designing learning models for ICT media. One model that can be considered is the POEER model (Predict, Observation, Explain, Extend, and Reflection) to teach physics using ICT. This model is the result of the modification of the POE (Predict, Observation, Explain) model. The addition of extend stages can facilitate students to develop concepts in new situations and the addition of reflection stages can facilitate students tomake continuous improvementsof learning outcomes.*
Keyword*: ICTlearning media, POE models, POEER models, physics learning applications*

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The use of information and communication technology in learning is a powerful way to prepare students to face a challenging global world.ICTsupported education can promote the acquisition of the knowledge and skills that will empower students for lifelong learning (Mayer, 2002). In twenty first century, personal success lies in being able to communicate, share, and use information to solve complex problems, in being able to adapt and innovate in response to new demands and changing circumstances, in being able to marshal and expand the power of technology to create new knowledge, and in expanding human capacity and productivity (Binkley et al, 2012).

More subject of matter emphasizes analytical thinking using mathematical equations that are still abstract. Through information and communication technology can facilitate students to concretize equations in the form of virtual visualization. With virtual and physical technology, not only students can touch and play with real-world physical manipulatives in their hands, but they can also see how the corresponding virtual manipulatives (ie, computer graphics) simultaneously change in real time (Ha, & Fang, 2018) Students will then have a better understanding of the limitations of a virtual experiment and how a physical experiment can help to find the corresponding virtual experiment (Lee, 2004).

In addition, through the use of information and communication technology (ICT) in learning, students' understanding of the material is expected to increase. Enhanced ways of thinking about learning, learning, and communication in the 21st century across content areas that can be extended beyond text, time, and geography can accelerate learning and retention in higher education, professional organizations, and learning environments (O 'Connor, McDonald, & Ruggiero, 2014). More than 72% of the tested students are considered the remote experiments the same or more effective than one (Malarić, Jurčević, Hegeduš, Cmuk, & Mostarac, 2008). Implementation of the Apps was particularly useful for the students' understanding of advanced concepts (Wang, Wu, Chien, Hwang, & Hsu, 2015). Learning based on Information Technology (IT) was able to encourage the active involvement of the students and demonstrate a significant improvement in physics learning but many teachers are not very quick to adopt these methods, and therefore the problem remains (Maharshak & Shoulder, 2004).

Teachers should be creative to create a pleasant classroom atmosphere so that students do not afraid to physics lessons. It's not an easy thing for teacherrs to make the physics class atmosphere into a fun class, mainly to make abstract physics concepts can be displayed in real terms so that students get new experiences in learning that are inherent in their minds. Sometimes teaching and learning activities are often faced with material that is abstract and outside the experience of students everyday so that this material becomes difficult to be taught by teachers and difficult to understand by students. Visualization is one way that can be done to concretize something abstract. Information and communication technology will easily visualize in the form of moving images (animation) which can also be added to the sound.

Implementation of the use of ICT is currently still carried out in one direction through direct learning, although many have facilitated students to operate their own multimedia to vary the variables to visualize abstract concepts, but it is still rare to be able to follow up on concepts learned in multimedia to be developed in new situations or new productivity. Therefore, it is necessary to formulateappropriate learning model to carry out information and communication technology in learning physics. One of the learning models suitable for learning using information and communication technology media is the POE (Prediction, Observation, Explain) model. POE learning model can improve the student's concept understanding (Rosdianto, & Murdani, 2017).The POE (predict-observe-explain) strategy can be used to improve physics misconceptions (Tyas, 2013).Related to this, researcherwas interested in analyzing learning based on ICT using POE (Prediction, Observation, and Explain) model. In this study, it will generate the idea how to formulate physics teachingusingICTeffectively by expanding POE model?

I. Methods

The method used in this research was literature review methods that recommended by Popay et al, (2006). Thestages of this method including (a) Identifying the review focus that was learning model to teach physics using ICT. Searching for and mapping the available evidence that was searching articles from Google scholar data base.(b) Specifying the review question, namely, how to formulate physics teachingusing ICT effectively by expanding POE model?(c) Identifying studies to include in the review that were primary sources, secondary source, and non-research literature. We searched the article by using keyword that were POE learning model, teaching physics base on ICT, and 7E learning models.(d) Data extraction and study quality appraisal. Data extracted with including title, author, full reference, purpose of study, type of study, setting, data collection method, major finding, and key thoughts/comments.(e) The synthesis,the key element of a literature review is the synthesis: that is the process that brings together the findings from the set of included studies in order to draw conclusions based on the body of evidence; and (f) Reporting the results of the review and dissemination.

II. Findings

The findings in this study will be presented on the theme of learning using ICT. this is done based on thinking sequences to find new ideas for an appropriate learning model to teach physics using ICT

1. How can ICT help transform the learning environment into learner-centered?

The main purpose of the use of ICT in education is divided into four areas, namely: data handling, information, communication and exploration (Gouveia, Fonseca, Câmara, & Ferreira, 2004). To support the optimal use of ICT, it is necessary to support adequate software and hardware. The need for supporting equipment can be classified into 4 parts: (1) digital data and video entry equipment to capture data in the form of images, (2) spreadsheets and graphical tools for data handling and analysis, (3) modeling and simulation tools including virtual animation, (4) information sources such as the internet or CD-ROMs(Terzopoulos,& Waters, 1990; Yee,1991; Shaughnessy, Garfield, & Greer,1996; &Kibirige, & DePalo, 2000).The characteristics of this ICT are linear, present dynamic visuals, are used in ways that have been determined by designers or developers, tend to present real concepts and abstentions physically, developed according to the principles of behavioral psychology and cognitive psychology, and often teacher-centered and not much involve learning activities interactively. Nevertheless, Learning effectiveness is strongly influenced by learning styles and how to learn.ICT can be created into a student-centered learning media by using a constructive learning model.

According to Mayer (2002), ICT can be created in learning, namely:(a) Active learning. ICT-enhanced learning mobilizes tools for examination, calculation and analysis of information, thus providing a platform for student inquiry, analysis and construction of new information; (b) Collaborative learning. ICT-supported learning encourages interaction and cooperation among students, teachers, and experts regardless of where they are. Apart from modeling real-world interactions, ICTsupported learning provides learners the opportunity to work with people from different cultures, thereby helping to enhance learners' teaming and communicative skills as well as their global awareness; (c) Creative Learning. ICTsupported learning promotes the manipulation of existing information and the creation of real-world products rather than the regurgitation of received information; (d) Integrative learning. ICTenhanced learning promotes a thematic, integrative approach to teaching and learning. This approach eliminates the artificial separation between the different disciplines and between theory and practice that characterizes the traditional classroom approach; and (e) Evaluative learning. ICTenhanced learning is student-directed and diagnostic. Unlike static, textor print-based educational technologies, ICTenhanced learning recognizes that there are many different learning pathways and many different articulations of knowledge.

In order to maximize the use of ICT in learning, teachers are required to be creative in choosing a learning model that is able to facilitate developing concepts that have been built through ICT. Teachers must be able to map the competencies that must be achieved using ICT and concepts that must be followed up to produce new products or solve problems in new situations.

2. Utilization ofICT in Physics Learning

ICT acts as a tool to form new information and understanding including: data processing, data recording, modeling, simulation, and moving images (Hanzl,2007; Harris, Mishra, & Koehler,2009). Davenport, 1993). ICT facilitates new methods of finding and obtaining various information available throughinternet, multimedia, visualization, tutorials and instructions (Olapiriyakul, & Scher, 2006; Tinio, 2003). In addition, ICT importance of learning programming with a focus on the development of computational thinking skills (Buitrago, 2017). In order for the technology to be synchronized with learning, the technology should be integrated into the learning system through the following stages: (1) determine relative benefits, (2) set goals and assessments, (3) design an integration strategy, (4) preparing instructional conditions; and (5) evaluation and improvement of integration strategies (Sosilo, 2017).

Computer applications in physics teaching, the first computer can capture and display data that comes from the real world quickly and accurately (Harris et al, 2009). Second, computers can present and display complicated simulations (Card,2017). Abstract concepts can be displayed in real terms which will be difficult if not done with the help of a computer (Bryson,1994). In some cases, computers have proven to be effective in helping students build reliable mental models through the ways students present and control the abstract visual appearance of the computer. Finally, the computer can be used as a modeling tool, so they feel real scientific activities rather than ordinary activities without the help of computers (Austin,Larson, & Ernst, 2002; Connolly, Lund, Mathiesen, & Leahy, 2010). If this computer modeling is combined with a data collection, students can learn the basics of science as a real world model and able to carry out scientific activities independently.

Multimedia types in physics learning are multimedia presentation and interactive multimedia. Multimedia presentations are used to explain the material that is theoretical, used in classical learning with quite a number of study groups. This media is quite effective because it uses a multimedia projector that has a fairly large transmit range. The advantage of this media is to combine all media elements such as text, video, animation, image, graphics and sound into a single presentation, so that it accommodates according to student learning modalities. This program can accommodate students who have visual, auditor and kinesthetic types.

Interactive multimedia is complete media elements including sound, animation, video, text and graphics. Some interactive multimedia models are: (1) Drill Model: is one of the learning strategies that aims to provide a more concrete learning experience through the creation of clones of forms of experience that approach the actual atmosphere (Hoppe, & Breitner,2003; &Delazer et al, 2005), (2) Tutorial Model: is a learning program using software in the form of a computer program that contains objectives, learning material and evaluation(Heffernan III,& Koedinger,2003), (3) Simulation Model: teaching with a computer for simulation in a special situation, or a system where students can interact(Janarthanam, & Lemon, 2009), (4) Game Model : This game model was developed based on fun learning where students will be faced with several instructions and rules of the game(Squire, 2011).

The availability of various software that supports physics learning is really something that is very beneficial for education actors. The availability and ease of accessing and obtaining the physics learning software is an excellent first step for the world of Indonesian education to move further. Based on its functions and utilization, the software can be categorized into (1) animated physics: MS Powerpoint, Macromedia flash(Cheema, & LaViola, 2012), (2) simulation of physics: PhET, Interactive physics(Chang,Chen, Lin, & Sung, 2008), (3) video analysis: OSP Tracker, Logger Pro(Derry, 2010),(4) data logging: Vernier LabPro, LabQuest(Avouris, Fiotakis, Kahrimanis, Margaritis, & Komis, 2007), (5) graph and data analysis: MS Excel, OSPdatatools (Leinhardt, Zaslavsky, & Stein, 1990).

3. POE (Predict-Observe-Explain) Learning Model

POE (predict-observe-explain) was developed to find the ability to predict students and their reasons for making predictions about the symptoms of something that aims to reveal students' ability to predict. The POE procedure is covering the prediction of students from the results of the demonstration (predict), conducting experiments (observing), discussing the reasons for the predictions (the results of the demonstration) they made and finally explaining the results of their predictions (explain).According to Teerasong et al (2010), the POE model provides opportunities for students to produce their own conceptual knowledge through reconciliation and negotiation between initial knowledge and new knowledge. This is because this learning model requires students to express their predictions and then make observations or observations and in the end the students are asked to explain the predictions that have been made in accordance with the observations they have made.Development of environmentally oriented POE oriented modules on pollution material can significantly improve learning outcomes(Widyaningrum, Sarwanto, & Karyanto, 2013).There is effect of Prediction, Observation, Explanation model to student's achievement learning physics (Tanzila,&Mahardika,2017).Problem

Based Learning Model through POE method has a positive effect and can improve the students' higher thinking ability of students who use the teacher method(Jayanti, Romlah, & Saregar, 2016).The POE (Predict-Observe-Explain) approach can improve students' creative thinking skills(Indriana, Arsyad, & Mulbar, 2015).

POE stands for Prediction, Observation, and Explanation (Suparno, 2007). Prediction is a process of systematically estimating something that is most likely to occur in the future based on past and present information that is owned. Prediction about an eventpresented usually through demonstrations. Demonstrations will make a passionate science and more knowledge about basic concepts. Demonstration can guide students to think demonstrations can speedup learningbecause they can focus attention in a concrete event and can make students ask about key concepts found in the experiment(Schaal, 1997). Through observation of event in demonstration process,students are asked to make guesses about what will happen. In predicting, the teacher emphasizes not to limit the ideas and concepts that arise from students' minds because the more guesses arise from students' minds.The teacher can understand how the concepts and understanding of students about the proposed problem, the teacher can also know the misconceptions occur in students' minds so this will be very important for teachers can make an explanation with the correct concept.

Observation is a fundamental scientific skill. Positive effect of self-observation is due to active observation of one's own actual performance(Fireman, Kose, & Solomon, 2003).In observation stage, students are invited to conduct experiment to test the truth of the predictions that they convey. The most important thing in this step is confirmation of their predictions. In this stage is to prove their guess by doing an experiment. By experimenting, it is hoped that there will be a process of imbalance between the new concepts lived and the concepts taken from the outside (built on common sense). In addition, through this stage, they held a repetition of observations, made measurements, analyzed, interpreted the data which then ended by drawing conclusions.

Explanation is giving an explanation especially about the suitability between expectations and experimental results at the observation stage. If the prediction results are in accordance with the results of the observation and after they get an explanation of the truth of the prediction, then the students are more convinced of the concept. However, if the assumption is not correct then students can look for an explanation of the inaccuracy of their predictions. Students will experience a change of concept from an incorrect concept to true. In this stage, students can learn from mistakes, and usually learning from mistakes will not be easily forgotten.

III. Discussion

How to teach physics using ICT?

Physics learning activities are inseparable from the delivery of material in the classroom and practical activities that will further deepen the mastery of the material that has been delivered in class. The implementation model of ICT utilization in classroom learning and laboratory activities can at least be classified into three parts, namely: (1) MBL/CBL (Microcomputer Based Laboratory/Calculator Based Laboratory), (2) VB/VBD (Video Based Laboratory/Video Based Demonstration), (3) SBL/ISE (Simulation Based Laboratory / Interactive Screen Experiment) (Hestenes, 1995). In Microcomputer Based Laboratory (MBL) is the use of computers that are focused on the process of automatically extracting experimental physics data.In the process, data retrieval uses various types of sensors so that they can make complete and automatic measurements (Bernhard, 2003; Thornton, & 1990; Adams, & Shrum, 1990).The use of computers in the Video Based Laboratory (VBL) is focused on analyzing physical phenomena/symptoms observed in digital video recording (previously using photographs or stroboscopic photographs)(Koleza,& Pappas,2008; Rodríguez,Silva, Rosano,Contreras,& Vitela, 2001). Simulation Based Laboratory (SBL) is a well-known category, whose application makes scientific (physics) symptoms through computer simulations based on mathematical models (Couture, 2004). The main strength in SBL is its ability to vary the experimental parameters to bring up a different response from the observed physical quantities.

Creating simple physical learning media based on ICT only requires power point mastery competencies for presentation (at least able to use background-text-color-graphic variations, custom animation variations, merge files, hyperlinks, navigation, insert picture-audio-video, insert flash files and insert applet files) and internet connections to browse images, animations, videos inserted in the power point. Supporting software used are Java Applets, Shockwave Player, Macromedia Flash, Quick Time Player and Macromedia Breeze. In addition, supporting software is also needed which is usually used in photo/video editing such as Ulead Video Studio, 3D Album, Xilisoft Video Converter and Camtasia. In making learning media requires the creativity of a teacher so that the media is interesting to be presented. Factors that influence the ability of teachers to implement ICT-based learning are lack of teacher ICT skills; lack of teacher confidence; lack of pedagogical teacher training; l lack of suitable educational software; limited access to ICT; rigid structure of traditional education systems; restrictive curricula (Buabeng, 2012).

The use of ICT in physics learning can be achieved by utilizing several software to formulate concepts and visualize physics equations, including Modellus applications, Phet applications, crocodile-clips, LiveWIRE, and Microsoft Encarta applications. Each of these applications has characteristics, advantages and disadvantages in presenting physics learning. The Modellus application is able to display various physics learning simulations from simple concepts to complex concepts (Neves, Neves, & Teodoro, 2013; Jimoyiannis, & Komis, 2001).To display simulations on the Modellus application, we first enter mathematical equations on the mathematical modeling menu. After that, several settings are needed to run the simulation. Through this application, students are guided to develop scientific skills independently to create visual experiments.

Physics learning simulation can also be done using the PhET application. This software is made by the University of Colorado, United States. PhET is a simulation application based on the Java Interface programming language (Neri, Noguez, Pérez, & Aguilar, 2011). This application is similar to Modellus and is capable of displaying two-dimensional animation and graphics. PhET can be used offline or online. PhET provides hundreds of millions of scientific trial simulations that have been uploaded in the PhET database and can be downloaded freely.

Software that is pretty good to use in physics learning is crocodile-clips, where this software can help schools that do not have complete science laboratory equipment. For physics, we can use Crocodile Physics. In this software, many examples of experiments are very fundamental to construct the concept of physics virtually (Concari, Giorgi, Cámara, & Giacosa, 2006). This is very helpful for students to understand the physics concepts they are learning.

Software that also can be used in physics learning is LiveWire. This application is an electronic simulation that is displayed in the form of animation and can sound to show the basic functions or principles of electronic circuits (Furse, 2005). The Livewire program includes application software which is a subclass of computer software that utilizes the ability of the computer directly to perform a task that the user wants. In terms of features this program is far less than other simulator programs in terms of its component data base, but this simulator program is quite helpful because there is a view of the flow or direction of the current flowing, making it easier for our mindset to run the current in the component.

Software that is no less interesting is Microsoft Encarta. This software titled Encyclopedia can summarize a variety of broad learning topics ranging from history, economics, politics, culture, social sciences, mathematics, computers, science, biology, chemistry, and physics (Tulloch, 2003; Charles,1998). Unlike other simulation software that requires input of mathematical equations or data logging, Microsoft Encarta is very easy to use and does not require any input. The colorful interface display (version of Encarta Kids) makes Microsoft Encarta look attractive, interactive, and quite inviting children's interest and interest, especially elementary school and junior high school students. Users simply click the menu tab available on the application's home page. The application will then display information in the form of text, articles, pictures, animations, clips and short videos of selected material. The application also provides trivia quizzes to just refresh the mind while testing how well the user is using the material after exploring this application.

How is the proper physics learning model in ICT-based learning?

Visualization of concepts and physics equations in ICT application media involves a lot of aspects of observation and analytical and critical thinking, so that one of the appropriate learning models is the POE learning model. Loduwik's (2016) research results show that with the application of POE learning models assisted by online learning media can improve learning outcomes and student activities in learning. In line with the results of the research Rizqillah, Ramalis, & Utama (2016) showed that the use of the Celestia Application on the Interactive Demonstration Inquiry learning model with effective POE model can significantly improve students' understanding of concepts. This learning prioritizes the discovery process to gain knowledge so that students are actively involved in building the concept. ICT applications can be used as virtual simulation media that can visualize physical phenomena that allow users to experience the universe and are able to display objects from various sides so that the role of the teacher as facilitator is clear as the maker and regulator of ICT application scenarios in accordance with the POE learning model. Another learning model that has a more complete syntax is the 7e model, where this model is a refinement of the 5e model. The 7E model facilitates students to learn effectively and organize the knowledge in a meaningful way. Then the students expand their knowledge while they apply the topic to other cases (Nuhoðlu, & Yalcin, 2006). The worksheets and conceptual text prepared according to the 7E model gave positive impressions to the students at the experimental group and at the same time students' misconceptions decreased and students gave better answers to the questions (Yılmaz, Ertem, & Çepni, 2010).

Based on the analogy of thinking from the transformation of the learning model 5e to 7e, the POE learning model can be modified into a POEER learning model (Prediction, Observation, Explanation, Extend, and Reflection. In this extend stage, students are required to think, search, find, and explain examples of application new concepts and skills that have been learned The teacher can direct students to obtain alternative explanations by using data or facts they explore in new situations.In addition, through this activity the teacher stimulates students to look for conceptual relationships they have learned with other concepts that have been or have not been studied.In this context the evaluation in the 7e model stage is replaced by reflection on the

POEER model with the reason that reflection is an attempt to improve and improve the understanding of concepts that have been constructed by students. While evaluation is part of learning that cannot be separated from learning activities using any model. Reflection (feedback) can be obtained from yourself, colleagues, and teachers. The word reflection is also used in lesson study activities namely plan, do, and see (reflection) (Lewis, 2000). Reflection reflects a continuous process of business improvement on a system. In the context of adding reflection phases to the POE model it is expected that improvements to misconceptions and seeking opportunities for improvement to the concepts that have been developed are expected.

IV. Conclusions

Many ICT applications have been developed in physics learning such as Modellus applications, Phet applications, crocodile-clips, Livewire, and Microsoft Encarta applications. Therefore, the teacher's creativity is required to choose the appropriate learning model to use ICT-based learning media in physics learning. One alternative that can be considered is the POEER learning model which is a modification of the POE learning model syntax, namely by adding stages of extend and reflection. The addition of the extend phase means that the concepts that have been observed and explained in the POE learning model can be developed in new situations while the addition of the reflection stages is intended to make continuousimprovement so that the concepts that have been constructed and developed receive feedback from peerand teacher.

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