THE COMPARISON OF ORIENTASI IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILL OF PHYSICS TEACHER CANDIDATES

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Abstract. This research aims to: (1) analyze the effectiveness of learning by using the Orientasi IPA Teaching Model and Problem Based Learning (PBL) Model based on the level of critical thinking skill (cts) improvement and (2) obtain a more effective teaching/learning model. A learning is said to be effective if: (1) there is a significant increase in student's cts at $\alpha = 5\%$, (2) the average N-gain is at least in moderate, and (3) student's response is at least positive. The research subject was 94 students in three groups (the Conventional Model as a control). Prior to the learning, students were given the cts test and after the learning, the students were given the same test. The data was analyzed by using Paired t-test, N-gain and Independent t-test. The results showed that: Each of Orientasi IPA, PBL, and Conventional can significantly increase students' cts at $\alpha = 5\%$, respectively with average N-gain medium (.60), medium (.48), and low (.14), with the student response of: very positive, very positive, and less positive. Conclusion: (1) The Orientasi IPA and PBL are effective to improve students' cts, while the Conventional is ineffective, and (2) the Orientasi IPA is more effective compared to the PBL.

Keywords: Critical thinking skill of physics teacher candidates, learning effectiveness, basic physics course, Orientasi IPA model, and PBL.

Introduction

In this 21st century, education has an important role in producing Human Resources (HR) that has the needed skills to work. Meanwhile, the demands of the curriculum and the development of globalization era require educational institutions to do beneficial innovations for the 21st century skill-based educational world (Turiman, Omar, Daud, & Osman, 2012; Griffin & Care, 2015). Permendikbud No.73 of 2013 on the Indonesian National Qualification Framework in the field of higher education requires universities to prepare curriculum for physics teacher candidates to have superior competence with various skills that are in line with 21st century demands, among them are:

critical thinking skills, skills to utilize Information and Communication Technology (ICT), and skills to solve problems (Griffin & Care, 2015; Jatmiko, Widodo, Martini, Budiyanto, Wicaksono, & Pandiangan, 2016; Kemdikbud, 2013; Pandiangan, Sanjaya, & Jatmiko, 2017). The 21st century learning process requires human resources with competence and the achievement of physics teacher candidates are directed to skills and learning innovations, among others are: Critical thinking skills, problem solving skills, decision making, creative thinking, responsibility, and ability to learn independently (Partnership for 21st Century Skills, 2014; Griffin & Care, 2015).

The development of critical thinking skills are considered as one of the most important goals of education for over a century (Forawi, Almekhlafi, & Al-Mekhlafy, 2012; Geertsen, 2003). Critical thinking has been defined and measured in a number of ways, but it usually involves an individual's ability to identify central issues and assumptions in arguments, recognize important relationships (Mason, 2017, Moon, 2007), make correct conclusions from data, infer provided information or data, interpret whether the conclusion is guaranteed or not based on the data provided (Facione, 2013; Mulnix, 2012). Furthermore, previous researchers explain that critical thinking is cognitive skill, it includes activities of interpretation, analysis, evaluation, inference, explanation, and self-management in problem solving (Bean, 2011; Cheong & Cheung, 2008, Dam & Volman, 2004; Ennis, 2011; Ernst & Monroe 2004; Jenicek, 2006; Marin & Halpern, 2011; Miri, David & Uri 2007; Mundilarto & Ismoyo, 2017; Popil, 2011; Siew & Mapeala, 2016 Snyder & Snyder , 2008; Womack & Jones, 2010). In this research, critical thinking skill is cognitive process which are carried out as a thinking guide by using reason judgments against evidence, context, standard, method, and conceptual structure by performing concepts, application, synthesis and / or information obtained from observation, experience, reflection, thinking , or communication as a basis for believing and doing an action and focusing on what to do. The critical thinking skill's indicators in this research are analysis, evaluation, interpretation, and inference based on the results of literature research and preliminary study by the investigator, these indicators are still low and needs to be accelerated in physics teacher candidates.

In connection with the improvement of the learning process and outcomes quality mentioned above, there are important problems faced by the world of education today, which is how to strive physics teacher candidates' critical thinking skill through learning (Krulik & Rudnick, 1996; Marzano, 1993). This needs to be done because there are many students who do not have a critical thinking skill (Brookfield, 2017). Critical thinking skill is an important thinking skill and should be trained but there are still many lecturers who do not understand how to train critical thinking skill. The results of Patrick's, Fallon, Campbell, Cretchley, Devenish, & Tayebjee (2014) and Pithers & Soden (2000) showed that critical thinking skill should be taught, but there are still some lecturers who do not know how to teach critical thinking skill effectively (Brownlee, Walker , Lennox, Exley, & Pearce, 2009; McPeck, 2016).

Martin, Mullis, Foy, & Stanco (2012) showed that most of Indonesian student are only able to recognize a number of basic facts and have not been able to communicate and relate various topics of science, especially in applying complex and abstract concepts. This fact is in line with the results of Rosyid, Jatmiko, & Supardi (2013) research, which indicated that the physics learning process is still and more emphasized on the process of knowledge transfer so it has not been able to make students able to construct knowledge. The low critical thinking skill of physics teacher candidates is suspected to have something to do with the teaching process being implemented (Browne, & Meuti, 1999; Staib, 2003; Wlodkowski, & Ginsberg, 2017). The implemented teaching model, which is the Conventional Teaching Model (Conventional Model) cannot facilitate in developing students' critical thinking skill, resulting in low learning achievement (Hammond et al., 2015; Mann & Kaitell, 2001). Therefore, to improve the quality and facilitate the development of physics teacher candidates, it is necessary to find out alternative solutions. The alternative solutions include implementing the Orientasi IPA Teaching Model (Orientasi IPA Model) and Problem Based

Learning Model (PBL Model). The results of previous research conducted by Rosyid, Budi, & Supardi (2013) showed that Orientasi IPA Model and PBL Model with supporting learning instruments can improve high school students' learning outcomes in Kabupaten Jember, East Java significantly at $\alpha = 5\%$ with moderate N-gain.

The Orientasi IPA Model is a problem-based learning model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Multi-representation teaching can stimulate students to perform analysis, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This was also applied to Ainsworth's (2008, 1999) and Ciais, Reichstein, Viovy, Granier, Ogée, Allard & Carrara (2005) studies which suggested that multi-representation learning has three main functions: complementary, interpretive, and can build a more comprehensive understanding. In this research, the Orientasi IPA Model has five syntaxes, namely: Problem Orientation, Problem Representation, Group Investigation, Presentation, Analysis and Evaluation (Rosyid, Budi, & Supardi, 2013). The interactive tasks in applying this Orientasi IPA Model to grow up the ability of critical thinking skill are referred to the phases in the syntax, namely: (1) **Orientation of Problem**, which is aimed to attract the students, focus the students, and motivate them to take an active role in the learning process; (2) **Representation of Problem**, which is aimed to assist students in understanding the material and solving the problems that will be discussed through various approaches that can be adapted to the objectives of learning and the presented material characteristics; (3) **Investigation**, which is aimed to collect information with the help of Student Worksheet, then the lecturer guides to carry out step-by-step investigations, explores the explanation, and solutions to build the critical thinking skill which includes (a) formulating the problem; (b) formulating the hypothesis; (c) identifying variables; (d) writing the operational variables definition; (e) writing down the experimental tools and materials; (f) conducting experiments; (g) organizing experiment data; (h) analyzing experimental data; and (i) making a conclusion; (4) **Presentation**, which is aimed to guide students in making conclusions and discussion of the investigation results in various representations, and assisting in the planning, preparing and presenting the works; and (5) **Analysis, Evaluation and Follow-up**, which is aimed to analyze and evaluate the problem-solving process of inquiry and process in various forms of representation, observe the students' work as the learning evidence, and facilitate follow-up learning through the assignment of structured tasks.

The PBL Model is a problem-based learning model that describes a view of education in which the school is seen as a mirror of society and class as a laboratory for the investigation of everyday life issues (Arends, 2012; Nilson, 2016). The PBL Model also has five syntaxes, namely: directing students to problems, organizing students to learn, helping independent and group investigations, developing and presenting artifacts and exhibits, and analyzing and evaluating problem-solving processes (Arends, 2012). Characteristics of the PBL Model are designed to help students improving their inquiry skills and problem-solving skills, social behavior and skills according to the role of adults, as well as independent learning skills (Arends, 2012; Arizaga, Bahar, Maker, Zimmerman, & Pease, 2016). The PBL Model begins with a complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a suitable learning environment for students (Caesar et al., 2016; Kong, Qin, Zhou, Mou, & Gao, 2014; Myers, 2017; Nuninger & Châtelet, 2017). The PBL Model also regulates a student-centered learning environment that is not viewed as an empty vessel, but is capable to bring its own distinct framework and learning (Chakravarthi, 2010; Efendioglu, 2015; Sern, Salleh, & Sulai, 2015). The PBL Model can enhance self-study skills and provide a more realistic picture of higher academic challenges, more confidence, better problem-solving skills, critical thinking skills, and provide the improvement of communication skills (Ates &

Eryilmaz, 2010; Benade, 2017 ; Efendioglu, 2015; Méllesis & Hurren, 2011; Leong, 2017; Malan, Ndlovu, & Engelbrecht, 2014; Myers, 2017; Sern, Salda, & Sulai, 2015; Tracey & Morrow, 2017; Tracey & Morrow, 2017; Williams, 2005; Zabit, 2010). The application of PBL Model will promote students to have motivation, confidence in learning and able to improve students' ability to solve more complex problems (Caesar et al., 2016; Chakravarthi, 2010; Ledesma, 2016; Malan, Ndlovu, & Engelbrecht, 2014; Nilson, 2016; Sern, Salleh, Mohamad, & Yunos, 2015; Tracey & Morrow, 2017). However, the PBL Model is still weak in terms of inquiry orientation components, alternative solutions, and difficult in formulating problems and preparing hypotheses (Ates & Eryilmaz, 2010; Chakravarthi, 2010; Sern, Salleh, & Sulai, 2015). Although the research shows that the PBL Model supports self-study and communication skills, critical skills improvement, creative thinking skills and problem-solving skills (Ates & Eryilmaz, 2010; Malan, Ndlovu, & Engelbrecht, 2014, Tracey & Morrow, 2017), however PBL's weaknesses are lack of initiation and timing, lack of student discipline, and more challenging authentic issues are needed (Ates & Eryilmaz, 2010; Thompson et al., 2012).

The State University of Surabaya (Unesa) as an institution of higher education has facilitated its lecturers with various teaching models that can be integrated with information and communication technology. However, the reality shows that there are still many lecturers who have not conducted the lesson by utilizing the facilities to provide learning experiences for teacher candidates. Most of the lecturer facilities provided by Unesa are only used as learning tools and have not been utilized to produce teaching/learning models. The teaching models gained through a series of research are less useful and ineffective because they have not been optimally utilized by lecturers at Unesa as it is in other higher education institutions, lecturers should be responsible for developing models, strategies, approaches, methods or instructional techniques in the era of the 21st century (Huba & Freed, 2000; Richards & Rodgers, 2014). Orientasi IPA Model and PBL Model are very useful to improve lecturers' competence in teaching. This is because the teaching becomes more interesting, more challenging, and better suited to the needs of students. The results of previous research indicates that the Orientasi IPA Model and PBL Model are effective and practical in improving critical thinking skills of Senior High School students in Jember Regency (Rosyid, Jatmiko, & Supardi, 2013).

Referring to the effectiveness of Orientasi IPA Model and PBL Model in improving the students' critical thinking skill, it needs to be reviewed and tested for further consistency in improving the critical thinking skill of physics teacher candidates from Unesa. This research is very important in order to develop models and learning theories that are able to answer the challenges and skills needs in the 21st century. The low critical thinking skill is theoretically caused, among other things, by: poor motivation and responsibility, poor analytical skills, and less discipline in learning (Adebayo, 2014). This is also due to the lack of ability to organize time, lazy to learn, and less supportive learning environment (Chakravarthi, 2010; Eaton, 2015). Therefore, it is necessary to compare the effectiveness between Orientasi IPA Model and PBL Model in improving student critical thinking skill. In order to be able to compare the effectiveness of the two models, then the preparation of learning instruction of Orientasi IPA Model and PBL Model was done firstly which is designed to be able to increase critical thinking skill of physics teacher candidates.

Problem of Research

The problem of this research is how to analyze the effectiveness of learning in the basic physics course with the Orientasi IPA Model and PBL Model to get more effective teaching/learning model to improve the critical thinking skill of physics teacher candidates. In addition, also how to get examples of learning instruments that are valid and reliable with an effective teaching model in improving the critical thinking skill of physics teacher candidates.

Research Focus

The focus of this research was to compare the effectiveness of learning in basic physics courses with Orientasi IPA Model and PBL Model in improving the critical thinking skill of physics teacher candidates. This research used control variables; it was the conventional leaning model. In detail, the focuses of this research were: (1) how is the validity and reliability of learning instruments in basic physics courses with Orientasi IPA Model and PBL Model to improve the critical thinking skill of physics teacher candidates, which includes: Semester Learning Plan, Lesson Plan, Student teaching materials, Student Worksheet, and student critical thinking skill test of physics teacher candidates?; (2) how is the effectiveness of learning with Orientasi IPA Model, PBL Model, and Conventional Model in improving the critical thinking skill of physics teacher candidates? and (3) which teaching model is the most effective to improve the critical thinking skill of physics teacher candidates?

Methodology of Research

General Background of Research

Critical thinking skill is a necessary thinking skill for the workforce of the 21st century, therefore researchers think on how to strive students' critical thinking skill to obtain results that match the expectations. During this time, the way to get the student's critical thinking skill is done by learning with PBL Model, but the previous research conducted on high school students in Jember, Indonesia by using learning with Orientasi IPA Model, which is a correction of the PBL Model to improve students' critical thinking skill showed results that are also effective and practical (can be applied). On the other hand, many students do not have critical thinking skill, so there are many lecturers who still do not understand how to teach critical thinking skill effectively to the students.

On the basis of the above problems, it is necessary to conduct research to analyze the effectiveness of Orientasi IPA Model and PBL Model in improving the critical thinking skill of physics teacher candidates and comparing the effectiveness of the two models so that it will be obtained a more effective learning. In addition, it is necessary to provide examples of learning instruments by using the Orientasi IPA Model and PBL Model, which meet the valid and reliable requirements of lecturers in order to teach the physics teacher candidates by using more effective learning instruments.

Sample of Research

The research was conducted to 94 students of Physics Education Study Program, Unesa, Indonesia, which came from a population of 123 students in three groups (experimental group-1 / Orientasi IPA Model, experimental group-2 / PBL Model, and control group / Conventional Model). The Conventional Model in this research was lecturer-centered teaching model, which includes lecture, presentation, and discussion. The calculation of the sample number was based on the Slovin formula, that was the sample = [population / (1 + e^2 × population)] with fault tolerance e = 5% (Sevilla, Ochave, Regala, & Uriarte, 1984; Tejada, & Punzalan, 2012). This research took three groups, namely: group of: experiment-1 came to 31 students; experiment-2 came to 30 students; and control came to 33 students, each of them were statistically in the same level of critical thinking skill.

Instrument and Procedures

This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design (Fraenkel, Wallen, & Hyun, 2012).

O_1	X_1	O_2
O_1	X_2	O_2
O_1	C	O_2

With:

O_1: Pre-test score, O_2: Post-test score, X_1: Orientasi IPA Model, X_2: PBL Model dan C: Conventional Model

Prior to the research, firstly the researchers set up learning instruments that covered these components: (1) Semester Learning Plan, (2) Lesson Plan, (3) Student teaching materials, (4) Student Worksheet, and (5) critical thinking skill test of physics teacher candidates, respectively for the Orientasi IPA Model and PBL Model. The data was collected by using the research instruments, which consisted of the following components: (1) Teaching Model Implementation Sheet and (2) Student Response Sheet. The validity of those learning instruments from both Orientasi IPA Model and PBL Model was then assessed by the physics education experts in terms of the content and construct. In order for the learning instruments to be able to be implemented, the leaning instruments have to meet the valid and reliable requirements.

The research began by giving the critical thinking skill pre-test (O_1) by using the critical thinking skill test of physics teacher candidates to each group of students, then providing learning with different models, namely: Orientasi IPA Model, PBL Model, and Conventional Model. Finally, after the entire learning process has been completed, all groups of students are awarded a post-test (O_2) of the critical thinking skill with the same materials and problems as in the pre-test.

Data Analysis

In order to get the validity of contents and construct for the learning instruments of the Orientasi IPA Model and PBL Model as well as the research instrument, thus the assessment of those instruments was done by the physics education expert based on the content and construct validity. Content validity is a description of needs and novelty, while construct validity is a description of the consistency of learning instruments of Orientasi IPA Model and PBL Model with theory/empirical and consistency between the instruments components (Plomp, 2013). The data was analyzed by reliability test; each of them was analyzed by using Cohen's Kappa, single measure interrater coeficient correlation (r_α) and Cronbach's alpha (α). The learning instruments and research instruments are said to be valid if r_α > r table and invalid if $r_\alpha \leq$ r table.

Meanwhile, the learning instruments and research instruments are said to be reliable if $0.6 \leq \alpha \leq 1.0$ and not reliable if $\alpha < 0.6$. In order to analyze learning with a more effective teching/learning model, an "effective" operational definition is required. Learning with Orientasi IPA Model, PBL Model, and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skill of physics teacher candidate at $\alpha = 5\%$, (2) the minimum N-gain is categorized as moderate, and (3) students' responses are at least positive. In this research, the pre-test and post-test results were analyzed as follows: when the normality assumption for the achieved score is met, the Paired t-test will be applied. If it is not met, non-parametric analysis will be used. In order to get increasing level of student's critical thinking skill score, the calculation was done by using N-gain with equation: N-gain = (Post-test score - Pre-test) / (maximum score - Pre-test) (Hake, 1998). By the criteria of: (1) N-gain > 0.70 (height); (2) 0.30 < N-gain < 0.70 (medium); and (3) N-gain < 0.30 (low). In order to test whether the improvements on students' critical thinking skill existed or not with the Orientasi IPA Model, PBL Model, and Conventional TeachingModel, Paired t-test against the pre-test score and post-test by using IBM SPSS Statistic 16 software was done. Meanwhile, to get more effective model in improving students' critical thinking skill after being given lessons, researchers compared the effectiveness of the three models by using Independent t-test. In order to see the responses of physics teacher candidates toward learning with Orientasi IPA Model, PBL Model, and Conventional Model, student responses data was analyzed by using qualitative descriptive (Prahani, Winata, & Yuanita, 2015; Riduwan, 2010). With the criteria of: (1) Response ≥ 75% (very positive); (2) 50% ≤ Response <75% (positive); (3) 25% ≤ Response <50% (less positive); and (4) Response <25% (not positive).

Results of Research

Validity of Learning Instruments and Research Instruments of Orientasi IPA Model and PBL Model

Before the research is done, learning instruments and research instruments that have been compiled must meet the requirements of validity and reliability. The validity of learning instruments of Orientasi IPA Model and PBL Model, and research instruments were assessed by two physicists of Unesa. The results of the validity assessment of the learning instruments and research instruments for Orientasi IPA Model and PBL Model, respectively, are shown in Table 1 and Table 2.

Table 1. The Result of Learning Instruments and Research Instrument Validity of Orientasi IPA Model.

Components	The Validity of Orientasi IPA Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	Cohen's kappa	R	r_α	V	α	R
Semester Learning Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.99	Reliable
Lesson Plan	.87	Reliable	.25	Valid	.97	Reliable	.87	Reliable	.25	Valid	.97	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.96	Reliable	.25	Valid	.99	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.96	Reliable	.25	Valid	.98	Reliale
Student Critical Thinking Skill Test of Physics Teacher Candidates	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes:
r_α = *Single measure interrater coeficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Tabel 2. The Validity of PBL Model Instruments.

Components	The Validity of PBL Model Instruments											
	Consteuct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	*Cohen's kappa*	R	r_α	V	α	R
Semester Learning Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Lesson Plan	.86	Reliable	.25	Valid	.96	Reliable	.86	Reliable	.25	Valid	.96	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.95	Reliable	.25	Valid	.96	Reliable
Student Critical Thinking Skill Test of physics teacher candidates	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Learning Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes:
r_α = *Single measure interrater coefficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Table 1 shows that the construct validity of the Orientasi IPA Model instruments include: Semester Learning Plan; Lesson Plan; Students Activity Sheet; Student Teaching Materials; Student critical thinking skill test of physics teacher candidate, and the research instruments, which includes: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the Orientasi IPA Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skill; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skill needs to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the learning instruments of the Orientasi IPA Model in order to be implemented.

Table 2 shows that the construct validity of the PBL Model instruments include: Semester Learning Plan; Lesson Plan; Students Activity Sheet; Student Teaching Materials; Student Critical Thinking Skill Test of physics teacher candidates, and the research instruments, which includes: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all componnents are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the PBL Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skill; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skill needs to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the learning instruments of the PBL Model in order to be implemented.

Based on the above description, it can be said that the learning instruments of Orientasi IPA Model and PBL Model have fulfilled the content and construct validity requirements to improve the critical thinking of physics teacher candidates. The learning instruments of Orientasi IPA Model and PBL Model can be implemented in the learning process of basic physics courses.

The Effectiveness of Orientasi IPA Model, PBL Model and Conventional Model for Critical Thinking Skill of Physics Teacher Candidates

The critical thinking skill score and N-gain of physics teacher candidates were obtained by providing the pre-test and post-test of the critical thinking skill. The detailed score of pre-test, post-test, and N-gain of physics teacher candidates in the Orientasi IPA Model, PBL Model, and Conventional Model are shown in Figure 1. While the critical thinking skill indicators of group-1: Orientasi IPA Model, group-2: PBL Model, and group-3: Conventional Model are presented in Table 3. Figure 1 shows that prior to the learning with Orientasi IPA Model, PBL Model, and Conventional Model, physics teacher candidates have low average of critical thinking skill. After the implementation of Orientasi IPA Model and PBL Model, physics teacher candidates have an increase in the average of critical thinking skill, but in Conventional Model, all physics teacher candidates still have average of critical thinking skill in low category. In general, the average of critical thinking skill for physics teacher candidates in post-test with Orientasi IPA Model, PBL Model, and Conventional Model is in high category (2.67); Medium (2.14); and low (1.00) and the score ranged from 1 - 4. The average N-gain of critical thinking skill owned by physics teacher candidates students for learning by using Orientasi IPA Model, PBL Model, and Conventional Model, is in the category of moderate (.63); moderate (.47); and low (.14), from the score range of 0 - 1.

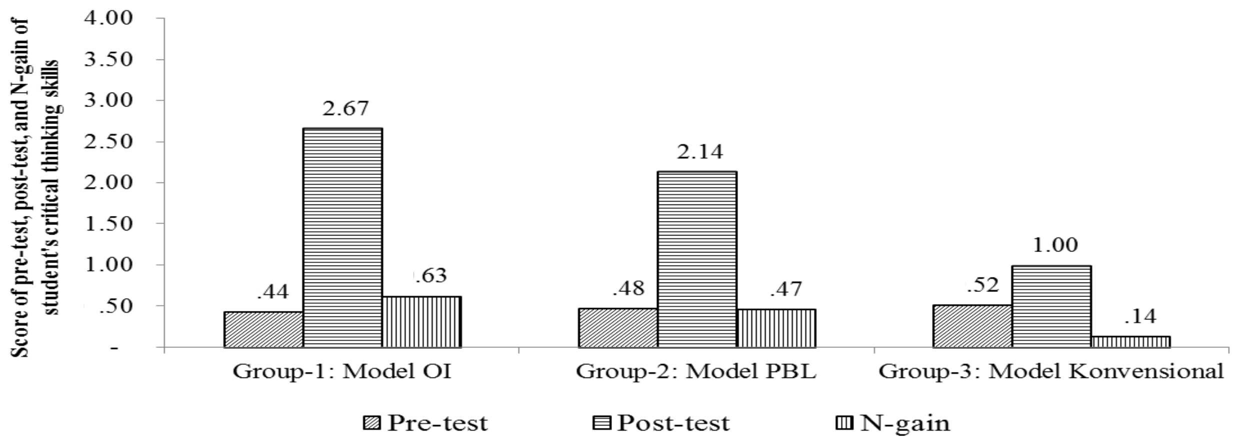

Figure 1: The Score of Pre-test, Post-test, dan N-gain of Critical Thinking Skill Owned by Physics Teachers Candidates with Orientasi IPA Model, PBL Model, and Conventional Model.

Figure 1 indicates that in order to increase the critical thinking skill of physics teacher candidates, the Orientasi IPA Model is better compared to the PBL Model and Conventional Model. While the PBL Model is better when compared to the Conventional Model

Table 3. The Critical Thinking Skill Indicator of Group-1: Orientasi IPA Model, Group-2: PBL Model, dan Group-3: Conventional Model

Group	Score	Indicators of Critical Thinking Skill			
		Analysis	Evaluation	Interpretation	Inference
Group-1: Orientasi IPA Model	Pre-test	.45	.31	.52	.45
	Post-test	2.91	2.47	3.00	1.96
	N-gain	.69	.59	.71	.43
Group-2: PBL Model	Pre-test	.59	.39	.82	.13
	Post-test	2.36	2.24	2.59	1.39
	N-gain	.52	.51	.56	.33
Group-3: Conventional Model	Pre-test	.49	.32	.71	.58
	Post-test	1.09	.69	1.29	.93
	N-gain	.17	.10	.18	.10

Table 3 shows that the results of critical thinking skill pre-test of physics teacher candidates for all critical thinking skill indicators were in the low category, whereas after the implementation of learning with Orientasi IPA Model, all the critical thinking skill indicators have increased. In general, the average N-gain for critical thinking skill indicator with Orientasi IPA Model was in medium and high category, with the value was above .43. The result of critical thinking skill pre-test of physics teacher candidate for all indicators was in low category, while after implementation of learning with PBL Model, all critical thinking skill indicators have increased. In general, the average N-gain of critical thinking skill indicator with PBL Model was in medium and high category with the value was above .33. The result of critical thinking skill pre-test of the physics teacher candidates for all critical thinking skill indicators was in low category, while after the implementation of learning with Conventional Model, all critical thinking skill indicator remain in low category. In general, the average N-gain of critical thinking skill indicators with Conventional Model was in low category with value above .10. Meanwhile, the lowest indicator of critical thinking skill in all groups was inference.

Paired T-test of Critical Thinking Skill Owned by Physics Teachers Candidates with Orientasi IPA Model, PBL, and Conventional Model.

The existence of critical thinking skill increase in the physics teacher candidates is measured by testing the average score of Pre-test and the Post-test score by using Paired t-test. Paired t-test is used (for parametric statistical test) because it has fulfilled the requirements: (1) Pre-test score and Post-test data of critical thinking skill of physics teacher candidates come from normal distributed population, conducted by normality test (Shapiro-Wilk); and (2) the average of Pre-test and Post-test score data is homogeneous when tested by using the two variance equality test. Paired t-test for the average score of Pre-test and Post-test of critical thinking skill conducted on Group-1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of Paired t-test against Pre-test and Post-test score of critical thinking skill of physics teacher candidates is presented in Table 4.

Table 4. The Results of Paired t-test of Critical Thinking Skill Owned by Physics Teacher Candidates in All Groups.

Group	N	*Paired t-test*				
		Mean	Std. error mean	t	df	p
Group-1: Orientasi IPA Model	31	-2.25	.13	-17.95	30	< .01
Group-2: PBL Model	30	-1.66	.08	-19.83	29	< .01
Group-3: Conventional Model	33	- .48	.05	-9.24	32	< .01

Table 4 shows that the mean scores of critical thinking skill for groups 1, 2 and 3 respectively for: Orientasi IPA Model, PBL, and Conventional Teaching Model are -2.25; -1.66; and - .48 with degrees of freedom (df) are 30; 29; 32, and giving t value of -17.95; -19,83; and -9.24. The result of Paired t-test for each group is significant, because p <.05. Therefore t counts the negative value, then clearly there is a significant difference at α = 5% between the pre-test score with the critical thinking skill Post-test in all groups. For learning with the Orientasi IPA Model, PBL, and Conventional Model, all of them show higher post-test score compared to the pre-test score, or the mean scores of critical thinking skill of physics teacher candidates after each learning process with the Orientasi IPA Model, PBL, and Conventional Model are higher than before.

Independent T-test of Critical Thiking Skill Owned by Physics Teachers Candidates with Orientasi IPA Model, PBL, and Conventional Model.

In order to analyze which model is more effective in increasing the critical thinking skill of physics teacher candidates among Group 1: Orientasi IPA Model Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model, among others, is done by testing the average N-gain of the critical thinking skill by using Independent t-test. Independent t-test is used (for parametric statistical tests) because it meets the requirements of: (1) the average N-gain of critical thinking skill of physics teacher candidates (Group 1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model) are derived from normally distributed populations, performed by normality test (Shapiro-Wilk); and (2) the average N-gain of critical thinking skill of physics teacher candidates (Group 1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model) is homogeneous when measured by using multiple-variance test equations. Independent t-test for the average N-gain was performed on Group 1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model. Independent t-test results on the average N-gain for all groups are presented in Table 5.

Table 5. Independent t-test results on the average N-gain for all groups.

Group	N	*Independent t-test*				
		Mean Difference	**Std. error mean**	**t**	**df**	**p**
Group 1: Orientasi IPA Model Group 2: PBL Model	61	.15	.04	3.58	59	< .01
Group 1: Orientasi IPA Model Group 3: Conventional Model	64	.49	.04	12.5	62	< .01
Group 2: PBL Model Group 3: Conventional Model	63	.34	.03	12.51	61	< .01

Table 5 shows that the mean difference of N-gain of critical thinking skill for groups: 1-2, 1-3, and 2-3 is .15; .49; .34 and respectively have degrees of freedom (df) = 59; 62; 61, gives a value of t = 3.58; 12.5; and 12.51. The score is significant, because p <.05. Therefore p <.05, it is clear that there is significant difference in mean of critical thinking skill N-gain in Group-1 that is the Orientasi IPA Teaching Model with Group-2 that is PBL Model, Group-1 that is the Orientasi IPA Teaching Model with Group-3 that is Conventional Teaching Model; Group-2 that is PBL Model with Group-3 that is Conventional Teaching Model, for each at α = 5%. The results of the above analysis show that the average N-gain of critical thinking skill of physics teacher candidate was higher after learning with the Orientasi IPA Teaching Model when compared to PBL Model and

Conventional Model. While learning with PBL Model gave higher average N-gain when compared to the Conventional Teaching Model.

The Physics Teacher Candidates Response toward the Orientasi IPA Model, PBL Model, and Conventional Model

The analysis of student's response toward learning with implemented model is done by giving the Student Response Sheet for physics teacher candidate after the learning process. The results of the physics teacher candidates' responses are presented in Table 6.

Table 6. The Physics Teacher Candidates Response toward the Orientasi IPA Model, PBL Model, and Conventional Model.

Group	N	Students' Positive Opinion on the Learning Process	Category
Group I: Orientasi IPA Model	31	89 %	Very Positive
Group II: PBL Model	30	89 %	Very Positive
Group III: Conventional Model	33	26 %	Less Positive

Table 6 shows that in general physics teacher candidates responded very positively to the learning instruments of the Orientasi IPA Model and PBL Model. As for the Conventional Model instruments, student responses show less positive.

Discussion

Validity of Orientasi IPA Model and PBL Model Instruments

Learning instruments is an operational form of a teaching/learning model, therefore teaching/learning instruments of Orientasi IPA Model and PBL Model are operational forms of the Orientasi IPA Model and PBL Model. The developed inistruments' components includes Semester Learning Plan, Lesson Plan, Student teaching materials, Student Worksheet, and critical thinking skill test of physics teacher candidates; and the Research Instruments, includes Teaching/Learning Model Implementation Sheet and Student Response Sheet. The assessment of all learning instruments' components is done by physics education experts in Unesa and has been declared valid as in Table 1 and Table 2. The implication of the instruments has been declared valid and can be used for the implementation of Orientasi IPA Model and PBL Model in improving the physics teacher candidate. In addition, Table 1 and Table 2 also show that all components of the learning instruments are included reliably, shown by the coefficients of Cohen's Kappa. The result of this validity is supported by the opinion of Plomp (2013) which said that a good product (teching/learning model) must meet the requirements, namely: validity: the validity of the model can be tested by testing the content and construct validity. Content validity is "there is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge", whereas the validity of constructs (construct validity) is "the intervention is 'logically' designed "(Nieveen, McKenney, & Akker, 2007). A valid device (content and construct) has an impact on the improvement of the critical thinking skill owned by the physics teacher candidates on the significant basic physics material as in Table 3 - 5. The statement is reinforced by the results of research stating that problem-based learning can develop critical thinking skill and analysis, and exposes students to exercises to solve problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009). The successful use of this teaching/learning model is determined by the preparation of learning environments and good learning media (Johnson, Rickel, & Lester, 2000) to support each lecturer and student activity (Woolf, 2010) in each stage of the Orientasi IPA Model and PBL Model syntax. It is a reflection that the developed instruments have been valid and can be implemented to improve the critical thinking skill owned by the physics teacher candidates.

The Effectiveness of Orientasi IPA Model, PBL Model, and Conventional Model to Improve the Critical Thinking Skill Owned by the Physics Teacher Candidates

The individual critical thinking skill score of the physics teacher candidates is obtained by providing the critical thinking skill test of physics teacher candidates before the learning (Pre-test) and after the learning process is done (Post-test). The data in Figure 1 shows that before the learning with Orientasi IPA Model, all students have low critical thinking skill. After the implementation of Orientasi IPA Model, all students experience increased their critical thinking skill. In general, the critical thinking skill of the physics teacher candidates in the post-test was in the high category of 2.27 from the range of 1 - 4. The general N-gain scores of physics teacher candidates with Orientasi IPA Model was in the medium category of .63. Table 3 shows that all the critical thinking skill indicators in the pre-test are in the low category, whereas after the implementation of learning with Orientasi IPA Model, all the critical thinking skill indicators have increased. The general N-gain of critical thinking skill indicators of the Orientasi IPA Model were in medium and high category with the value was above .43. The results of this research are supported by the work of John Dewey who describes the views of education, with the school as a mirror of the larger society, the class becomes a laboratory for investigation, and solving real-life problems (phase 3). Pedagogy Dewey encourages lecturers to engage students in problem-oriented projects and helps to investigate important social and intellectual issues. Dewey and his followers affirm that learning in school should be more meaningful, not too abstract (Helterbran, 2010; Loughran, 2013). The vision of purposeful learning in problem centered is supported by the student's innate desire to explore personal situations for students. The findings of cognitive psychology provide the theoretical foundation for Orientasi IPA Model. The basic premise in cognitive psychology is that learning is a process of constructing new knowledge based on current knowledge. Chi, Glaser, & Farr (2014) and Jonassen & Land (2012) assumed that learning is a constructive process and not an acceptance.

Pre-test, Post-test, and N-gain score of the critical thinking skill owned by physics teacher candidates in the PBL Model are shown in Figure 1. Based on the data in Figure 1, before the learning with PBL Model was done, all students have low critical thinking skill. After the implementation of learning with PBL Model, all students' critical thinking skill increase. In general, the physics teacher candidates gained medium category of 2.14 for their post-test. The general N-gain of physics teacher candidates by using PBL Model was in the medium category of .47. Table 3 shows that all physics teacher candidates' pre-test indicators were in the low category, whereas after the implementation of learning with PBL Model, all the indicators of their critical thinking skill have increased. The general N-gain indicators of critical thinking skill of PBL Model were in medium and high category with value above .33. The results of this research are supported by the characteristics of PBL Model that was designed to assist students in improving the skills of inquiry and problem solving skills, social behavior and skills according to the role of adults, as well as independent learning skills (Arends, 2012: Arizaga, Bahar, Maker, Zimmerman, & Pease , 2016), the PBL Model begins with complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a student-friendly learning environment (Nuninger & Châtelet, 2017), where they acquire complex problem-solving skills in real life and problem situations, student-centered learning environments, and constructivism approaches (Caesar et al., 2016; Chakravarthi, 2010; Efendioglu, 2015; Kong, Qin, Zhou, Mou, & Gao, 2014; Myers, 2017; Sern, Salleh, & Sulai, 2015). The results of this research are also reinforced by previous research findings that the PBL Model is very useful to improve motivation, self-confidence, self-study skills, creative thinking skills, critical thinking skill, problem-solving skills, assisting in better retention of knowledge and memory skills, and apply meaningful information with real life situations (Ates & Eryilmaz, 2010; Chakravarthi, 2010; Ledesma, 2016; Caesar et al., 2016; Malan, Ndlovu & & Engelbrecht 2014; Myers, 2017 Nilson, 2016; Sern, Salleh, Mohamad, & Yunos, 2015; Tracey & Morrow, 2017; Tracey & Morrow, 2017).

The pre-test, Post-test, and N-gain scores of the physics teacher candidates in the Conventional Model are shown in Figure 1. Based on the data in Figure 1, before the learning process by using the Conventional Model, all students had critical thinking skill in low category. After the implementation of learning process by using Conventional Model, all students still had critical thinking skill in low category. In general, critical thinking skill of physics teacher candidates in Post-test were in the medium category of 1.00. The general N-gain for physics teacher candidates with Conventional Model was in the medium category of .14. Table 3 shows that all critical thinking skill indicators in the pre-test were in low category, whereas after the implementation of learning with the Conventional Model all critical thinking skill indicators remained in the low category. The general N-gain of critical thinking skill indicators with a Conventional Model was in the low category with values above .10. The low critical thinking skill of physics teacher candidates is suspected to have something to do with the learning process that is implemented. The lesson model that is implemented, the Conventional Model is not able to facilitate in developing the critical thinking skill owned by physics teacher candidates, resulting in low learning achievement (Hammond et al., 2015; Mann, & Kaitell, 2001).

The result of Paired t-test presented in Table 4 shows that the mean of critical thinking skill for groups 1, 2, and 3 is -2.25; -1.66; - .48. The whole score is significant, because $p < .05$. Since the result of the calculation was negative, it clearly showed that there was a significant difference between the mean of the pre-test score and the post-test score for the critical thinking skill in all groups, the post-test group was higher than the pre-test group. The low critical thinking skill in theory can be caused by: motivation, lack of responsibility, low analytical skills, and lack of discipline in learning (Adebayo, 2014). This can also be due to a lack of ability to organize time, lazy to learn, and less supportive learning environments (Chakravarthi, 2010; Eaton, 2015). The low critical thinking skill of physics teacher candidates is suspected to have something to do with the learning process that is implemented. The Orientasi IPA Model and PBL Model are able to motivate students to investigate and solve problems in real life situations as well as stimulate students to produce a product in improving the critical thinking skill. Problem-based learning can develop critical thinking skill and analysis and expose students to practice to solve problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009).

The independent t-test for the average N-gain is performed on Group-1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of the average t-test of the N-gain by using Independent Samples Test is presented in Table 5, shows that the mean difference of critical thinking skill N-gain for groups 1-2, 1-3 groups, and 2-3 groups is .15; .49; .34 and all are significant, because $p < .05$. This clearly indicates that there is a significant difference between the mean N-gain of critical thinking skill in Group-1: Orientasi IPA Model with Group-2: PBL Model, Group-1: Orientasi IPA Model with Group-3 Conventional Model; and Group-2: PBL

Model with Group-3: Conventional Model. The results of this analysis indicates that the critical thinking skill N-gain of physics teacher candidates after the learning process with Orientasi IPA Model is higher when compared to PBL Model and Conventional Model. The Orientasi IPA Model is more effective when compared to the PBL Model in improving the critical thinking skill of physics teacher candidates. The findings are supported by other research that the Orientasi IPA Model is a multi-representation physics study that can stimulate students in analyzing, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This is also consistent with Ainsworth's research (2008, 1999); Ciais et al. (2005) which stated that multi-representation learning has three main functions, namely: as a complement, interpretation barrier, and build a more comprehensive understanding. The PBL Model has been proven to improve self-study skills and provides a more realistic picture of higher academic challenges, more confidence, improve problem-solving skills, critical thinking skills, and improved communication skills (Ates & Eryilmaz, 2010; Benade , 2017, Kangersis & Hurren, 2011; Leong, 2017; Malan, Ndlovu, & Engelbrecht, 2014; Myers, 2017; Sern, Salleh, & Sulai, 2015; Tracey & Morrow, 2017 ; Williams, 2005; Zabit, 2010). However, the weakness of the PBL Model is the lack of initiation and timing, lack of student discipline, and more challenging authentic issues (Ates & Eryilmaz, 2010; Thompson et al., 2012). The findings of this research are supported by questionnaire results of the responses form physics teacher canddates that is presented in Table 6. The data in Table 6 shows that in general the students of physics teacher candidates give positive responses to the learning instruments of the Orientasi IPA Model. While the result of questionnaire response of physics teacher candidates toward the learning instruments and Conventional Model generally show less positive response. The findings are supported by other research that the Conventional Model is less facilitating students in developing their critical thinking skill, so according to Hammond et al (2015) and Mann & Kaitell (2001) this resulted in low learning achievement. The student response data in Table 6 reinforces that the Orientasi IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model to increase the critical thinking skill of physics teacher candidates.

The results of previous studies conducted at the State Junior High School in Jember, Indonesia showed that the Orientasi IPA Model and PBL Model with implemented learning instruments can significantly improve learning outcomes with moderate N-gain (Rosyid, Budi, & Supardi, 2013). The Orientasi IPA Model is a teaching model that has 5 (five) syntaxes and is designed specifically to improve the weakness of the PBL Model in improving student critical thinking skill. The Orientasi IPA Model is a problem-based Teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Therefore, the Orientasi IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model in improving the critical thinking skill of physics teacher candidates.

Conclusions

Based on the results of this research and discussion described above, it can be concluded as follows: (1) The learning instruments of Orientasi IPA Model and PBL Model to improve the critical thinking skill of physics teacher candidates has been prepared, including: Semester Learning Plan, Lesson Plan, Student Learning Materials, Student Activity Sheet, and critical thinking skill tests of physics teacher candidates. The critical thinking skill tests of physics teacher candidates has fulfilled the validity requirements ($r_\alpha \sim .26$) and reliability ($\alpha = .96 - .99$) the content and construct can be implemented in the learning process; (2) Learning process by using Orientasi IPA Model and PBL Model is effective, as indicated by: (a) there was a significant increase in student's critical thinking skill at $\alpha = 5\%$; (b) the average N-gain of learning by using Orientasi IPA Model and PBL

Model are categorized as: moderate (.60) and moderate (.48); and (c) students' responses in each learning process were categorized as very positive (89%). Meanwhile, learning process by using the Conventional Model was ineffective, as indicated by: (a) there was a significant increase in students' critical thinking skill at α = 5%, (b) low N-gain (.14) and student responses were less positive (26%); and (3) Learning with Orientasi IPA Model is more effective in improving student critical thinking skill when compared to PBL Model.

As an implication of this research is that, the learning process by using the Orientasi IPA Model can be a solution to improve critical thinking skill of physics teacher candidates.

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THE COMPARISON OF ORIENTASI IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILL OF PHYSICS TEACHER CANDIDATES

180108.jbse_JL-he_review

Abstract. This research aims to: (1) analyze the effectiveness of learning by using the Orientasi IPA Teaching Model and Problem Based Learning (PBL) Model based on the level of critical thinking skill (cts) improvement and (2) obtain a more effective teaching/learning model. A learning is said to be effective if: (1) there is a significant increase in student's cts at α = 5%, (2) the average N-gain is at least in moderate, and (3) student's response is at least positive. The research subject was 94 students in three groups (the Conventional Model as a control). Prior to the learning, students were given the cts test and after the learning, the students were given the same test. The data was analyzed by using Paired t-test, N-gain and Independent t-test. The results showed that: Each of Orientasi IPA, PBL, and Conventional can significantly increase students' cts at α = 5%, respectively with average N-gain medium (.60), medium (.48), and low (.14), with the student response of: very positive, very positive, and less positive. Conclusion: (1) The Orientasi IPA and PBL are effective to improve students' cts, while the Conventional is ineffective, and (2) the Orientasi IPA is more effective compared to the PBL.

Keywords: Critical thinking skill of physics teacher candidates, learning effectiveness, basic physics course, Orientasi IPA model, and PBL.

Introduction

In this 21st century, education has an important role in producing Human Resources (HR) that has the needed skills to work. Meanwhile, the demands of the curriculum and the development of globalization era require educational institutions to do beneficial innovations for the 21st century skill-based educational world (Turiman, Omar, Daud, & Osman, 2012; Griffin & Care, 2015). Permendikbud No.73 of 2013 on the Indonesian National Qualification Framework in the field of higher education requires universities to prepare curriculum for physics teacher candidates to have superior competence with various skills that are in line with 21st century demands, among them are: critical thinking skills, skills to utilize Information and Communication Technology (ICT), and skills to solve problems (Griffin & Care, 2015; Jatmiko, Widodo, Martini, Budiyanto, Wicaksono, & Pandiangan, 2016; Kemdikbud, 2013; Pandiangan, Sanjaya, & Jatmiko, 2017). The 21st century learning process requires human resources with competence and the achievement of physics teacher candidates are directed to skills and learning innovations, among others are: Critical thinking skills, problem solving skills, decision making, creative thinking, responsibility, and ability to learn independently (Partnership for 21st Century Skills, 2014; Griffin & Care, 2015).

The development of critical thinking skills are considered as one of the most important goals of education for over a century (Forawi, Almekhlafi, & Al-Mekhlafy, 2012; Geertsen, 2003). Critical thinking has been defined and measured in a number of ways, but it usually involves an individual's ability to identify central issues and assumptions in arguments, recognize important relationships (Mason, 2017, Moon, 2007), make correct conclusions from data, infer provided information or data, interpret whether the conclusion is guaranteed or not based on the data provided (Facione, 2013; Mulnix, 2012). Furthermore, previous researchers explain that critical thinking is cognitive skill, it includes activities of interpretation, analysis, evaluation, inference, explanation,

Comment [V1]: Maybe skills?

Comment [V2]: The title is confusing and unclear

Comment [V3]: The abstract is not well written and does not really tell a gripping story to the reader. It is open to misinterpretation at this point.

My suggestion: Follow the following process to write/construct the abstract:
- Explain to the reader what the problem is AND/OR why the research was conducted.
- Mention the research design
- Mention the type of data gathering tools used
- Size of sample (if applicable and selection procedure)
- Theoretical perspectives and/OR theoretical framework.
- Summary of results
- Implications of results

Do the above in between 180 to 200 words.

Comment [V4]: Or teaching?

Comment [V5]: What does it mean?

Comment [V6]: ????

Comment [V7]: What?

Comment [V8]: ????

Comment [V9]: ?????

Comment [V10]: Not suitable

Comment [V11]: **The APA Manual (6th ed.) says: "Order the citations of two or more works within the same parentheses alphabetically" (6.16 on page 177).**

Comment [V12]: Maybe educational process?

Comment [V13]: Pre-service?

and self-management in problem solving (Bean, 2011; Cheong & Cheung, 2008, Dam & Volman, 2004; Ennis, 2011; Ernst & Monroe 2004; Jenicek, 2006; Marin & Halpern, 2011; Miri, David & Uri 2007; Mundilarto & Ismoyo, 2017; Popil, 2011; Siew & Mapeala, 2016 Snyder & Snyder , 2008; Womack & Jones, 2010). In this research, critical thinking skill is cognitive process which are carried out as a thinking guide by using reason judgments against evidence, context, standard, method, and conceptual structure by performing concepts, application, synthesis and / or information obtained from observation, experience, reflection, thinking , or communication as a basis for believing and doing an action and focusing on what to do. The critical thinking skill's indicators in this research are analysis, evaluation, interpretation, and inference based on the results of literature research and preliminary study by the investigator, these indicators are still low and needs to be accelerated in physics teacher candidates.

In connection with the improvement of the learning process and outcomes quality mentioned above, there are important problems faced by the world of education today, which is how to strive physics teacher candidates' critical thinking skill through learning (Krulik & Rudnick, 1996; Marzano, 1993). This needs to be done because there are many students who do not have a critical thinking skill (Brookfield, 2017). Critical thinking skill is an important thinking skill and should be trained but there are still many lecturers who do not understand how to train critical thinking skill. The results of Patrick's, Fallon, Campbell, Cretchley, Devenish, & Tayebjee (2014) and Pithers & Soden (2000) showed that critical thinking skill should be taught, but there are still some lecturers who do not know how to teach critical thinking skill effectively (Brownlee, Walker , Lennox, Exley, & Pearce, 2009; McPeck, 2016).

Martin, Mullis, Foy, & Stanco (2012) showed that most of Indonesian student are only able to recognize a number of basic facts and have not been able to communicate and relate various topics of science, especially in applying complex and abstract concepts. This fact is in line with the results of Rosyid, Jatmiko, & Supardi (2013) research, which indicated that the physics learning process is still and more emphasized on the process of knowledge transfer so it has not been able to make students able to construct knowledge. The low critical thinking skill of physics teacher candidates is suspected to have something to do with the teaching process being implemented (Browne, & Meuti, 1999; Staib, 2003; Wlodkowski, & Ginsberg, 2017). The implemented teaching model, which is the Conventional Teaching Model (Conventional Model) cannot facilitate in developing students' critical thinking skill, resulting in low learning achievement (Hammond et al., 2015; Mann & Kaitell, 2001). Therefore, to improve the quality and facilitate the development of physics teacher candidates, it is necessary to find out alternative solutions. The alternative solutions include implementing the Orientasi IPA Teaching Model (Orientasi IPA Model) and Problem Based Learning Model (PBL Model). The results of previous research conducted by Rosyid, Budi, & Supardi (2013) showed that Orientasi IPA Model and PBL Model with supporting learning instruments can improve high school students' learning outcomes in Kabupaten Jember, East Java significantly at $\alpha = 5\%$ with moderate N-gain.

The Orientasi IPA Model is a problem-based learning model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Multi-representation teaching can stimulate students to perform analysis, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This was also applied to Ainsworth's (2008, 1999) and Ciais, Reichstein, Viovy, Granier, Ogée, Allard & Carrara (2005) studies which suggested that multi-representation learning has three main functions: complementary, interpretive, and can build a more comprehensive understanding. In this research, the Orientasi IPA Model has five syntaxes, namely: Problem Orientation, Problem Representation, Group Investigation, Presentation, Analysis and Evaluation (Rosyid, Budi, & Supardi, 2013). The interactive tasks in applying this Orientasi IPA Model to grow up the ability of critical thinking skill are referred to the phases in the syntax, namely: (1)

Comment [V14]: Again…please be consistent…students are learning…teachers are teaching…together we have education process….When I am learning something, I do not use any models…I do not take care of that. This is a teaching process matter to take care about models, techniques etc.

Comment [V15]: Sometimes to teach, sometimes to train? Keep consistency

Comment [V16]: Students?

Comment [V17]: Unclear term

Comment [V18]: Full source the first time = ALL AUTHORS. Then subsequent references can be et al.
If there were six authors, you might mention only the first `+ "et al". Five and fewer authors must all be listed in full (first time).

Comment [V19]: Confusing

Comment [V20]: What does this word mean? Just use English name

Orientation of Problem, which is aimed to attract the students, focus the students, and motivate them to take an active role in the learning process; (2) **Representation of Problem**, which is aimed to assist students in understanding the material and solving the problems that will be discussed through various approaches that can be adapted to the objectives of learning and the presented material characteristics; (3) **Investigation**, which is aimed to collect information with the help of Student Worksheet, then the lecturer guides to carry out step-by-step investigations, explores the explanation, and solutions to build the critical thinking skill which includes (a) formulating the problem; (b) formulating the hypothesis; (c) identifying variables; (d) writing the operational variables definition; (e) writing down the experimental tools and materials; (f) conducting experiments; (g) organizing experiment data; (h) analyzing experimental data; and (i) making a conclusion; (4) **Presentation**, which is aimed to guide students in making conclusions and discussion of the investigation results in various representations, and assisting in the planning, preparing and presenting the works; and (5) **Analysis, Evaluation and Follow-up**, which is aimed to analyze and evaluate the problem-solving process of inquiry and process in various forms of representation, observe the students' work as the learning evidence, and facilitate follow-up learning through the assignment of structured tasks.

The PBL Model is a problem-based learning model that describes a view of education in which the school is seen as a mirror of society and class as a laboratory for the investigation of everyday life issues (Arends, 2012; Nilson, 2016). The PBL Model also has five syntaxes, namely: directing students to problems, organizing students to learn, helping independent and group investigations, developing and presenting artifacts and exhibits, and analyzing and evaluating problem-solving processes (Arends, 2012). Characteristics of the PBL Model are designed to help students improving their inquiry skills and problem-solving skills, social behavior and skills according to the role of adults, as well as independent learning skills (Arends, 2012; Arizaga, Bahar, Maker, Zimmerman, & Pease, 2016). The PBL Model begins with a complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a suitable learning environment for students (Caesar et al., 2016; Kong, Qin, Zhou, Mou, & Gao, 2014; Myers, 2017; Nuninger & Châtelet, 2017). The PBL Model also regulates a student-centered learning environment that is not viewed as an empty vessel, but is capable to bring its own distinct framework and learning (Chakravarthi, 2010; Efendioglu, 2015; Sern, Salleh, & Sulai, 2015). The PBL Model can enhance self-study skills and provide a more realistic picture of higher academic challenges, more confidence, better problem-solving skills, critical thinking skills, and provide the improvement of communication skills (Ates & Eryilmaz, 2010; Benade, 2017 ; Efendioglu, 2015; Méllesis & Hurren, 2011; Leong, 2017; Malan, Ndlovu, & Engelbrecht, 2014; Myers, 2017; Sern, Salda, & Sulai, 2015; Tracey & Morrow, 2017; Tracey & Morrow, 2017; Williams, 2005; Zabit, 2010). The application of PBL Model will promote students to have motivation, confidence in learning and able to improve students' ability to solve more complex problems (Caesar et al., 2016; Chakravarthi, 2010; Ledesma, 2016; Malan, Ndlovu, & Engelbrecht, 2014; Nilson, 2016; Sern, Salleh, Mohamad, & Yunos, 2015; Tracey & Morrow, 2017). However, the PBL Model is still weak in terms of inquiry orientation components, alternative solutions, and difficult in formulating problems and preparing hypotheses (Ates & Eryilmaz, 2010; Chakravarthi, 2010; Sern, Salleh, & Sulai, 2015). Although the research shows that the PBL Model supports self-study and communication skills, critical skills improvement, creative thinking skills and problem-solving skills (Ates & Eryilmaz, 2010; Malan, Ndlovu, & Engelbrecht, 2014, Tracey & Morrow, 2017), however PBL's weaknesses are lack of initiation and timing, lack of student discipline, and more challenging authentic issues are needed (Ates & Eryilmaz, 2010; Thompson et al., 2012).

Comment [V21]: So irrelevant info to explain again and again so well known things … this is not a textbook

The State University of Surabaya (Unesa) as an institution of higher education has facilitated its lecturers with various teaching models that can be integrated with information and communication technology. However, the reality shows that there are still many lecturers who have not conducted the lesson by utilizing the facilities to provide learning experiences for teacher candidates. Most of the lecturer facilities provided by Unesa are only used as learning tools and have not been utilized to produce teaching/learning models. The teaching models gained through a series of research are less useful and ineffective because they have not been optimally utilized by lecturers at Unesa as it is in other higher education institutions, lecturers should be responsible for developing models, strategies, approaches, methods or instructional techniques in the era of the 21st century (Huba & Freed, 2000; Richards & Rodgers, 2014). Orientasi IPA Model and PBL Model are very useful to improve lecturers' competence in teaching. This is because the teaching becomes more interesting, more challenging, and better suited to the needs of students. The results of previous research indicates that the Orientasi IPA Model and PBL Model are effective and practical in improving critical thinking skills of Senior High School students in Jember Regency (Rosyid, Jatmiko, & Supardi, 2013).

Referring to the effectiveness of Orientasi IPA Model and PBL Model in improving the students' critical thinking skill, it needs to be reviewed and tested for further consistency in improving the critical thinking skill of physics teacher candidates from Unesa. This research is very important in order to develop models and learning theories that are able to answer the challenges and skills needs in the 21st century. The low critical thinking skill is theoretically caused, among other things, by: poor motivation and responsibility, poor analytical skills, and less discipline in learning (Adebayo, 2014). This is also due to the lack of ability to organize time, lazy to learn, and less supportive learning environment (Chakravarthi, 2010; Eaton, 2015). Therefore, it is necessary to compare the effectiveness between Orientasi IPA Model and PBL Model in improving student critical thinking skill. In order to be able to compare the effectiveness of the two models, then the preparation of learning instruction of Orientasi IPA Model and PBL Model was done firstly which is designed to be able to increase critical thinking skill of physics teacher candidates.

Problem of Research

The problem of this research is how to analyze the effectiveness of learning in the basic physics course with the Orientasi IPA Model and PBL Model to get more effective teaching/learning model to improve the critical thinking skill of physics teacher candidates. In addition, also how to get examples of learning instruments that are valid and reliable with an effective teaching model in improving the critical thinking skill of physics teacher candidates.

Comment [V22]: I do not see any problem here,…somehow as a question

Comment [V23]: Should be reworked

Research Focus

The focus of this research was to compare the effectiveness of learning in basic physics courses with Orientasi IPA Model and PBL Model in improving the critical thinking skill of physics teacher candidates. This research used control variables; it was the conventional leaning model. In detail, the focuses of this research were: (1) how is the validity and reliability of learning instruments in basic physics courses with Orientasi IPA Model and PBL Model to improve the critical thinking skill of physics teacher candidates, which includes: Semester Learning Plan, Lesson Plan, Student teaching materials, Student Worksheet, and student critical thinking skill test of physics teacher candidates?; (2) how is the effectiveness of learning with Orientasi IPA Model, PBL Model, and Conventional Model in improving the critical thinking skill of physics teacher candidates? and (3) which teaching model is the most effective to improve the critical thinking skill of physics teacher candidates?

Comment [V24]: Repetition …

Methodology of Research

General Background of Research

Critical thinking skill is a necessary thinking skill for the workforce of the 21st century, therefore researchers think on how to strive students' critical thinking skill to obtain results that match the expectations. During this time, the way to get the student's critical thinking skill is done by learning with PBL Model, but the previous research conducted on high school students in Jember, Indonesia by using learning with Orientasi IPA Model, which is a correction of the PBL Model to improve students' critical thinking skill showed results that are also effective and practical (can be applied). On the other hand, many students do not have critical thinking skill, so there are many lecturers who still do not understand how to teach critical thinking skill effectively to the students.

On the basis of the above problems, it is necessary to conduct research to analyze the effectiveness of Orientasi IPA Model and PBL Model in improving the critical thinking skill of physics teacher candidates and comparing the effectiveness of the two models so that it will be obtained a more effective learning. In addition, it is necessary to provide examples of learning instruments by using the Orientasi IPA Model and PBL Model, which meet the valid and reliable requirements of lecturers in order to teach the physics teacher candidates by using more effective learning instruments.

Sample of Research

The research was conducted to 94 students of Physics Education Study Program, Unesa, Indonesia, which came from a population of 123 students in three groups (experimental group-1 / Orientasi IPA Model, experimental group-2 / PBL Model, and control group / Conventional Model). The Conventional Model in this research was lecturer-centered teaching model, which includes lecture, presentation, and discussion. The calculation of the sample number was based on the Slovin formula, that was the sample = [population / (1 + e^2 × population)] with fault tolerance e = 5% (Sevilla, Ochave, Regala, & Uriarte, 1984; Tejada, & Punzalan, 2012). This research took three groups, namely: group of: experiment-1 came to 31 students; experiment-2 came to 30 students; and control came to 33 students, each of them were statistically in the same level of critical thinking skill.

Instrument and Procedures

This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design (Fraenkel, Wallen, & Hyun, 2012).

O_1	X_1	O_2
O_1	X_2	O_2
O_1	C	O_2

With:
O_1: Pre-test score, O_2: Post-test score, X_1: Orientasi IPA Model, X_2: PBL Model dan C: Conventional Model

Prior to the research, firstly the researchers set up learning instruments that covered these components: (1) Semester Learning Plan, (2) Lesson Plan, (3) Student teaching materials, (4)

Comment [V25]: Why do we need it? Repetition again

Comment [V26]: General description of research is important in order to show the basis of the research. It is like a very brief introduction to the methodology section as a whole… indicate also research type, time and scope

Comment [V27]: Why only?

Comment [V28]: What is it?

Comment [V29]: There is nothing on gender and ethical issues

Comment [V30]: ???

Comment [V31]: Is it learning?

Student Worksheet, and (5) critical thinking skill test of physics teacher candidates, respectively for the Orientasi IPA Model and PBL Model. The data was collected by using the research instruments, which consisted of the following components: (1) Teaching Model Implementation Sheet and (2) Student Response Sheet. The validity of those learning instruments from both Orientasi IPA Model and PBL Model was then assessed by the physics education experts in terms of the content and construct. In order for the learning instruments to be able to be implemented, the leaning instruments have to meet the valid and reliable requirements.

Comment [V32]: were

The research began by giving the critical thinking skill pre-test (O_1) by using the critical thinking skill test of physics teacher candidates to each group of students, then providing learning with different models, namely: Orientasi IPA Model, PBL Model, and Conventional Model. Finally, after the entire learning process has been completed, all groups of students are awarded a post-test (O_2) of the critical thinking skill with the same materials and problems as in the pre-test.

Data Analysis

In order to get the validity of contents and construct for the learning instruments of the Orientasi IPA Model and PBL Model as well as the research instrument, thus the assessment of those instruments was done by the physics education expert based on the content and construct validity. Content validity is a description of needs and novelty, while construct validity is a description of the consistency of learning instruments of Orientasi IPA Model and PBL Model with theory/empirical and consistency between the instruments components (Plomp, 2013). The data was analyzed by reliability test; each of them was analyzed by using Cohen's Kappa, single measure interrater coeficient correlation (r_α) and Cronbach's alpha (α). The learning instruments and research instruments are said to be valid if r_α > r table and invalid if $r_\alpha \leq$ r table.

Meanwhile, the learning instruments and research instruments are said to be reliable if $0.6 \leq \alpha \leq 1.0$ and not reliable if $\alpha < 0.6$. In order to analyze learning with a more effective teching/learning model, an "effective" operational definition is required. Learning with Orientasi IPA Model, PBL Model, and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skill of physics teacher candidate at α = 5%, (2) the minimum N-gain is categorized as moderate, and (3) students' responses are at least positive. In this research, the pre-test and post-test results were analyzed as follows: when the normality assumption for the achieved score is met, the Paired t-test will be applied. If it is not met, non-parametric analysis will be used. In order to get increasing level of student's critical thinking skill score, the calculation was done by using N-gain with equation: N-gain = (Post-test score - Pre-test) / (maximum score - Pre-test) (Hake, 1998). By the criteria of: (1) N-gain > 0.70 (height); (2) 0.30 < N-gain < 0.70 (medium); and (3) N-gain < 0.30 (low). In order to test whether the improvements on students' critical thinking skill existed or not with the Orientasi IPA Model, PBL Model, and Conventional TeachingModel, Paired t-test against the pre-test score and post-test by using IBM SPSS Statistic 16 software was done. Meanwhile, to get more effective model in improving students' critical thinking skill after being given lessons, researchers compared the effectiveness of the three models by using Independent t-test. In order to see the responses of physics teacher candidates toward learning with Orientasi IPA Model, PBL Model, and Conventional Model, student responses data was analyzed by using qualitative descriptive (Prahani, Winata, & Yuanita, 2015; Riduwan, 2010). With the criteria of: (1) Response ≥ 75% (very positive); (2) 50% ≤ Response <75% (positive); (3) 25% ≤ Response <50% (less positive); and (4) Response <25% (not positive).

Results of Research

Validity of Learning Instruments and Research Instruments of Orientasi IPA Model and PBL Model

Before the research is done, learning instruments and research instruments that have been compiled must meet the requirements of validity and reliability. The validity of learning instruments of Orientasi IPA Model and PBL Model, and research instruments were assessed by two physicists of Unesa. The results of the validity assessment of the learning instruments and research instruments for Orientasi IPA Model and PBL Model, respectively, are shown in Table 1 and Table 2.

Table 1. The Result of Learning Instruments and Research Instrument Validity of Orientasi IPA Model.

Components	The Validity of Orientasi IPA Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	Cohen's kappa	R	r_α	V	α	R
Semester Learning Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.99	Reliable
Lesson Plan	.87	Reliable	.25	Valid	.97	Reliable	.87	Reliable	.25	Valid	.97	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.96	Reliable	.25	Valid	.99	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.96	Reliable	.25	Valid	.98	Reliale
Student Critical Thinking Skill Test of Physics Teacher Candidates	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes:

r_α = *Single measure interrater coeficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Tabel 2. The Validity of PBL Model Instruments.

Components	The Validity of PBL Model Instruments											
	Consteuct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	***Cohen's kappa***	R	r_α	V	α	R
Semester Learning Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Lesson Plan	.86	Reliable	.25	Valid	.96	Reliable	.86	Reliable	.25	Valid	.96	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.95	Reliable	.25	Valid	.96	Reliable
Student Critical Thinking Skill Test of physics teacher	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Components	The Validity of PBL Model Instruments											
	Consteuct Validity						Content Validity					
	Cohen's kappa	**R**	**r_α**	**V**	**α**	**R**	***Cohen's kappa***	**R**	**r_α**	**V**	**α**	**R**
candidates Learning Model	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Implementation Sheet Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes:
r_α = *Single measure interrater coefficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Table 1 shows that the construct validity of the Orientasi IPA Model instruments include: Semester Learning Plan; Lesson Plan; Students Activity Sheet; Student Teaching Materials; Student critical thinking skill test of physics teacher candidate, and the research instruments, which includes: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the Orientasi IPA Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skill; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skill needs to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the learning instruments of the Orientasi IPA Model in order to be implemented.

Table 2 shows that the construct validity of the PBL Model instruments include: Semester Learning Plan; Lesson Plan; Students Activity Sheet; Student Teaching Materials; Student Critical Thinking Skill Test of physics teacher candidates, and the research instruments, which includes: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all componnents are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the PBL Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skill; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skill needs to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the learning instruments of the PBL Model in order to be implemented.

Based on the above description, it can be said that the learning instruments of Orientasi IPA Model and PBL Model have fulfilled the content and construct validity requirements to improve the critical thinking of physics teacher candidates. The learning instruments of Orientasi IPA Model and PBL Model can be implemented in the learning process of basic physics courses.

The Effectiveness of Orientasi IPA Model, PBL Model and Conventional Model for Critical Thinking Skill of Physics Teacher Candidates

The critical thinking skill score and N-gain of physics teacher candidates were obtained by providing the pre-test and post-test of the critical thinking skill. The detailed score of pre-test, post-test, and N-gain of physics teacher candidates in the Orientasi IPA Model, PBL Model, and Conventional Model are shown in Figure 1. While the critical thinking skill indicators of group-1: Orientasi IPA Model, group-2: PBL Model, and group-3: Conventional Model are presented in Table 3. Figure 1 shows that prior to the learning with Orientasi IPA Model, PBL Model, and Conventional Model, physics teacher candidates have low average of critical thinking skill. After the implementation of Orientasi IPA Model and PBL Model, physics teacher candidates have an increase in the average of critical thinking skill, but in Conventional Model, all physics teacher candidates still have average of critical thinking skill in low category. In general, the average of critical thinking skill for physics teacher candidates in post-test with Orientasi IPA Model, PBL Model, and Conventional Model is in high category (2.67); Medium (2.14); and low (1.00) and the score ranged from 1 - 4. The average N-gain of critical thinking skill owned by physics teacher candidates students for learning by using Orientasi IPA Model, PBL Model, and Conventional Model, is in the category of moderate (.63); moderate (.47); and low (.14), from the score range of 0 - 1.

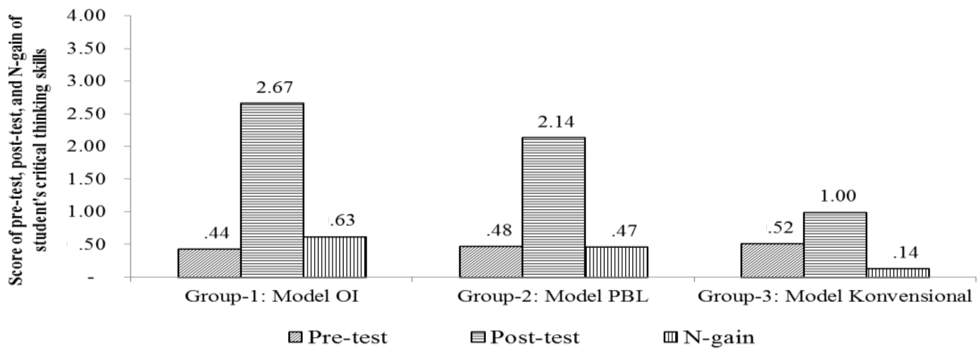

Figure 1: The Score of Pre-test, Post-test, dan N-gain of Critical Thinking Skill Owned by Physics Teachers Candidates with Orientasi IPA Model, PBL Model, and Conventional Model.

Figure 1 indicates that in order to increase the critical thinking skill of physics teacher candidates, the Orientasi IPA Model is better compared to the PBL Model and Conventional Model. While the PBL Model is better when compared to the Conventional Model

Table 3. The Critical Thinking Skill Indicator of Group-1: Orientasi IPA Model, Group-2: PBL Model, dan Group-3: Conventional Model

Group	Score	Indicators of Critical Thinking Skill			
		Analysis	Evaluation	Interpretation	Inference
Group-1: Orientasi IPA Model	Pre-test	.45	.31	.52	.45
	Post-test	2.91	2.47	3.00	1.96
	N-gain	.69	.59	.71	.43
Group-2: PBL Model	Pre-test	.59	.39	.82	.13

	Post-test	2.36	2.24	2.59	1.39
	N-gain	.52	.51	.56	.33
	Pre-test	.49	.32	.71	.58
Group-3: Conventional Model	Post-test	1.09	.69	1.29	.93
	N-gain	.17	.10	.18	.10

Table 3 shows that the results of critical thinking skill pre-test of physics teacher candidates for all critical thinking skill indicators were in the low category, whereas after the implementation of learning with Orientasi IPA Model, all the critical thinking skill indicators have increased. In general, the average N-gain for critical thinking skill indicator with Orientasi IPA Model was in medium and high category, with the value was above .43. The result of critical thinking skill pre-test of physics teacher candidate for all indicators was in low category, while after implementation of learning with PBL Model, all critical thinking skill indicators have increased. In general, the average N-gain of critical thinking skill indicator with PBL Model was in medium and high category with the value was above .33. The result of critical thinking skill pre-test of the physics teacher candidates for all critical thinking skill indicators was in low category, while after the implementation of learning with Conventional Model, all critical thinking skill indicator remain in low category. In general, the average N-gain of critical thinking skill indicators with Conventional Model was in low category with value above .10. Meanwhile, the lowest indicator of critical thinking skill in all groups was inference.

Paired T-test of Critical Thinking Skill Owned by Physics Teachers Candidates with Orientasi IPA Model, PBL, and Conventional Model.

The existence of critical thinking skill increase in the physics teacher candidates is measured by testing the average score of Pre-test and the Post-test score by using Paired t-test. Paired t-test is used (for parametric statistical test) because it has fulfilled the requirements: (1) Pre-test score and Post-test data of critical thinking skill of physics teacher candidates come from normal distributed population, conducted by normality test (Shapiro-Wilk); and (2) the average of Pre-test and Post-test score data is homogeneous when tested by using the two variance equality test. Paired t-test for the average score of Pre-test and Post-test of critical thinking skill conducted on Group-1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of Paired t-test against Pre-test and Post-test score of critical thinking skill of physics teacher candidates is presented in Table 4.

Table 4. The Results of Paired t-test of Critical Thinking Skill Owned by Physics Teacher Candidates in All Groups.

Group	**N**	***Paired t-test***				
		Mean	**Std. error mean**	**t**	**df**	**p**
Group-1: Orientasi IPA Model	31	-2.25	.13	-17.95	30	< .01
Group-2: PBL Model	30	-1.66	.08	-19.83	29	< .01
Group-3: Conventional Model	33	- .48	.05	-9.24	32	< .01

Table 4 shows that the mean scores of critical thinking skill for groups 1, 2 and 3 respectively for: Orientasi IPA Model, PBL, and Conventional Teaching Model are -2.25; -1.66; and - .48 with degrees of freedom (df) are 30; 29; 32, and giving t value of -17.95; -19,83; and -9.24. The result of Paired t-test for each group is significant, because $p < .05$. Therefore t counts the negative value, then clearly there is a significant difference at $\alpha = 5\%$ between the pre-test score with the critical thinking skill Post-test in all groups. For learning with the Orientasi IPA Model, PBL, and Conventional Model, all of them show higher post-test score compared to the pre-test score, or the mean scores of critical thinking skill of physics teacher candidates after each learning process with the Orientasi IPA Model, PBL, and Conventional Model are higher than before.

Independent T-test of Critical Thiking Skill Owned by Physics Teachers Candidates with Orientasi IPA Model, PBL, and Conventional Model.

In order to analyze which model is more effective in increasing the critical thinking skill of physics teacher candidates among Group 1: Orientasi IPA Model Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model, among others, is done by testing the average N-gain of the critical thinking skill by using Independent t-test. Independent t-test is used (for parametric statistical tests) because it meets the requirements of: (1) the average N-gain of critical thinking skill of physics teacher candidates (Group 1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model) are derived from normally distributed populations, performed by normality test (Shapiro-Wilk); and (2) the average N-gain of critical thinking skill of physics teacher candidates (Group 1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model) is homogeneous when measured by using multiple-variance test equations. Independent t-test for the average N-gain was performed on Group 1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model. Independent t-test results on the average N-gain for all groups are presented in Table 5.

Table 5. Independent t-test results on the average N-gain for all groups.

Group	N	*Independent t-test*				
		Mean Difference	**Std. error mean**	**t**	**df**	**p**
Group 1: Orientasi IPA Model Group 2: PBL Model	61	.15	.04	3.58	59	< .01
Group 1: Orientasi IPA Model Group 3: Conventional Model	64	.49	.04	12.5	62	< .01
Group 2: PBL Model Group 3: Conventional Model	63	.34	.03	12.51	61	< .01

Table 5 shows that the mean difference of N-gain of critical thinking skill for groups: 1-2, 1-3, and 2-3 is .15; .49; .34 and respectively have degrees of freedom (df) = 59; 62; 61, gives a value of t = 3.58; 12.5; and 12.51. The score is significant, because $p < .05$. Therefore $p < .05$, it is clear that there is significant difference in mean of critical thinking skill N-gain in Group-1 that is the Orientasi IPA Teaching Model with Group-2 that is PBL Model, Group-1 that is the Orientasi IPA Teaching Model with Group-3 that is Conventional Teaching Model; Group-2 that is PBL Model with Group-3 that is Conventional Teaching Model, for each at $\alpha = 5\%$. The results of the above analysis show that the average N-gain of critical thinking skill of physics teacher candidate was higher after learning with the Orientasi IPA Teaching Model when compared to PBL Model and Conventional Model. While learning with PBL Model gave higher average N-gain when compared to the Conventional Teaching Model.

The Physics Teacher Candidates Response toward the Orientasi IPA Model, PBL Model, and Conventional Model

The analysis of student's response toward learning with implemented model is done by giving the Student Response Sheet for physics teacher candidate after the learning process. The results of the physics teacher candidates' responses are presented in Table 6.

Table 6. The Physics Teacher Candidates Response toward the Orientasi IPA Model, PBL Model, and Conventional Model.

Group	N	Students' Positive Opinion on the Learning Process	Category
Group I: Orientasi IPA Model	31	89 %	Very Positive
Group II: PBL Model	30	89 %	Very Positive
Group III: Conventional Model	33	26 %	Less Positive

Table 6 shows that in general physics teacher candidates responded very positively to the learning instruments of the Orientasi IPA Model and PBL Model. As for the Conventional Model instruments, student responses show less positive.

Discussion

Validity of Orientasi IPA Model and PBL Model Instruments

Learning instruments is an operational form of a teaching/learning model, therefore teaching/learning instruments of Orientasi IPA Model and PBL Model are operational forms of the Orientasi IPA Model and PBL Model. The developed inistruments' components includes Semester Learning Plan, Lesson Plan, Student teaching materials, Student Worksheet, and critical thinking skill test of physics teacher candidates; and the Research Instruments, includes Teaching/Learning Model Implementation Sheet and Student Response Sheet. The assessment of all learning instruments' components is done by physics education experts in Unesa and has been declared valid as in Table 1 and Table 2. The implication of the instruments has been declared valid and can be used for the implementation of Orientasi IPA Model and PBL Model in improving the physics teacher candidate. In addition, Table 1 and Table 2 also show that all components of the learning instruments are included reliably, shown by the coefficients of Cohen's Kappa. The result of this validity is supported by the opinion of Plomp (2013) which said that a good product (teching/learning model) must meet the requirements, namely: validity: the validity of the model can be tested by testing the content and construct validity. Content validity is "there is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge", whereas the validity of constructs (construct validity) is "the intervention is 'logically' designed "(Nieveen, McKenney, & Akker, 2007). A valid device (content and construct) has an impact on the improvement of the critical thinking skill owned by the physics teacher candidates on the significant basic physics material as in Table 3 - 5. The statement is reinforced by the results of research stating that problem-based learning can develop critical thinking skill and analysis, and exposes students to exercises to solve problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009). The successful use of this teaching/learning model is determined by the preparation of learning environments and good learning media (Johnson, Rickel, & Lester, 2000) to support each lecturer and student activity (Woolf, 2010) in each stage of the Orientasi IPA Model and PBL Model syntax. It is a reflection

Comment [V33]: there is a big and so free usage (interplay) with the basic terms – "learning" and "teaching". Sometimes it is not clear at all what process is described/analyzed. This is a serious disadvantage.

that the developed instruments have been valid and can be implemented to improve the critical thinking skill owned by the physics teacher candidates.

The Effectiveness of Orientasi IPA Model, PBL Model, and Conventional Model to Improve the Critical Thinking Skill Owned by the Physics Teacher Candidates

The individual critical thinking skill score of the physics teacher candidates is obtained by providing the critical thinking skill test of physics teacher candidates before the learning (Pre-test) and after the learning process is done (Post-test). The data in Figure 1 shows that before the learning with Orientasi IPA Model, all students have low critical thinking skill. After the implementation of Orientasi IPA Model, all students experience increased their critical thinking skill. In general, the critical thinking skill of the physics teacher candidates in the post-test was in the high category of 2.27 from the range of 1 - 4. The general N-gain scores of physics teacher candidates with Orientasi IPA Model was in the medium category of .63. Table 3 shows that all the critical thinking skill indicators in the pre-test are in the low category, whereas after the implementation of learning with Orientasi IPA Model, all the critical thinking skill indicators have increased. The general N-gain of critical thinking skill indicators of the Orientasi IPA Model were in medium and high category with the value was above .43. The results of this research are supported by the work of John Dewey who describes the views of education, with the school as a mirror of the larger society, the class becomes a laboratory for investigation, and solving real-life problems (phase 3). Pedagogy Dewey encourages lecturers to engage students in problem-oriented projects and helps to investigate important social and intellectual issues. Dewey and his followers affirm that learning in school should be more meaningful, not too abstract (Helterbran, 2010; Loughran, 2013). The vision of purposeful learning in problem centered is supported by the student's innate desire to explore personal situations for students. The findings of cognitive psychology provide the theoretical foundation for Orientasi IPA Model. The basic premise in cognitive psychology is that learning is a process of constructing new knowledge based on current knowledge. Chi, Glaser, & Farr (2014) and Jonassen & Land (2012) assumed that learning is a constructive process and not an acceptance.

Pre-test, Post-test, and N-gain score of the critical thinking skill owned by physics teacher candidates in the PBL Model are shown in Figure 1. Based on the data in Figure 1, before the learning with PBL Model was done, all students have low critical thinking skill. After the implementation of learning with PBL Model, all students’ critical thinking skill increase. In general, the physics teacher candidates gained medium category of 2.14 for their post-test. The general N-gain of physics teacher candidates by using PBL Model was in the medium category of .47. Table 3 shows that all physics teacher candidates’ pre-test indicators were in the low category, whereas after the implementation of learning with PBL Model, all the indicators of their critical thinking skill have increased. The general N-gain indicators of critical thinking skill of PBL Model were in medium and high category with value above .33. The results of this research are supported by the characteristics of PBL Model that was designed to assist students in improving the skills of inquiry and problem solving skills, social behavior and skills according to the role of adults, as well as independent learning skills (Arends, 2012: Arizaga, Bahar, Maker, Zimmerman, & Pease , 2016), the PBL Model begins with complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a student-friendly learning environment (Nuninger & Châtelet, 2017), where they acquire complex problem-solving skills in real life and problem situations, student-centered learning environments, and constructivism approaches (Caesar et al., 2016; Chakravarthi, 2010; Efendioglu, 2015; Kong, Qin, Zhou, Mou, & Gao, 2014; Myers, 2017;

Sern, Salleh, & Sulai, 2015). The results of this research are also reinforced by previous research findings that the PBL Model is very useful to improve motivation, self-confidence, self-study skills, creative thinking skills, critical thinking skill, problem-solving skills, assisting in better retention of knowledge and memory skills, and apply meaningful information with real life situations (Ates & Eryilmaz, 2010; Chakravarthi, 2010; Ledesma, 2016; Caesar et al., 2016; Malan, Ndlovu & & Engelbrecht 2014; Myers, 2017 Nilson, 2016; Sern, Salleh, Mohamad, & Yunos, 2015; Tracey & Morrow, 2017; Tracey & Morrow, 2017).

The pre-test, Post-test, and N-gain scores of the physics teacher candidates in the Conventional Model are shown in Figure 1. Based on the data in Figure 1, before the learning process by using the Conventional Model, all students had critical thinking skill in low category. After the implementation of learning process by using Conventional Model, all students still had critical thinking skill in low category. In general, critical thinking skill of physics teacher candidates in Post-test were in the medium category of 1.00. The general N-gain for physics teacher candidates with Conventional Model was in the medium category of .14. Table 3 shows that all critical thinking skill indicators in the pre-test were in low category, whereas after the implementation of learning with the Conventional Model all critical thinking skill indicators remained in the low category. The general N-gain of critical thinking skill indicators with a Conventional Model was in the low category with values above .10. The low critical thinking skill of physics teacher candidates is suspected to have something to do with the learning process that is implemented. The lesson model that is implemented, the Conventional Model is not able to facilitate in developing the critical thinking skill owned by physics teacher candidates, resulting in low learning achievement (Hammond et al., 2015; Mann, & Kaitell, 2001).

The result of Paired t-test presented in Table 4 shows that the mean of critical thinking skill for groups 1, 2, and 3 is -2.25; -1.66; - .48. The whole score is significant, because $p < .05$. Since the result of the calculation was negative, it clearly showed that there was a significant difference between the mean of the pre-test score and the post-test score for the critical thinking skill in all groups, the post-test group was higher than the pre-test group. The low critical thinking skill in theory can be caused by: motivation, lack of responsibility, low analytical skills, and lack of discipline in learning (Adebayo, 2014). This can also be due to a lack of ability to organize time, lazy to learn, and less supportive learning environments (Chakravarthi, 2010; Eaton, 2015). The low critical thinking skill of physics teacher candidates is suspected to have something to do with the learning process that is implemented. The Orientasi IPA Model and PBL Model are able to motivate students to investigate and solve problems in real life situations as well as stimulate students to produce a product in improving the critical thinking skill. Problem-based learning can develop critical thinking skill and analysis and expose students to practice to solve problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009).

The independent t-test for the average N-gain is performed on Group-1: Orientasi IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of the average t-test of the N-gain by using Independent Samples Test is presented in Table 5, shows that the mean difference of critical thinking skill N-gain for groups 1-2, 1-3 groups, and 2-3 groups is .15; .49; .34 and all are significant, because $p < .05$. This clearly indicates that there is a significant difference between the mean N-gain of critical thinking skill in Group-1: Orientasi IPA Model with Group-2: PBL Model, Group-1: Orientasi IPA Model with Group-3 Conventional Model; and Group-2: PBL Model with Group-3: Conventional Model. The results of this analysis indicates that the critical thinking skill N-gain of physics teacher candidates after the learning process with Orientasi IPA Model is higher when compared to PBL Model and Conventional Model. The Orientasi IPA Model is more effective when compared to the PBL Model in improving the critical thinking skill of physics teacher candidates. The findings are supported by other research that the Orientasi IPA Model is a multi-representation physics study that can stimulate students in analyzing, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This is also consistent with Ainsworth's research (2008, 1999); Ciais et al. (2005) which stated that multi-representation learning has three main functions, namely: as a complement, interpretation barrier, and build a more comprehensive understanding. The PBL Model has been proven to improve self-study skills and provides a more realistic picture of higher academic challenges, more confidence, improve problem-solving skills, critical thinking skills, and improved communication skills (Ates & Eryilmaz, 2010; Benade , 2017, Kangersis & Hurren, 2011; Leong, 2017; Malan, Ndlovu, & Engelbrecht, 2014; Myers, 2017; Sern, Salleh, & Sulai, 2015; Tracey & Morrow, 2017 ; Williams, 2005; Zabit, 2010). However, the weakness of the PBL Model is the lack of initiation and timing, lack of student discipline, and more challenging authentic issues (Ates & Eryilmaz, 2010; Thompson et al., 2012). The findings of this research are supported by questionnaire results of the responses form physics teacher canddates that is presented in Table 6. The data in Table 6 shows that in general the students of physics teacher candidates give positive responses to the learning instruments of the Orientasi IPA Model. While the result of questionnaire response of physics teacher candidates toward the learning instruments and Conventional Model generally show less positive response. The findings are supported by other research that the Conventional Model is less facilitating students in developing their critical thinking skill, so according to Hammond et al (2015) and Mann & Kaitell (2001) this resulted in low learning achievement. The student response data in Table 6 reinforces that the Orientasi IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model to increase the critical thinking skill of physics teacher candidates.

The results of previous studies conducted at the State Junior High School in Jember, Indonesia showed that the Orientasi IPA Model and PBL Model with implemented learning instruments can significantly improve learning outcomes with moderate N-gain (Rosyid, Budi, & Supardi, 2013). The Orientasi IPA Model is a teaching model that has 5 (five) syntaxes and is designed specifically to improve the weakness of the PBL Model in improving student critical thinking skill. The Orientasi IPA Model is a problem-based Teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Therefore, the Orientasi IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model in improving the critical thinking skill of physics teacher candidates.

Conclusions

Based on the results of this research and discussion described above, it can be concluded as follows: (1) The learning instruments of Orientasi IPA Model and PBL Model to improve the critical thinking skill of physics teacher candidates has been prepared, including: Semester Learning Plan, Lesson Plan, Student Learning Materials, Student Activity Sheet, and critical thinking skill tests of physics teacher candidates. The critical thinking skill tests of physics teacher candidates has fulfilled the validity requirements ($r_\alpha \sim .26$) and reliability ($\alpha = .96 - .99$) the content and construct can be implemented in the learning process; (2) Learning process by using Orientasi IPA Model and PBL Model is effective, as indicated by: (a) there was a significant increase in student's critical thinking skill at $\alpha = 5\%$; (b) the average N-gain of learning by using Orientasi IPA Model and PBL Model are categorized as: moderate (.60) and moderate (.48); and (c) students' responses in each learning process were categorized as very positive (89%). Meanwhile, learning process by using the Conventional Model was ineffective, as indicated by: (a) there was a significant increase in students' critical thinking skill at $\alpha = 5\%$, (b) low N-gain (.14) and student responses were less positive (26%); and (3) Learning with Orientasi IPA Model is more effective in improving student critical thinking skill when compared to PBL Model.

Comment [V34]: Make the conclusions more clear and transparent. Some results and statistics are doubtful elements here.

As an implication of this research is that, the learning process by using the Orientasi IPA Model can be a solution to improve critical thinking skill of physics teacher candidates.

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Comment [V37]: not needed. See APA

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Comment [V38]: The list of references should be carefully checked for an appropriate use of dots, commas, intervals, italic, capital letters etc.

JOURNAL OF BALTIC SCIENCE EDUCATION

Web site: http://www.scientiasocialis.lt/jbse/

JOURNAL OF BALTIC SCIENCE EDUCATION

TITLE OF ARTICLE:	THE COMPARISON OF ORIENTASI IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILL OF PHYSICS TEACHER CANDIDATES
ID:	180108.jbse_JL-he_review

1.	Is the article original, and does it contribute something new to the field? (Importance of article / Relevance and Appeal to national / international scholarly community)	Excellent	Good	Moderate	Poor
2.	Do the title and abstract together give an adequate summary of the article / paper?	Excellent	Good	Moderate	Poor
3.	Statement of problem (s) / aim (s) / objective (s)	Excellent	Good	Moderate	Poor
4.	Theoretical basis / Theoretical framework / Literature review / Clarification of concepts	Excellent	Good	Moderate	Poor
5.	Appropriateness of the research plan and design (if applicable) /Appropriateness of data-collection and procedure /Data analysis /Trustworthiness/ reliability and validity	Excellent	Good	Moderate	Poor
6.	Steps taken to ensure that the research complies with standard ethical guidelines (if applicable)	Excellent	Good	Moderate	Poor
7.	Data presentation / Discussion (Are the results clearly and correctly presented? Are they consistent with the methodology?)	Excellent	Good	Moderate	Poor
8.	To what extent is the line of argumentation in the article clear, cohesive and logical?	Excellent	Good	Moderate	Poor
9.	Does the paper satisfy accepted criteria for academic writing in terms of coherence, grammar, layout and organisation?	Excellent	Good	Moderate	Poor
10.	Do the references adhere to APA?	Excellent	Good	Moderate	Poor
11.	Conclusions /Implications and/or recommendations are relevant and useful.	Excellent	Good	Moderate	Poor
12.	Is the language fluent and precise?	Excellent	Good	Moderate	Poor
13.	Is article significantly international in nature to be of value to global audience? /underline/ (Of Local Interest Only) (Of Regional Interest) (Of International Interest)	Excellent	Good	Moderate	Poor
14.	Overall assessment of content	Excellent	Good	Moderate	Poor

15.	Does the paper address relevant scientific questions within the scope of JBSE?	**Excellent**	**Good**	**Moderate**	**Poor**

16. Please write a brief narrative report on the article in which you provide a general or overall assessment of the manuscript and its suitability for publication.

The manuscript report a large project where the authors have developed "Orientasi IPA Teaching Model" and evaluation of this model, including the the comparison of outcomes obtained with the developed model and Problem Based Learning (PBL) Model. The developed model emphasises learning of critical thinkin skills.

Basically the developed model is linked to the relevant learning science research. However, one or two practical examples of the designed activities could be introduced in the appendix.

Several research instruments have been designed and tested. Their reliability and validity have been evaluated. However, the instruments could be provided in the appendix.

According to the analysis, the developed Orientasi IPA, PBL, and Conventional teaching can significantly increase students' learning outcomes measured by the test. However, The Orientasi IPA and PBL are more effective.

17. Please indicate the strong aspects of the research that is reported.

Good presentation of the research design, evaluation of the instrument, presentation of the data and argumentation based on the results.

18. Please indicate the weak aspects of the research reported.

The report is very large. However, I am not able to recommend, how to make it shorter.
Some minor topics could be made better:

- A short description of the site and students
- Some example of concrete tasks of the "Orientasi IPA Teaching Model" and PBL
- Research instruments in the appendix
- The English language should be revised again.

19. Final recommendation:

Accept without revision	
Accept with minor revisions	
Accept: with moderate revisions	X
Pre-accept: major revisions and re-evaluation	
Reject: Rework and re-submit	
Reject: do NOT re-submit	

20. Comments: Please indicate in the space below any comments and suggestions for improving the article.

Some minor topics could be made better:

- a short description of the site and students
- some example of concrete tasks of the “Orientasi IPA Teaching Model” and PBL
- research instruments in the appendix

P.S. The similarity index is 27 per cent. The authors should pay attention to this.

Date: February 2nd

Prof. Dr. Vincentas Lamanauskas, Siauliai University, Lithuania
Scientific Methodical Center "Scientia Educologica"
The Associated Member of Lithuanian Scientific Society
European Society for the History of Science (ESHS) and ICASE
Donelaicio Street 29, LT-78115 Siauliai, Lithuania

February, 12 2018

Dear Editor-in-Chief,

Thanks to editors and reviewers for having spent a great deal of time and care to provide positive recommendations for our articles. Researchers welcome all positive recommendations with pleasure because reviewer feedback has greatly helped improve the quality of our articles. Title: The Comparison of ORIENTASI IPA Teaching Model and Problem Based Learning Model Effectiveness to Improve Critical Thinking Skills of Pre-Service Physics Teachers; ID: 180203.JBSE_review_Jatmiko & 180203.jbse_JL-he_reviewed_corr. Researchers have revised all feedback from the reviewer (attached). Our great hope is our article can be received at Journal of Baltic Science Education. Thank you very much.

Best Regrads

Budi Jatmiko

Responses of 180203.jbse_JL-he_reviewed_corr

Reviewer:
Comment [V1]: Maybe skills?

Author:
Thanks to the reviewer has given a positive recommendation for our article. Researchers change skill to skills. Researchers have made a revision on page 1.

Reviewer:
Comment [V2]: The title is confusing and unclear

Author:
Researchers receive positive advice from reviewers according to existing reference studies. Researchers change the title ”The comparison of OR-IPA teaching model and problem based learning model effectiveness to improve critical thinking skills of pre-service physics teachers.” Researchers have revised on page 1.

Reviewer:
Comment [V3]: The abstract is not well written and does not really tell a gripping story to the reader. It is open to misinterpretation at this point. My suggestion: Follow the following process to write/construct the abstract:

- *Explain to the reader what the problem is AND/OR why the research was conducted.*
- *Mention the research design*
- *Mention the type of data gathering tools used*
- *Size of sample (if applicable and selection procedure)*
- *Theoretical perspectives and/OR theoretical framework.*
- *Summary of results*
- *Implications of results*

Do the above in between 180 to 200 words.

Comment [V4]: Or teaching?
Comment [V5]: What does it mean?
Comment [V6]: ????
Comment [V7]: What?
Comment [V8]: ????
Comment [V9]: ?????
Comment [V10]: Not suitable

Author:
Thanks to the reviewer has given a positive suggestion for our abstract. Researchers change the abstract. Researchers have made a revision on page 1.

Reviewer:
Comment [V11]: The APA Manual (6th ed.) says: "Order the citations of two or more works within the same parentheses alphabetically" (6.16 on page 177).

Author:
Researchers thanked the review for improving new knowledge about the APA Manual (6th ed.). Researchers receive advice from the reviewer according to the review and have revised on page 1.

Reviewer:
Comment [V12]: Maybe educational process?

Author:
Researchers receive positive advice from reviewers according to the study to change the learning process into educational process. Researchers have made a revision on page 1.

Reviewer:
Comment [V13]: Pre-service?

Author:
Researchers receive positive advice from reviewers according to the study to change the physics teacher candidates into pre-service physics teacher. Researchers have made a revision on page 1.

Reviewer:
Comment [V14]: Again…please be consistent…students are learning…teachers are teaching…together we have education process….When I am learning something, I do not use any models…I do not take care of that. This is a teaching process matter to take care about models, techniques etc.

Author:
Researchers receive positive advice from reviewers according to the study to change the learning process into teaching process. Researchers have made a revision on page 2.

Reviewer:
Comment [V15]: Sometimes to teach, sometimes to train? Keep consistency

Author:
Researchers receive positive advice from reviewers according to *keep consistency*. Researchers have made a revision on page 2.

Reviewer:
Comment [V16]: Students?

Author:
Researchers receive positive advice from reviewers according to the study to change student into students. Researchers have made a revision on page 2.

Reviewer:
Comment [V17]: Unclear term

Author:
Researchers receive advice from reviewers according to the study to change physics teacher candidates to pre-service physics teacher. Researchers have made a revision on page 2.

Reviewer:
Comment [V18]: Full source the first time = ALL AUTHORS. Then subsequent references can be et al. If there were six authors, you might mention only the first `+ "et al". Five and fewer authors must all be listed in full (first time).

Author:
Researchers thanked the review for improving new knowledge about the APA Manual (6th ed.). Researchers receive advice from the reviewer according to the review and have revised on page 2.

Reviewer:
Comment [V19]: Confusing

Author:
Researchers receive positive advice from reviewers according to not confusing. Researchers have made a revision on page 2.

Reviewer:
Comment [V20]: What does this word mean? Just use English name

Author:
Researchers thanked the review for improving new knowledge about name of Teaching Model in English. Researchers receive positive advice from the reviewer according to to ORIENTASI IPA to OR-IPA the review and have revised on page 2.

Reviewer:
Comment [V21]: So irrelevant info to explain again and again so well known things … this is not a textbook

Author:
Researchers thanked the review for improving new knowledge. Researchers receive positive advice from the reviewer according to the review and have revised on page 3.

Reviewer:
Comment [V22]: I do not see any problem here, …somehow as a question
Comment [V23]: Should be reworked

Author:
Researchers thanked the review for improving new knowledge of Problem of Research. Researchers receive positive advice from the reviewer according to the review and have reworked on page 4.

Reviewer:
Comment [V24]: Repetition …

Author:
Researchers thanked the review for improving new knowledge of Research Focus. Researchers receive positive advice from the reviewer according to the review and have reworked on page 4.

Reviewer:
Comment [V25]: Why do we need it? Repetition again
Comment [V26]: General description of research is important in order to show the basis of the research. It is like a very brief introduction to the methodology section as a whole… indicate also research type, time and scope.

Author:
Researchers thanked the review for improving new knowledge of General Background of Research. Researchers receive positive advice from the reviewer according to the review and have reworked on page 5.

Reviewer:
Comment [V27]: Why only?
Comment [V28]: What is it?
Comment [V29]: There is nothing on gender and ethical issues

Author:
Researchers thanked the review for improving new knowledge of Sample of Research. Researchers receive positive advice from the reviewer according to the review and have reworked on page 5.

Reviewer:
Comment [V30]: ???
Comment [V31]: Is it learning?
Comment [V32]: were

Author:
Researchers thanked the review for improving new knowledge of *Instrument and Procedures*. Researchers receive positive advice from the reviewer according to the review and have reworked on page 5,6.

Reviewer:
Comment [V33]: there is a big and so free usage (interplay) with the basic terms – "learning" and "teaching". Sometimes it is not clear at all what process is described/analyzed. This is a serious disadvantage.

Author:
Researchers thanked the review for improving new knowledge of Discussion. Researchers receive positive advice from the reviewer according to the review and have reworked on page 13.

Reviewer:
Comment [V34]: Make the conclusions more clear and transparent. Some results and statistics are doubtful elements here.

Author:
Researchers thanked the review for improving new knowledge of Conclusions. Researchers receive positive advice from the reviewer according to the review and have reworked on page 16.

Reviewer:
Comment [V35]: comma
Comment [V36]: comma
Comment [V37]: not needed. See APA
Comment [V38]: The list of references should be carefully checked for an appropriate use of dots, commas, intervals, italic, capital letters etc.

Author:
Researchers thanked the review for improving new knowledge about the APA Manual (6th ed.). Researchers receive advice from the reviewer according to the review and have revised on page 17-20.

Responses of 180203.JBSE_review_Jatmiko

Reviewer:
The manuscript report a large project where the authors have developed "Orientasi IPA Teaching Model" and evaluation of this model, including the comparison of outcomes obtained with the developed model and Problem Based Learning (PBL) Model. The developed model emphasizes learning of critical thinking skills.

Author:
Researchers are motivated even more to write and conduct research of critical thinking skills in science education.

Reviewer:
Basically the developed model is linked to the relevant learning science research. However, one or two practical examples of the designed activities could be introduced in the appendix.

Author:
Thanks to the reviewer has given a positive recommendation for our article. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles.

Reviewer:
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Author:
Researchers are motivated even more to write and conduct research in innovative education process.

Please indicate the strong aspects of the research that is reported.
Reviewer:
"Good presentation of the research design, evaluation of the instrument, presentation of the data and argumentation based on the results."

Author:
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Please indicate the weak aspects of the research reported.
Reviewer:
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Reviewer:
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- Research instruments in the appendix
P.S. The similarity index is 27 per cent. The authors should pay attention to this.

Author:
Thanks to the reviewer has given a positive recommendation for our article. Researchers have revised the article. Check plagiarism attached with this article. Researchers welcome all feedback with pleasure because reviewer feedback has greatly helped improve the quality of our articles.

THE COMPARISON OF OR-IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILLS OF PRE-SERVICE PHYSICS TEACHERS

Budi Jatmiko, Binar Kurnia Prahani, Munasir, Z. A. Imam Supardi
State University of Surabaya, Indonesia

Iwan Wicaksono, Nia Erlina
University of Jember, Indonesia

Paken Pandiangan
Indonesia Open University, Indonesia

Rosyid Althaf
Public Senior High School 3 Jember, Indonesia

Zainuddin
Syiah Kuala University, Indonesia

Abstract. *Critical thinking skills are one of the 21st century skills that are effectively trained by using the OR-IPA and Problem Based Learning (PBL) Model, therefore this research aims to compare the effectiveness of both. Research design used True Experiment with Randomized Subject Control-group Pre-test and Post-test with 94 pre-service physics teachers. Data collected using the critical thinking skills test and the student response sheet, and then analyzed using t-test and N-gain. The results showed: (1) the teaching instruments of OR-IPA and PBL Model have fulfilled the validity requirements ($r_\alpha \sim .26$) and reliability ($\alpha = .96$ - $.99$). (2) Each of OR-IPA, PBL, and Conventional Model can significantly increase critical thinking skills at α = 5%, respectively with average N-gain: medium (.60), medium (.48), and low (.14); with the student response of: very positive, very positive, and less positive. (3) The OR-IPA and PBL Model are effective to improve critical thinking skills, while the Conventional Model is ineffective, and the OR-IPA Model is more effective compared to the PBL Model. Implication of this research is that the OR-IPA Model can be an innovative solution to improve critical thinking skills, but there is still a need for repetitive research like this.*
Keywords: *basic physics, critical thinking skills, OR-IPA model, pre-service physics teachers, and PBL model.*

Introduction

In this 21st century, education has an important role in producing Human Resources (HR) that has the needed skills to work. Meanwhile, the demands of the curriculum and the development of globalization era require educational institutions to do beneficial innovations for the 21st century skills-based educational world (Griffin & Care, 2015; Turiman, Omar, Daud, & Osman, 2012). Permendikbud No.73 of 2013 on the Indonesian National Qualification Framework in the field of higher education requires universities to prepare curriculum for pre-service physics teacher to have superior competence with various skills that are in line with 21st century demands, among them are: critical thinking skills, skills to utilize Information and Communication Technology (ICT), and skills to solve problems (Griffin & Care, 2015; Jatmiko, Widodo, Martini, Budiyanto, Wicaksono, & Pandiangan, 2016; Kemdikbud, 2013; Pandiangan, Sanjaya, & Jatmiko, 2017). The 21st century educational process requires human resources with competence and the achievement of pre-service physics teachers are directed to skills and learning innovations, among others are: Critical thinking skills, problem solving skills, decision making, creative thinking, responsibility, and ability to learn independently (Griffin & Care, 2015; Pandiangan, Sanjaya, & Jatmiko, 2017).

The development of critical thinking skills is considered as one of the most important goals of education for over a century (Forawi, Almekhlafi, & Al-Mekhlafy, 2012; Geertsen, 2003). Critical thinking has been defined and measured in a number of ways, but it usually involves an individual's ability to identify central issues and assumptions in arguments, recognize important relationships (Mason, 2017, Moon, 2007), make correct conclusions from data, infer provided information or data, interpret whether the conclusion is guaranteed or not based on the data provided (Facione, 2013; Mulnix, 2012). Furthermore, previous researchers explain that critical thinking is cognitive skills, it includes activities of interpretation, analysis, evaluation, inference, explanation, and self-management in problem solving (Bean, 2011; Cheong & Cheung, 2008, Dam & Volman, 2004; Ennis, 2011; Ernst & Monroe 2004; Jenicek, 2006; Marin & Halpern, 2011; Miri, David & Uri 2007; Mundilarto & Ismoyo, 2017; Popil, 2011; Siew & Mapeala, 2016; Snyder & Snyder, 2008; Womack & Jones, 2010). In this research, critical thinking skills is a cognitive process which is carried out as a thinking guide by using reason judgments against evidence, context, standard, method, and conceptual structure by performing concepts, application, synthesis and information obtained from observation, experience, reflection, thinking, or communication as a basis for believing and doing an action and focusing on what to do. The critical thinking skills’ indicators in this research are analysis, evaluation, interpretation, and inference based on the results of literature research and preliminary study by the investigator, these indicators are still low and need to be accelerated in pre-service physics teachers.

In connection with the improvement of the teaching process and outcomes quality mentioned above, there are important problems faced by the world of education today, which is how to strive pre-service physics teachers’ critical thinking skills through teaching (Krulik & Rudnick, 1996; Marzano, 1993). This needs to be done because there are many students who do not have critical thinking skills (Brookfield, 2017). Critical thinking skills are important thinking skills and should be taught, but there are still many lecturers who do not understand how to teach critical thinking skills. The results of Patrick's, Fallon, Campbell, Cretchley, Devenish, & Tayebjee (2014) and Pithers & Soden (2000) showed that critical thinking skills should be taught, but there are still some lecturers who do not know how to teach critical thinking skills effectively (Brownlee, Walker, Lennox, Exley, & Pearce, 2009; McPeck, 2016).

Martin, Mullis, Foy, & Stanco (2012) showed that most of Indonesian students are only able to recognize a number of basic facts and have not been able to communicate and relate various topics of science, especially in applying complex and abstract concepts. This fact is in line with the results of Rosyid, Jatmiko, & Supardi (2013) research, which indicated that the physics teaching process is still and more emphasized on the process of knowledge transfer, so it has not been able to make students able to construct knowledge. The low critical thinking skills of pre-service physics teachers are suspected to have something to do with the teaching process being implemented (Browne, & Meuti, 1999; Staib, 2003; Wlodkowski, & Ginsberg, 2017). The implemented teaching model, which is the Conventional Teaching Model (i.e. Conventional Model) cannot facilitate in developing students’ critical thinking skills, resulting in low learning achievement (Hammond, Barron, Pearson, Schoenfeld, Stage, Zimmerman, & Tilson, 2015; Mann & Kaitell, 2001). Therefore, to improve the quality and facilitate the development of pre-service physics teachers, it is necessary to find out alternative solutions. The alternative solutions include implementing the OR-IPA Teaching Model (i.e. OR-IPA Model) and Problem Based Learning Model (i.e. PBL Model). The results of previous research conducted by Rosyid, Budi, & Supardi (2013) showed that OR-IPA Model and PBL Model with supporting teaching instruments can improve high school students' learning outcomes in Kabupaten Jember, East Java significantly at $\alpha = 5\%$ with moderate N-gain.

The OR-IPA Model is a problem-based teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Multi-representation teaching can stimulate students to perform analysis, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This was also applied to Ainsworth's (2008, 1999) and Ciais, Reichstein, Viovy, Granier, Ogée, Allard & Carrara (2005) studies which suggested that multi-representation learning has three main functions: complementary, interpretive, and can build a more comprehensive understanding. In this research, the OR-IPA Model has five syntaxes, namely: (1) **O**rientation of Problem, (2) **R**epresentation of Problem, (3) **I**nvestigation, (4) **P**resentation, (5) **A**nalysis, Evaluation and Follow-up (Rosyid, Budi, & Supardi, 2013). The interactive tasks in applying this OR-IPA Model to grow up the ability of critical thinking skills are referred to the phases in the syntax, namely: (1) **O**rientation of Problem, which is aimed to attract the students, focus the students, and motivate them to take an active role in the teaching process; (2) **R**epresentation of Problem, which is aimed to assist students in understanding the material and solving the problems that will be discussed through various approaches that can be adapted to the objectives of teaching and the presented material characteristics; (3) **I**nvestigation, which is aimed to collect information with the help of Student Worksheet, then the lecturer guides to carry out step-by-step investigations, explores the explanation, and solutions to build the critical thinking skills which includes (a) formulating the problem; (b) formulating the hypothesis; (c) identifying variables; (d) writing the operational variables definition; (e) writing down the experimental tools and materials; (f) conducting experiments; (g) organizing experiment data; (h) analyzing experimental data; and (i) making a conclusion; (4) **P**resentation, which is aimed to guide students in making conclusions and discussion of the investigation results in various representations, and assisting in the planning, preparing and presenting the works; and (5) **A**nalysis, Evaluation and Follow-up, which is aimed to analyze and evaluate the problem-solving process of inquiry and process in various forms of representation, observe the students' work as the learning evidence, and facilitate follow-up learning through the assignment of structured tasks.

The PBL Model has five syntaxes, namely: directing students to problems, organizing students to learn, helping independent and group investigations, developing and presenting artifacts and exhibits, and analyzing and evaluating problem-solving processes (Arends, 2012). Characteristics of the PBL Model are designed to help students improving their inquiry skills and problem-solving skills, social behavior and skills according to the role of adults, as well as independent learning skills for the investigation of everyday life issues (Arends, 2012; Arizaga, Bahar, Maker, Zimmerman, & Pease, 2016; Nilson, 2016). The PBL Model begins with a complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a suitable learning environment for students (Caesar, Jawawi, Matzin, R., Shahrill, Jaidin, & Mundia, 2016; Nuninger & Châtelet, 2017). The PBL Model also regulates a student-centered learning environment that is not viewed as an empty vessel but is capable to bring its own distinct framework and learning (Chakravarthi, 2010; Efendioglu, 2015). The PBL Model can enhance self-study skills and provide a more realistic picture of higher academic challenges, more confidence, better problem-solving skills, critical thinking skills, and provide the improvement of communication skills (Malan, Ndlovu, & Engelbrecht, 2014; Méllesis & Hurren, 2011; Williams, 2005). The application of PBL Model will promote students to have motivation, confidence in learning and able to improve students' ability to solve more complex problems (Caesar et al., 2016; Nilson, 2016; Sern, Salleh, Mohamad, & Yunos, 2015; Tracey & Morrow, 2017). However, the PBL Model is still weak in terms of inquiry orientation components, alternative solutions, and difficult in formulating problems and preparing hypotheses (Ates & Eryilmaz, 2010; Chakravarthi, 2010). Although the research shows that the PBL Model supports self-study and communication skills, critical skills improvement, creative thinking skills and problem-solving skills (Ates & Eryilmaz, 2010; Malan, Ndlovu, & Engelbrecht, 2014), however PBL's weaknesses are lack of initiation and timing, lack of student discipline, and more challenging authentic issues are needed (Ates & Eryilmaz, 2010; Thompson, McInerney, Manning, Mapukata-Sondzaba, Chipamaunga, & Maswanganyi, 2012).

The State University of Surabaya (Unesa) as an institution of higher education has facilitated its lecturers with various teaching models that can be integrated with information and communication technology. However, the reality shows that there are still many lecturers who have not conducted the lesson by utilizing the facilities to provide learning experiences for pre-service physics teachers. Most of the lecturer facilities provided by Unesa are only used as teaching tools and have not been utilized to produce teaching models. The teaching models gained through a series of research are less useful and ineffective because they have not been optimally utilized by lecturers at Unesa as it is in other higher education institutions, lecturers should be responsible for developing models, strategies, approaches, methods or instructional techniques in the era of the 21st century (Huba & Freed, 2000; Richards & Rodgers, 2014). OR-IPA Model and PBL Model are very useful to improve lecturers' competence in teaching. This is because the teaching becomes more interesting, more challenging, and better suited to the needs of students. The results of previous research indicate that the OR-IPA Model and PBL Model are effective and practical in improving critical thinking skills of Senior High School students in Jember Regency (Rosyid, Jatmiko, & Supardi, 2013).

Referring to the effectiveness of OR-IPA Model and PBL Model in improving the students' critical thinking skills, it needs to be reviewed and tested for further consistency in improving the critical thinking skills of pre-service physics teacher from Unesa. This research is very important in order to develop models and learning theories that are able to answer the challenges and skills needs in the 21st century. The low critical thinking skills are theoretically caused, among other things, by: poor motivation and responsibility, poor analytical skills, and less discipline in teach (Adebayo, 2014). This is also due to the lack of ability to organize time, lazy to learn, and less supportive learning environment (Chakravarthi, 2010; Eaton, 2015). Therefore, it is necessary to compare the effectiveness between OR-IPA Model and PBL Model in improving student critical thinking skills. In order to be able to compare the effectiveness of the two models, then the preparation of teaching instruction of OR-IPA Model and PBL Model was done firstly which is designed to be able to increase critical thinking skills of pre-service physics teachers.

Problem of Research

The problem of this research is how to analyze the effectiveness of teaching in the basic physics course with the OR-IPA Model and PBL Model to get more effective teaching model to improve the critical thinking skills of pre-service physics teacher. In addition, also how to get examples of teaching instruments that are valid and reliable with an effective teaching model in improving the critical thinking skills of pre-service physics teachers. In detail, the focuses of this research were: (1) how is the validity and reliability of teaching instruments in basic physics course with OR-IPA Model and PBL Model to improve the critical thinking skills of pre-service physics teachers, which includes: Semester Teaching Plan, Lesson Plan, Student Teaching Materials, Student Worksheet, and Student Critical Thinking Skills Test of pre-service physics teachers? (2) how is the effectiveness of teaching process with OR-IPA Model, PBL Model, and Conventional Model in improving the critical thinking skills of pre-service physics teachers? and (3) which teaching model is the most effective to improve the critical thinking skills of pre-service physics teachers?

Research Focus

During this time, the way to get the student's critical thinking skills is done by teaching with PBL Model, but the previous research conducted on senior high school students in Jember, Indonesia by using teaching with OR-IPA Model, which is a correction of the PBL Model to improve students' critical thinking skills showed results that are also effective and practical (can be applied). On the other hand, many students do not have critical thinking skills, so there are many lecturers who still do not understand how to teach critical thinking skills effectively to the pre-service physics teachers. The focus of this research was to compare the effectiveness of teaching in basic physics courses with OR-IPA Model and PBL Model in improving the critical thinking skills of pre-service physics teacher. This research used control variables; it was the Conventional Model.

Methodology of Research

General Background

This research was conducted at State University of Surabaya in June - December 2017. The scope of this research is the first-year students who took Basic Physics course in academic year 2017/2018. This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design. This research is emphasized on the analysis of the OR-IPA Model, PBL Model, and Conventional Model effectiveness by analyzing the increase of critical thinking skills of pre-service physics teachers before and after following the process of physics teaching with CRBT model. The Conventional Model in this research was lecturer-centered teaching model, which includes lecture, presentation, and discussion. The teaching instruments and research instruments are said to be valid if r_{α} > r table and invalid if $r_{\alpha} \leq$ r table. Physics teaching process with OR-IPA Model, PBL Model, and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skills of pre-service physics teachers at $\alpha = 5\%$, (2) the minimum N-gain is categorized as moderate, and (3) students' responses are at least positive.

Sample

The research was conducted to 94 students of Physics Education Study Program, Unesa, Indonesia, which came from a population of 123 students in three groups (experimental group-1 / OR-IPA Model, experimental group-2 / PBL Model, and control group / Conventional Model). The calculation of the sample number was based on the Slovin formula, that was the sample = [population / (1 + e^2 × population)] with error tolerance e = 5% (Sevilla, Ochave, Regala, & Uriarte, 1984; Tejada, & Punzalan, 2012). This research took three groups, namely: group of: experiment group-1 came to 31 students; experiment group-2 came to 30 students; and control group came to 33 students, each of them was statistically in the same level of critical thinking skills.

Instrument and Procedures

This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design (Fraenkel, Wallen, & Hyun, 2012).

O_1	X_1	O_2
O_1	X_2	O_2
O_1	C	O_2

With:

O_1: Pre-test score, O_2: Post-test score, X_1: OR-IPA Model, X_2: PBL Model and C: Conventional Model

Prior to the research, firstly the researchers set up teaching instruments that covered these components: (1) Semester Teaching Plan, (2) Lesson Plan, (3) Student Teaching Materials, (4) Student Worksheet, and (5) Critical Thinking Skills Test of pre-service physics teacher, respectively for the OR-IPA Model and PBL Model. The data were collected by using the research instruments, which consisted of the following components: (1) Teaching Model Implementation Sheet and (2) Student Response Sheet. The validity of those teaching instruments from both OR-IPA Model and PBL Model was then assessed by the physics education experts in terms of the content and construct. In order for the teaching instruments to be able to be implemented, the leaning instruments have to meet the valid and reliable requirements.

The research began by giving the critical thinking skills pre-test (O_1) by using the critical thinking skills test of pre-service physics teacher to each group of students, then providing teaching with different models, namely: OR-IPA Model, PBL Model, and Conventional Model. Finally, after the entire teaching process has been completed, all groups of students are awarded a post-test (O_2) of the critical thinking skills with the same materials and problems as in the pre-test.

Data Analysis

In order to get the validity of contents and construct for the teaching instruments of the OR-IPA Model and PBL Model as well as the research instrument, the assessment of those instruments was done by the physics education expert based on the content and construct validity. Content validity is a description of needs and novelty, while construct validity is a description of the consistency of teaching instruments of OR-IPA Model and PBL Model with theory/empirical and consistency between the instrument components (Plomp, 2013). The data was analyzed by reliability test; each of them was analyzed by using Cohen's Kappa, single measure interrater coefficient correlation (r_α) and Cronbach's alpha (α). The teaching instruments and research instruments are said to be valid if $r_\alpha > r_{table}$ and invalid if $r_\alpha \leq r_{table}$. Meanwhile, the teaching instruments and research instruments are said to be reliable if $.6 \leq \alpha \leq 1.0$ and not reliable if $\alpha < .6$. In order to analyze physics teaching with a more effective teaching model, an "effective" operational definition is required. Physics teaching process with OR-IPA Model, PBL Model and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skills of pre-service physics teachers at $\alpha = 5\%$, (2) the average N-gain at least in moderate category, and (3) students' responses are at least positive. In this research, the pre-test and post-test results were analyzed as follows: when the normality assumption for the achieved score is fulfilled, the Paired t-test will be applied. If it is not fulfilling, non-parametric analysis will be used. In order to get increasing level of student's critical thinking skills score, the calculation was done by using N-gain with equation: N-gain = (Post-test score - Pre-test) / (maximum score - Pre-test) (Hake, 1998). By the criteria of: (1) N-gain > .70 (height); (2) .30 < N-gain < .70 (medium); and (3) N-gain < .30 (low). In order to test whether the improvements on students' critical thinking skills existed or not with the OR-IPA Model, PBL Model, and Conventional Model, Paired t-test against the pre-test score and post-test by using IBM SPSS Statistic 16 software was done. Meanwhile, to get more effective model in improving students' critical thinking skills after being given lessons, researchers compared the effectiveness of the three models by using Independent t-test. In order to see the responses of pre-service physics teachers toward teaching with OR-IPA Model, PBL Model, and Conventional Model, student responses data was analyzed by using qualitative descriptive (Prahani, Winata, & Yuanita, 2015; Riduwan, 2010). With the criteria of: (1) Response ≥ 75% (very positive); (2) 50% ≤ Response < 75% (positive); (3) 25% ≤ Response < 50% (less positive); and (4) Response < 25% (not positive).

Results of Research

Validity of Teaching Instruments and Research Instruments of OR-IPA Model and PBL Model

Before the research is done, teaching instruments and research instruments that have been compiled must meet the requirements of validity and reliability. The validity of teaching instruments of OR-IPA Model and PBL Model, and research instruments were assessed by two physicists of Unesa. The results of the validity assessment of the teaching instruments and research instruments for OR-IPA Model and PBL Model, respectively, are shown in Table 1 and Table 2.

Table 1. The result of teaching instruments and research instruments validity of OR-IPA model.

Components	The Validity of OR-IPA Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	Cohen's kappa	R	r_α	V	α	R
Semester Teaching Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.99	Reliable
Lesson Plan	.87	Reliable	.25	Valid	.97	Reliable	.87	Reliable	.25	Valid	.97	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.96	Reliable	.25	Valid	.99	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.96	Reliable	.25	Valid	.98	Reliable
Critical Thinking Skills Test of Pre-Service Physics Teacher	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes:
r_α = *Single measure interrater coefficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Table 2. The validity of PBL model instruments.

Components	The Validity of PBL Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	*Cohen's kappa*	R	r_α	V	α	R
Semester Teaching Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Lesson Plan	.86	Reliable	.25	Valid	.96	Reliable	.86	Reliable	.25	Valid	.96	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.95	Reliable	.25	Valid	.96	Reliable

Components	The Validity of PBL Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	*Cohen's kappa*	R	r_α	V	α	R
Critical Thinking Skills Test of Pre-Service Physics Teacher	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes: r_α = *Single measure interrater coefficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Table 1 shows that the construct validity of the OR-IPA Model instruments includes: Semester Teaching Plan; Lesson Plan; Students Worksheet; Student Teaching Materials; Critical Thinking Skills Test of pre-service physics teachers, and the research instruments, which includes: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the OR-IPA Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skills; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skills need to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the teaching instruments of the OR-IPA Model in order to be implemented.

Table 2 shows that the construct validity of the PBL Model instruments includes: Semester Teaching Plan; Lesson Plan; Students Activity Sheet; Student Teaching Materials; Student Critical Thinking Skills Test of pre-service physics teacher, and the research instruments, which include: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the PBL Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skills; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skills need to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the teaching instruments of the PBL Model in order to be implemented.

Based on the above description, it can be said that the teaching instruments of OR-IPA Model and PBL Model have fulfilled the content and construct validity requirements to improve the critical thinking of pre-service physics teacher. The teaching instruments of OR-IPA Model and PBL Model can be implemented in the teaching process of basic physics courses.

The Effectiveness of OR-IPA Model, PBL Model and Conventional Model for Critical Thinking Skills of Pre-Service Physics Teachers

The critical thinking skills score and N-gain of pre-service physics teachers were obtained by providing the pre-test and post-test of the critical thinking skills. The detailed score of pre-test, post-test, and N-gain of pre-service physics teachers in the OR-IPA Model, PBL Model, and Conventional Model are shown in Figure 1. While the critical thinking skills indicators of group-1: OR-IPA Model, group-2: PBL Model and group-3: Conventional Model is presented in Table 3. Figure 1 shows that prior to the teaching with OR-IPA Model, PBL Model, and Conventional Model, pre-service physics teachers have low average of critical thinking skills. After the implementation of OR-IPA Model and PBL Model, pre-service physics teachers have an increase in the average of critical thinking skills, but in Conventional Model, all pre-service physics teachers still have average of critical thinking skills in low category. In general, the average of critical thinking skills for pre-service physics teachers in post-test with OR-IPA Model, PBL Model, and Conventional Model is in high category (2.67); Medium (2.14); and low (1.00) and the score ranged from 1 - 4. The average N-gain of critical thinking skills owned by pre-service physics teachers for teaching by using OR-IPA Model, PBL Model, and Conventional Model, is in the category of moderate (.63); moderate (.47); and low (.14), from the score range of 0 - 1.

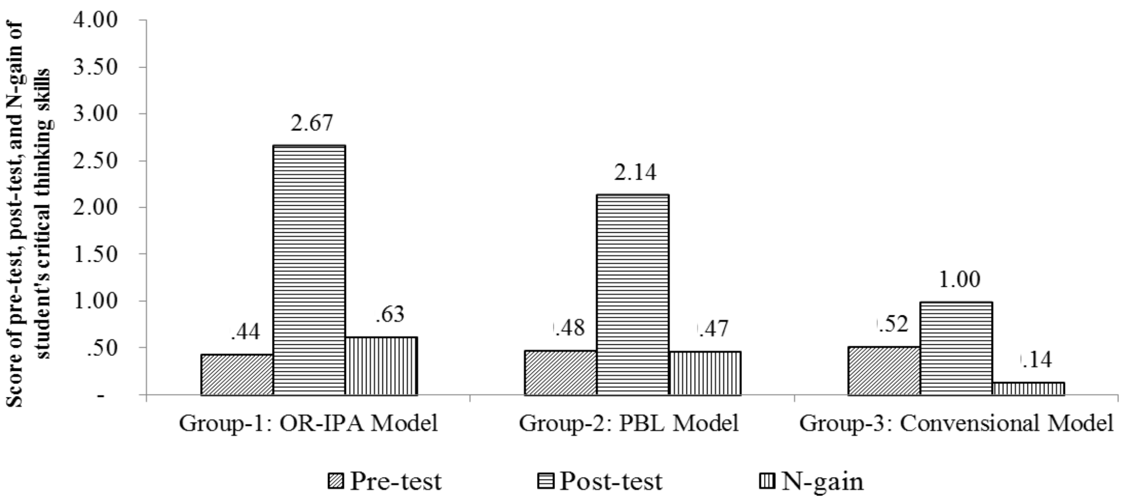

Figure 1: The score of pre-test, post-test, and N-gain of critical thinking skills owned by pre-service physics teachers with OR-IPA model, PBL model, and Conventional Model.

Figure 1 indicates that in order to increase the critical thinking skills of pre-service physics teachers; the OR-IPA Model is better compared to the PBL Model and Conventional Model. While the PBL Model is better when compared to the Conventional Model.

Table 3. The critical thinking skills indicator of group-1: OR-IPA model, group-2: PBL model, and group-3: conventional model.

Group	Score	Indicators of Critical Thinking Skills

		Analysis	Evaluation	Interpretation	Inference
Group-1: OR-IPA Model	Pre-test	.45	.31	.52	.45
	Post-test	2.91	2.47	3.00	1.96
	N-gain	.69	.59	.71	.43
	Pre-test	.59	.39	.82	.13
Group-2: PBL Model	Post-test	2.36	2.24	2.59	1.39
	N-gain	.52	.51	.56	.33
	Pre-test	.49	.32	.71	.58
Group-3: Conventional Model	Post-test	1.09	.69	1.29	.93
	N-gain	.17	.10	.18	.10

Table 3 shows that the results of critical thinking skills pre-test of pre-service physics teachers for all critical thinking skills indicators were in the low category, whereas after the implementation of teaching with OR-IPA Model, all the critical thinking skills indicators have increased. In general, the average N-gain for critical thinking skills indicator with OR-IPA Model was in medium and high category, with the value was above .43. The result of critical thinking skills pre-test of pre-service physics teachers for all indicators was in low category, while after implementation of teaching with PBL Model, all critical thinking skills indicators have increased. In general, the average N-gain of critical thinking skills indicator with PBL Model was in medium and high category with the value above .33. The result of critical thinking skills pre-test of the pre-service physics teacher for all critical thinking skills indicators was in low category, while after the implementation of teaching with Conventional Model, all critical thinking skills indicators remain in low category. In general, the average N-gain of critical thinking skills indicators with Conventional Model was in low category with value above .10. Meanwhile, the lowest indicator of critical thinking skills in all groups was inference.

Paired T-test of Critical Thinking Skills Owned by Physics Teachers Candidates with OR-IPA Model, PBL Model, and Conventional Model

The existence of critical thinking skills increase in the pre-service physics teachers is measured by testing the average score of Pre-test and the Post-test score by using Paired t-test. Paired t-test is used (for parametric statistical test) because it has fulfilled the requirements: (1) Pre-test score and Post-test data of critical thinking skills of pre-service physics teacher come from normal distributed population, conducted by normality test (Shapiro-Wilk); and (2) the average of Pre-test and Post-test score data is homogeneous when tested by using the two-variance equality test. Paired t-test for the average score of Pre-test and Post-test of critical thinking skills conducted on Group-1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of Paired t-test against Pre-test and Post-test score of critical thinking skills of pre-service physics teachers are presented in Table 4.

Table 4. The results of paired t-test of critical thinking skills owned by pre-service physics teachers in all groups.

Group	N	*Paired t-test*				
		Mean	Std. error mean	t	df	p
Group-1: OR-IPA Model	31	-2.25	.13	-17.95	30	< .01
Group-2: PBL Model	30	-1.66	.08	-19.83	29	< .01
Group-3: Conventional Model	33	- .48	.05	-9.24	32	< .01

Table 4 shows that the mean scores of critical thinking skills for groups 1, 2 and 3 respectively for: OR-IPA Model, PBL, and Conventional Teaching Model are -2.25; -1.66; and - .48

with degrees of freedom (df) are 30; 29; 32 and giving t value of -17.95; -19.83; and -9.24. The result of Paired t-test for each group is significant, because p < .05. Therefore, t counts the negative value, then clearly there is a significant difference at α = 5% between the pre-test score with the critical thinking skills Post-test in all groups. For teaching with the OR-IPA Model, PBL Model, and Conventional Model, all of them show higher post-test score compared to the pre-test score, or the mean scores of critical thinking skills of pre-service physics teachers after each teaching process with the OR-IPA Model, PBL Model, and Conventional Model are higher than before.

Independent T-test of Critical Thinking Skills Owned by Pre-Service Physics Teachers with OR-IPA Model, PBL, and Conventional Model

In order to analyze which model is more effective in increasing the critical thinking skills of pre-service physics teachers among Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model, among others, is done by testing the average N-gain of the critical thinking skills by using Independent t-test. Independent t-test is used (for parametric statistical tests) because it meets the requirements of: (1) the average N-gain of critical thinking skills of pre-service physics teachers (Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model) are derived from normally distributed populations, performed by normality test (Shapiro-Wilk); and (2) the average N-gain of critical thinking skills of pre-service physics teachers (Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model) is homogeneous when measured by using multiple-variance test equations. Independent t-test for the average N-gain was performed on Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. Independent t-test results on the average N-gain for all groups are presented in Table 5.

Table 5. Independent t-test results on the average N-gain for all groups.

Group	N	*Independent t-test*				
		Mean Difference	**Std. error mean**	**t**	**df**	**p**
Group 1: OR-IPA Model Group 2: PBL Model	61	.15	.04	3.58	59	< .01
Group 1: OR-IPA Model Group 3: Conventional Model	64	.49	.04	12.5	62	< .01
Group 2: PBL Model Group 3: Conventional Model	63	.34	.03	12.51	61	< .01

Table 5 shows that the mean difference of N-gain of critical thinking skills for groups: 1-2, 1-3, and 2-3 is .15; .49; .34 and respectively have degrees of freedom (df) = 59; 62; 61, gives a value of t = 3.58; 12.50; and 12.51. The score is significant, because p < .05. Therefore, p < .05, it is clear that there is significant difference in mean of critical thinking skills N-gain in Group-1 that is the OR-IPA Model with Group-2 that is PBL Model, Group-1 that is the OR-IPA Model with Group-3 that is Conventional Model; Group-2 that is PBL Model with Group-3 that is Conventional Model, for each at α = 5%. The results of the above analysis show that the average N-gain of critical thinking skills of pre-service physics teachers was higher after teaching with the OR-IPA Model when compared to PBL Model and Conventional Model. While teaching with PBL Model gave higher average N-gain when compared to the Conventional Model.

The Pre-Service Physics Teachers Response toward the OR-IPA Model, PBL Model, and Conventional Model

The analysis of student's response toward teaching with implemented model is done by giving the Student Response Sheet for pre-service physics teachers after the physics teaching process. The results of the pre-service physics teachers' responses are presented in Table 6.
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Table 6. The pre-service physics teachers' response toward the OR-IPA model, PBL model, and Conventional model.

Group	N	Students' Positive Opinion on the Physics Teaching Process	Category
Group I: OR-IPA Model	31	89 %	Very Positive
Group II: PBL Model	30	89 %	Very Positive
Group III: Conventional Model	33	26 %	Less Positive

Table 6 shows that in general pre-service physics teacher responded very positively to the teaching instruments of the OR-IPA Model and PBL Model. As for the Conventional Model instruments, student responses show less positive.

Discussion

Validity of OR-IPA Model and PBL Model Instruments

The developed teaching instruments' components include Semester Teaching Plan, Lesson Plan, Student Teaching Materials, Student Worksheet, and Critical Thinking Skills Test of pre-service physics teacher; and the Research Instruments include Teaching Model Implementation Sheet and Student Response Sheet. The assessment of all teaching instruments' components is done by physics education experts in Unesa and has been declared valid as in Table 1 and Table 2. The implication of the instruments has been declared valid and can be used for the implementation of OR-IPA Model and PBL Model in improving the pre-service physics teachers. In addition, Table 1 and Table 2 also show that all components of the teaching instruments are included reliably, shown by the coefficients of Cohen's Kappa. The result of this validity is supported by the opinion of Plomp (2013) which said that a good product (teaching model) must meet the requirements, namely: validity: the validity of the model can be tested by testing the content and construct validity. Content validity is when there is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge; whereas the validity of constructs (construct validity) is the intervention and is 'logically' designed (Nieveen, McKenney, & Akker, 2007). A valid device (content and construct) has an impact on the improvement of the critical thinking skills owned by the pre-service physics teachers on the significant basic physics material as in Table 3 - 5. The statement is reinforced by the results of research stating that PBL can develop critical thinking skills and analysis and exposes students to exercises to solve problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009). The successful use of this teaching model is determined by the preparation of learning environments and good learning media (Johnson, Rickel, & Lester, 2000) to support each lecturer and student activity (Woolf, 2010) in each stage of the OR-IPA Model and PBL Model syntax. It is a reflection that the developed instruments have been valid and can be implemented to improve the critical thinking skills owned by the pre-service physics teachers.

The individual critical thinking skills score of the pre-service physics teachers is obtained by providing the critical thinking skills test of pre-service physics teachers before the teaching (Pre-test) and after the teaching process is done (Post-test). The data in Figure 1 shows that before the teaching with OR-IPA Model, all students have low critical thinking skills. After the implementation of OR-IPA Model, all students experience increased their critical thinking skills. In general, the critical thinking skills of the pre-service physics teachers in the post-test were in the high category of 2.27 from the range of 1 - 4. The general N-gain scores of pre-service physics teachers with OR-IPA Model were in the medium category of .63. Table 3 shows that all the critical thinking skills indicators in the pre-test are in the low category, whereas after the implementation of teaching with OR-IPA Model, all the critical thinking skills indicators have increased. The general N-gain of critical thinking skills indicators of the OR-IPA Model were in medium and high category with the value was above .43. The results of this research are supported by the work of John Dewey who describes the views of education, with the school as a mirror of the larger society, the class becomes a laboratory for investigation, and solving real-life problems (phase 3). Pedagogy Dewey encourages lecturers to engage students in problem-oriented projects and helps to investigate important social and intellectual issues. Dewey and his followers affirm that teaching in school should be more meaningful, not too abstract (Helterbran, 2010; Loughran, 2013). The vision of purposeful teaching in problem centered is supported by the student's innate desire to explore personal situations for students. The findings of cognitive psychology provide the theoretical foundation for OR-IPA Model. The basic premise in cognitive psychology is that teaching is a process of constructing new knowledge based on current knowledge. Chi, Glaser, & Farr (2014) and Jonassen & Land (2012) assumed that teaching is a constructive process and not an acceptance.

Pre-test, Post-test, and N-gain score of the critical thinking skills owned by pre-service physics teachers in the PBL Model are shown in Figure 1. Based on the data in Figure 1, before the teaching with PBL Model was done, all students have low critical thinking skills. After the implementation of PBL Model, all students' critical thinking skills increase. In general, the pre-service physics teachers gained medium category of 2.14 for their post-test. The general N-gain of pre-service physics teachers by using PBL Model was in the medium category of .47. Table 3 shows that all pre-service physics teachers' pre-test indicators were in the low category, whereas after the implementation of teaching with PBL Model, all the indicators of their critical thinking skills have increased. The general N-gain indicators of critical thinking skills of PBL Model were in medium and high category with value above .33. The results of this research are supported by the characteristics of PBL Model that was designed to assist students in improving the skills of inquiry and problem solving skills, social behavior and skills according to the role of adults, as well as independent learning skills (Arends, 2012: Arizaga, Bahar, Maker, Zimmerman, & Pease , 2016), the PBL Model begins with complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a student-friendly learning environment (Nuninger & Châtelet, 2017), where they acquire complex problem-solving skills in real life and problem situations, student-centered learning environments, and constructivism approaches (Caesar et al., 2016; Chakravarthi, 2010; Kong, Qin, Zhou, Mou, & Gao, 2014). The results of this research are also reinforced by previous research findings that the PBL Model is very useful to improve motivation, self-confidence, self-study skills, creative thinking skills, critical thinking skills, problem-solving skills, assisting in better retention of knowledge and memory skills, and apply meaningful information with real life situations (Ates & Eryilmaz, 2010; Malan, Ndlovu & & Engelbrecht 2014; Myers, 2017; Nilson, 2016).

The pre-test, Post-test, and N-gain scores of the pre-service physics teachers in the Conventional Model are shown in Figure 1. Based on the data in Figure 1, before the teaching process by using the Conventional Model, all students had critical thinking skills in low category. After the implementation of teaching process by using Conventional Model, all students still had critical thinking skills in low category. In general, critical thinking skills of pre-service physics teacher in Post-test were in the medium category of 1.00. The general N-gain for pre-service physics teacher with Conventional Model was in the medium category of .14. Table 3 shows that all critical thinking skills indicators in the pre-test were in low category, whereas after the implementation of teaching with the Conventional Model all critical thinking skills indicators remained in the low category. The general N-gain of critical thinking skills indicators with a Conventional Model was in the low category with values above .10. The low critical thinking skills of pre-service physics teacher are suspected to have something to do with the teaching process that is implemented. The lesson model that is implemented, the Conventional Model is not able to facilitate in developing the critical thinking skills owned by pre-service physics teacher, resulting in low teaching achievement (Hammond et al., 2015; Mann, & Kaitell, 2001).

The result of Paired t-test presented in Table 4 shows that the mean of critical thinking skills for groups 1, 2, and 3 is -2.25; -1.66; - .48. The whole score is significant, because $p <.05$. Since the result of the calculation was negative, it clearly showed that there was a significant difference between the mean of the pre-test score and the post-test score for the critical thinking skills in all groups, the post-test group was higher than the pre-test group. The low critical thinking skills in theory can be caused by: motivation, lack of responsibility, low analytical skills, and lack of discipline in learning (Adebayo, 2014). This can also be due to a lack of ability to organize time, lazy to learn, and less supportive learning environments (Chakravarthi, 2010; Eaton, 2015). The low critical thinking skills of pre-service physics teacher are suspected to have something to do with the teaching process that is implemented. The OR-IPA Model and PBL Model are able to motivate students to investigate and solve problems in real life situations as well as stimulate students to produce a product in improving the critical thinking skills. Problem-based learning can develop critical thinking skills and analysis and expose students to practice solving problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009).

The independent t-test for the average N-gain is performed on Group-1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of the average t-test of the N-gain by using Independent Samples Test is presented in Table 5, shows that the mean difference of critical thinking skills N-gain for groups 1-2, 1-3 groups, and 2-3 groups is .15; .49; .34 and all are significant, because $p < .05$. This clearly indicates that there is a significant difference between the mean N-gain of critical thinking skills in Group-1: OR-IPA Model with Group-2: PBL Model, Group-1: OR-IPA Model with Group-3 Conventional Model; and Group-2: PBL Model with Group-3: Conventional Model. The results of this analysis indicate that the critical thinking skills N-gain of pre-service physics teachers after the teaching process with OR-IPA Model is higher when compared to PBL Model and Conventional Model. The OR-IPA Model is more effective when compared to the PBL Model in improving the critical thinking skills of pre-service physics teachers. The findings are supported by other research that the OR-IPA Model is a multi-representation physics study that can stimulate students in analyzing, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This is also consistent with Ainsworth's research (2008, 1999); Ciais et al. (2005) which stated that multi-representation learning has three main functions, namely: as a complement, interpretation barrier, and build a more comprehensive understanding. The PBL Model has been proven to improve self-study skills and provides a more realistic picture of higher academic challenges, more confidence, improves problem-solving skills, critical thinking skills, and improved communication skills (Benade, 2017, Leong, 2017; Myers, 2017; Zabit, 2010). However, the weakness of the PBL Model is the lack of initiation and timing, lack of student discipline, and more challenging authentic issues (Ates & Eryilmaz, 2010; Thompson et al., 2012). The findings of this research are supported by questionnaire results of the responses from pre-service physics teachers that are presented in Table 6. The data in Table 6 shows that in general the students of pre-service physics teacher give positive responses to the teaching instruments of the OR-IPA Model. While the result of questionnaire response of pre-service physics teacher toward the teaching instruments and Conventional Model generally shows less positive response. The findings are supported by other research that the Conventional Model is less facilitating students in developing their critical thinking skills, so according to Hammond et al (2015) and Mann & Kaitell (2001) this resulted in low learning achievement. The student response data in Table 6 reinforces that the OR-IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model to increase the critical thinking skills of pre-service physics teacher.

The results of previous studies conducted at the State Junior High School in Jember, Indonesia showed that the OR-IPA Model and PBL Model with implemented teaching instruments can significantly improve teaching outcomes with moderate N-gain (Rosyid, Budi, & Supardi, 2013). The OR-IPA Model is a teaching model that has 5 (five) syntaxes and is designed specifically to improve the weakness of the PBL Model in improving student critical thinking skills. The OR-IPA Model is a problem-based teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Therefore, the OR-IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model in improving the critical thinking skills of pre-service physics teachers.

Conclusions

Based on the results of this research and discussion described above, it can be concluded as follows: (1) The teaching instruments of OR-IPA Model and PBL Model to improve the critical thinking skills of pre-service physics teachers has been prepared, including: Semester Teaching Plan, Lesson Plan, Student Learning Materials, Student Worksheet, and Critical Thinking Skills Tests of pre-service physics teacher. The Critical Thinking Skills Tests of pre-service physics teachers have fulfilled the validity requirements ($r_\alpha \sim .26$) and reliability ($\alpha = .96 - .99$) the content and construct can be implemented in the teaching process; (2) Teaching process by using OR-IPA Model and PBL Model is effective, as indicated by: (a) there was a significant increase in critical thinking skills of pre-service physics teachers at $\alpha = 5\%$; (b) the average N-gain of physics teaching by using OR-IPA Model and PBL Model are categorized as: moderate (.60) and moderate (.48); and (c) students' responses in each teaching process were categorized as very positive (89%). Meanwhile, physics teaching process by using the Conventional Model was ineffective, as indicated by: (a) there was a significant increase in students' critical thinking skills at $\alpha = 5\%$, (b) low N-gain (.14) and student responses were less positive (26%); and (3) There is significant difference in mean of critical thinking skills N-gain in Group-1 that is the OR-IPA Model with Group-2 that is PBL Model, Group-1 that is the OR-IPA Model with Group-3 that is Conventional Model; Group-2 that is PBL Model with Group-3 that is Conventional Model, for each at $\alpha = 5\%$. Physics teaching process with OR-IPA Model is more effective in improving student critical thinking skills when compared to PBL Model and Conventional Model. The average N-gain of critical thinking skills of pre-service physics teachers was higher after teaching process with the OR-IPA Model when compared to PBL Model and Conventional Model.

Implication of this research is that the OR-IPA Model can be an innovative solution to improve critical thinking skills, but there is still a need for repetitive research like this.

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Appendix

CRITICAL THINKING SKILL TEST
BASIC PHYSICS I

Maximum Time: 3 x 50 minutes.

1. Suppose you are a high school Physics teacher should buy just one long measuring instrument to teach your students how to measure book thickness (± 70.0 mm). Meanwhile, there are two options: ruler and sliding term. Based on the advantages and disadvantages of each gauge, which measuring tool would you buy? Give reasons!

2. There are several length measuring instruments as shown in Figure 1, namely: screw micrometer, slider term, and ruler, one wants to measure the "inner diameter" of a pipe that is approximately 50.0 mm. Which measuring tool is the most accurate for that purpose? Give your arguments!

Screw micrometer | Slider term | Ruler

Figure 1: length measuring tool

3. Suppose you are a physics teacher who are assigning your three students; each of your students is asked to measure the depth of a ± 80.0 mm pipe with a very small diameter, ± 10.0 mm in a measurement laboratory. Within several minutes later, your students get back and say that they are not successful in measuring the depth of the pipe even though the laboratory has a measuring instrument. What is your conclusion about the length measurement problem? Give your reasons!

4. Two cars move straight in the opposite direction as shown in Figure 2. Car I has a speed of 72.0 km / h to the south. After 4 minutes then car II departs with speed 80.0 km / h to the north. If the distance between the two cars is 20.0 km, what will happen after the car I run for 10.0 minutes? Give your reasons!

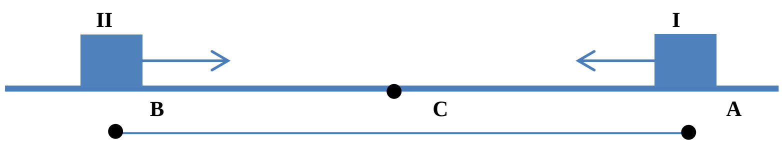

Figure 2: Two cars move straight in the opposite direction

5. An eagle perched on tree limb 19.5 m above the water spots a fish swimming near the surface. The eagle pushed off from the branch and descends toward the water. By adjusting its body in flight, the eagle maintains a constant speed of 3.1 m/s at an angle of 20.0^0 below the horizontal. After 17.0 s flew from the branch into the water, did the eagle catch the fish? Give your arguments!

6 Figure 3 shows position - time graphs for Joszi and Heike paddling canons in a local river; (a) Interpret the position of Joszi against Heike after Heike moves: 0.5 h, 1 h and 1.5 h, (b) What is your conclusion about the rate of the canons.

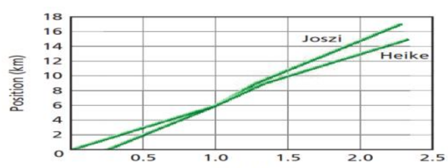

Figure 3: Potition - time graphs for Joszi and Heike
(Source: Zitzewitz, et al. 2005)

7. The archerfish hunts by dislodging an unsuspecting insect from its resting place with a stream of water expelled from the fish's mouth (Figure 4). Suppose the archerfish squirts water with an initial speed of 2.3 m/s at an angle of 19.5^0 above the horizontal. When the stream of water reaches a beetle on a leaf at height 30.0 mm above the water's surface will water wet the beetle's body? Give your reasons!

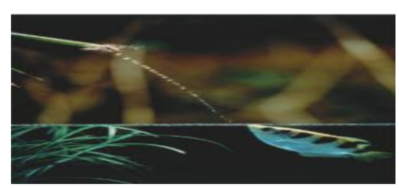

Figure 4: The archerfish hunts by dislodging an unsuspecting insect
(Source: Zitzewitz, et al. 2005)

8. A park ranger driving on a back country road suddenly sees a deer "frozen" in the headlights. The ranger, who is driving at 11.4 m/s, immediately applies the breaks and slows with an acceleration of 3.8 m/s^2. If the dear is 20.0 m from the ranger's vehicle when the breaks are applied, what will happen with the ranger's vehicle? Give your reasons!

9. Observation at the rate of a running car produces graph in Figure 5. Based on the graph, interpret when is the car accelerated and how fast is the car after traveling 30.0 km? Give your reasons!

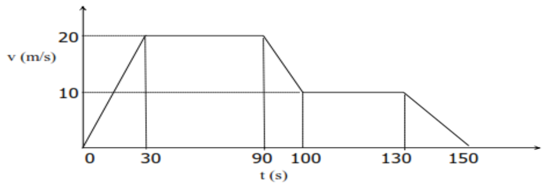

Figure 5: Graph of time - rate for a moving car
(Source: Santoso, 2004)

10. A roadway is banked at proper angle, a car can round a corner without any assistance from friction between the tires and the road. If the angle of the road bend is 26.7°, is the 900-kg car traveling at 20.5 m / s in a turn of the radius of 85.0 m crossing the bend will be safe? Give your reasons!

11. How would you interpret the sprinter's velocity and acceleration as shown in the graph in Figure 6? Give your reasons!

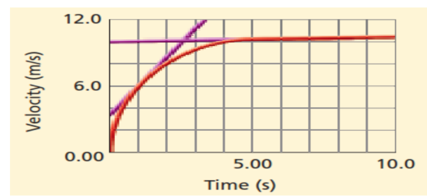

Figure 6: Sprinter's velocity and acceleration
Source: Zitzewitz, et al. 2005

12. A 1200.0 kg car rounds a corner of radius r = 45.0 m. The coefficient of static friction between the tires and the road is 0.8, what can the car run in corner without skidding? Give your reasons!

13. While driving along a country lane with a constant speed of 17.0 m/s, you encounter a dip in the road (Figure 7). The dip can be approximated as a circular arc, with a radius of 65.0 m. If the car seat is only able to withstand 1000.0 N loads, will the car seat be damaged when a mass of 80.0 kg sits in the car seat while the car is at the bottom of the dip as the car's position on the image? Give your reasons!

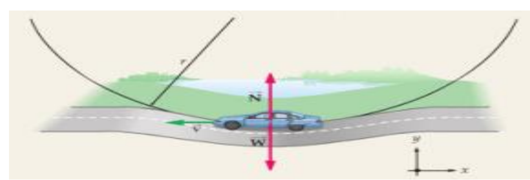

Figure 7: A car crosses the road on a decreasing radius with a radius of 65.0 m depth
(Source: Zitzewitz, et al. 2005)

14. Two youngsters dive off an overhang into a lake. Diver 1 drops straight down, Diver 2 runs off the cliff with an initial horizontal speed v_0. Evaluate the splashdown speed of Diver 2, is **(a)** greater than, **(b)** less than, or **(c)** equal to the splashdown speed of Diver I? Give your arguments!

15. If the height *h* is increased the previous example but the width *w* remains the same, Evaluate the minimum speed needed to cross the crevasse, does it **(a)** increase, **(b)** decrease, **(c)** or stay the same? Give your arguments!

16. From the data indicates that many vehicles are slip when passing a bend in a particular place, what is your conclusion about the path? Give your arguments!

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THE COMPARISON OF OR-IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILLS OF PRE-SERVICE PHYSICS TEACHERS

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Abstract. *Critical thinking skills are one of the 21st century skills that are effectively trained by using the OR-IPA and Problem Based Learning (PBL) Model, therefore this research aims to compare the effectiveness of both. Research design used True Experiment with Randomized Subject Control-group Pre-test and Post-test with 94 pre-service physics teachers. Data collected using the critical thinking skills test and the student response sheet, and then analyzed using t-test and N-gain. The results showed: (1) the teaching instruments of OR-IPA and PBL Model have fulfilled the validity requirements ($r_\alpha \sim .26$) and reliability ($\alpha = .96$ - $.99$). (2) Each of OR-IPA, PBL, and Conventional Model can significantly increase critical thinking skills at α = 5%, respectively with average N-gain: medium (.60), medium (.48), and low (.14); with the student response of: very positive, very positive, and less positive. (3) The OR-IPA and PBL Model are effective to improve critical thinking skills, while the Conventional Model is ineffective, and the OR-IPA Model is more effective compared to the PBL Model. Implication of this research is that the OR-IPA Model can be an innovative solution to improve critical thinking skills, but there is still a need for repetitive research like this.*
Keywords: *basic physics, critical thinking skills, OR-IPA model, pre-service physics teachers, and PBL model.*

Introduction

In this 21st century, education has an important role in producing Human Resources (HR) that has the needed skills to work. Meanwhile, the demands of the curriculum and the development of globalization era require educational institutions to do beneficial innovations for the 21st century skills-based educational world (Griffin & Care, 2015; Turiman, Omar, Daud, & Osman, 2012). Permendikbud No.73 of 2013 on the Indonesian National Qualification Framework in the field of higher education requires universities to prepare curriculum for pre-service physics teacher to have superior competence with various skills that are in line with 21st century demands, among them are: critical thinking skills, skills to utilize Information and Communication Technology (ICT), and skills to solve problems (Griffin & Care, 2015; Jatmiko, Widodo, Martini, Budiyanto, Wicaksono, & Pandiangan, 2016; Kemdikbud, 2013; Pandiangan, Sanjaya, & Jatmiko, 2017). The 21st century educational process requires human resources with competence and the achievement of pre-service physics teachers are directed to skills and learning innovations, among others are: Critical thinking skills, problem solving skills, decision making, creative thinking, responsibility, and ability to learn independently (Griffin & Care, 2015; Pandiangan, Sanjaya, & Jatmiko, 2017; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018).

The development of critical thinking skills is considered as one of the most important goals of education for over a century (Forawi, Almekhlafi, & Al-Mekhlafy, 2012; Geertsen, 2003). Critical thinking has been defined and measured in a number of ways, but it usually involves an individual's ability to identify central issues and assumptions in arguments, recognize important relationships (Mason, 2017, Moon, 2007), make correct conclusions from data, infer provided information or data, interpret whether the conclusion is guaranteed or not based on the data provided (Facione, 2013; Mulnix, 2012). Furthermore, previous researchers explain that critical thinking is cognitive skills, it includes activities of interpretation, analysis, evaluation, inference, explanation, and self-management in problem solving (Bean, 2011; Cheong & Cheung, 2008, Dam & Volman, 2004; Ennis, 2011; Ernst & Monroe 2004; Jenicek, 2006; Marin & Halpern, 2011; Miri, David & Uri 2007; Mundilarto & Ismoyo, 2017; Popil, 2011; Siew & Mapeala, 2016; Snyder & Snyder, 2008; Womack & Jones, 2010). In this research, critical thinking skills is a cognitive process which is carried out as a thinking guide by using reason judgments against evidence, context, standard, method, and conceptual structure by performing concepts, application, synthesis and information obtained from observation, experience, reflection, thinking, or communication as a basis for believing and doing an action and focusing on what to do. The critical thinking skills' indicators in this research are analysis, evaluation, interpretation, and inference based on the results of literature research and preliminary study by the investigator, these indicators are still low and need to be accelerated in pre-service physics teachers.

In connection with the improvement of the teaching process and outcomes quality mentioned above, there are important problems faced by the world of education today, which is how to strive pre-service physics teachers' critical thinking skills through teaching (Krulik & Rudnick, 1996; Marzano, 1993). This needs to be done because there are many students who do not have critical thinking skills (Brookfield, 2017). Critical thinking skills are important thinking skills and should be taught, but there are still many lecturers who do not understand how to teach critical thinking skills. The results of Patrick's, Fallon, Campbell, Cretchley, Devenish, & Tayebjee (2014) and Pithers & Soden (2000) showed that critical thinking skills should be taught, but there are still some lecturers who do not know how to teach critical thinking skills effectively (Brownlee, Walker, Lennox, Exley, & Pearce, 2009; McPeck, 2016).

Martin, Mullis, Foy, & Stanco (2012) showed that most of Indonesian students are only able to recognize a number of basic facts and have not been able to communicate and relate various topics of science, especially in applying complex and abstract concepts. This fact is in line with the results of Rosyid, Jatmiko, & Supardi (2013) research, which indicated that the physics teaching process is still and more emphasized on the process of knowledge transfer, so it has not been able to make students able to construct knowledge. The low critical thinking skills of pre-service physics teachers are suspected to have something to do with the teaching process being implemented (Browne, & Meuti, 1999; Staib, 2003; Wlodkowski, & Ginsberg, 2017). The implemented teaching model, which is the Conventional Teaching Model (i.e. Conventional Model) cannot facilitate in developing students' critical thinking skills, resulting in low learning achievement (Hammond, Barron, Pearson, Schoenfeld, Stage, Zimmerman, & Tilson, 2015; Mann & Kaitell, 2001). Therefore, to improve the quality and facilitate the development of pre-service physics teachers, it is necessary to find out alternative solutions. The alternative solutions include implementing the OR-IPA Teaching Model (i.e. OR-IPA Model) and Problem Based Learning Model (i.e. PBL Model). The results of previous research conducted by Rosyid, Budi, & Supardi (2013) showed that OR-IPA Model and PBL Model with supporting teaching instruments can improve high school students' learning outcomes in Kabupaten Jember, East Java significantly at $\alpha = 5\%$ with moderate N-gain.

The OR-IPA Model is a problem-based teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Multi-representation teaching can stimulate students to perform analysis, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This was also applied to Ainsworth's (2008, 1999) and Ciais, Reichstein, Viovy, Granier, Ogée, Allard & Carrara (2005) studies which suggested that multi-representation learning has three main functions: complementary, interpretive, and can build a more comprehensive understanding. In this research, the OR-IPA Model has five syntaxes, namely: (1) **O**rientation of Problem, (2) **R**epresentation of Problem, (3) **I**nvestigation, (4) **P**resentation, (5) **A**nalysis, Evaluation and Follow-up (Rosyid, Budi, & Supardi, 2013). The interactive tasks in applying this OR-IPA Model to grow up the ability of critical thinking skills are referred to the phases in the syntax, namely: (1) **O**rientation of Problem, which is aimed to attract the students, focus the students, and motivate them to take an active role in the teaching process; (2) **R**epresentation of Problem, which is aimed to assist students in understanding the material and solving the problems that will be discussed through various approaches that can be adapted to the objectives of teaching and the presented material characteristics; (3) **I**nvestigation, which is aimed to collect information with the help of Student Worksheet, then the lecturer guides to carry out step-by-step investigations, explores the explanation, and solutions to build the critical thinking skills which includes (a) formulating the problem; (b) formulating the hypothesis; (c) identifying variables; (d) writing the operational variables definition; (e) writing down the experimental tools and materials; (f) conducting experiments; (g) organizing experiment data; (h) analyzing experimental data; and (i) making a conclusion; (4) **P**resentation, which is aimed to guide students in making conclusions and discussion of the investigation results in various representations, and assisting in the planning, preparing and presenting the works; and (5) **A**nalysis, Evaluation and Follow-up, which is aimed to analyze and evaluate the problem-solving process of inquiry and process in various forms of representation, observe the students' work as the learning evidence, and facilitate follow-up learning through the assignment of structured tasks.

The PBL Model has five syntaxes, namely: directing students to problems, organizing students to learn, helping independent and group investigations, developing and presenting artifacts and exhibits, and analyzing and evaluating problem-solving processes (Arends, 2012). Characteristics of the PBL Model are designed to help students improving their inquiry skills and problem-solving skills, social behavior and skills according to the role of adults, as well as independent learning skills for the investigation of everyday life issues (Arends, 2012; Arizaga, Bahar, Maker, Zimmerman, & Pease, 2016; Nilson, 2016). The PBL Model begins with a complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a suitable learning environment for students (Caesar, Jawawi, Matzin, R., Shahrill, Jaidin, & Mundia, 2016; Nuninger & Châtelet, 2017). The PBL Model also regulates a student-centered learning environment that is not viewed as an empty vessel but is capable to bring its own distinct framework and learning (Chakravarthi, 2010; Efendioglu, 2015). The PBL Model can enhance self-study skills and provide a more realistic picture of higher academic challenges, more confidence, better problem-solving skills, critical thinking skills, and provide the improvement of communication skills (Malan, Ndlovu, & Engelbrecht, 2014; Méllesis & Hurren, 2011; Williams, 2005). The application of PBL Model will promote students to have motivation, confidence in learning and able to improve students' ability to solve more complex problems (Caesar et al., 2016; Nilson, 2016; Sern, Salleh, Mohamad, & Yunos, 2015; Tracey & Morrow, 2017). However, the PBL Model is still weak in terms of inquiry orientation components, alternative solutions, and difficult in formulating problems and preparing hypotheses (Ates & Eryilmaz, 2010; Chakravarthi, 2010). Although the research shows that the PBL Model supports self-study and communication skills, critical skills improvement, creative thinking skills and problem-solving skills (Ates & Eryilmaz, 2010; Malan, Ndlovu, & Engelbrecht, 2014; Prahani, Nur, Yuanita, & Limatahu, 2016), however PBL's weaknesses are lack of initiation and timing, lack of student discipline, and more challenging authentic issues are needed (Ates & Eryilmaz, 2010; Thompson, McInerney, Manning, Mapukata-Sondzaba, Chipamaunga, & Maswanganyi, 2012).

The State University of Surabaya (Unesa) as an institution of higher education has facilitated its lecturers with various teaching models that can be integrated with information and communication technology. However, the reality shows that there are still many lecturers who have not conducted the lesson by utilizing the facilities to provide learning experiences for pre-service physics teachers. Most of the lecturer facilities provided by Unesa are only used as teaching tools and have not been utilized to produce teaching models. The teaching models gained through a series of research are less useful and ineffective because they have not been optimally utilized by lecturers at Unesa as it is in other higher education institutions, lecturers should be responsible for developing models, strategies, approaches, methods or instructional techniques in the era of the 21st century (Huba & Freed, 2000; Richards & Rodgers, 2014). OR-IPA Model and PBL Model are very useful to improve lecturers' competence in teaching. This is because the teaching becomes more interesting, more challenging, and better suited to the needs of students. The results of previous research indicate that the OR-IPA Model and PBL Model are effective and practical in improving critical thinking skills of Senior High School students in Jember Regency (Rosyid, Jatmiko, & Supardi, 2013).

Referring to the effectiveness of OR-IPA Model and PBL Model in improving the students' critical thinking skills, it needs to be reviewed and tested for further consistency in improving the critical thinking skills of pre-service physics teacher from Unesa. This research is very important in order to develop models and learning theories that are able to answer the challenges and skills needs in the 21st century. The low critical thinking skills are theoretically caused, among other things, by: poor motivation and responsibility, poor analytical skills, and less discipline in teach (Adebayo, 2014). This is also due to the lack of ability to organize time, lazy to learn, and less supportive learning environment (Chakravarthi, 2010; Eaton, 2015). Therefore, it is necessary to compare the effectiveness between OR-IPA Model and PBL Model in improving student critical thinking skills. In order to be able to compare the effectiveness of the two models, then the preparation of teaching instruction of OR-IPA Model and PBL Model was done firstly which is designed to be able to increase critical thinking skills of pre-service physics teachers.

Problem of Research

The problem of this research is how to analyze the effectiveness of teaching in the basic physics course with the OR-IPA Model and PBL Model to get more effective teaching model to improve the critical thinking skills of pre-service physics teacher. In addition, also how to get examples of teaching instruments that are valid and reliable with an effective teaching model in improving the critical thinking skills of pre-service physics teachers. In detail, the focuses of this research were: (1) how is the validity and reliability of teaching instruments in basic physics course with OR-IPA Model and PBL Model to improve the critical thinking skills of pre-service physics teachers, which includes: Semester Teaching Plan, Lesson Plan, Student Teaching Materials, Student Worksheet, and Student Critical Thinking Skills Test of pre-service physics teachers? (2) how is the effectiveness of teaching process with OR-IPA Model, PBL Model, and Conventional Model in improving the critical thinking skills of pre-service physics teachers? and (3) which teaching model is the most effective to improve the critical thinking skills of pre-service physics teachers?

Research Focus

During this time, the way to get the student's critical thinking skills is done by teaching with PBL Model, but the previous research conducted on senior high school students in Jember, Indonesia by using teaching with OR-IPA Model, which is a correction of the PBL Model to improve students' critical thinking skills showed results that are also effective and practical (can be applied). On the other hand, many students do not have critical thinking skills, so there are many lecturers who still do not understand how to teach critical thinking skills effectively to the pre-service physics teachers. The focus of this research was to compare the effectiveness of teaching in basic physics courses with OR-IPA Model and PBL Model in improving the critical thinking skills of pre-service physics teacher. This research used control variables; it was the Conventional Model.

Methodology of Research

General Background

This research was conducted at State University of Surabaya in June - December 2017. The scope of this research is the first-year students who took Basic Physics course in academic year 2017/2018. This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design. This research is emphasized on the analysis of the OR-IPA Model, PBL Model, and Conventional Model effectiveness by analyzing the increase of critical thinking skills of pre-service physics teachers before and after following the process of physics teaching with CRBT model. The Conventional Model in this research was lecturer-centered teaching model, which includes lecture, presentation, and discussion. The teaching instruments and research instruments are said to be valid if $r_\alpha > r$ table and invalid if $r_\alpha \leq r$ table. Physics teaching process with OR-IPA Model, PBL Model, and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skills of pre-service physics teachers at $\alpha = 5\%$, (2) the minimum N-gain is categorized as moderate, and (3) students' responses are at least positive.

Sample

The research was conducted to 94 students of Physics Education Study Program, Unesa, Indonesia, which came from a population of 123 students in three groups (experimental group-1 / OR-IPA Model, experimental group-2 / PBL Model, and control group / Conventional Model). The calculation of the sample number was based on the Slovin formula, that was the sample = [population / (1 + e^2 × population)] with error tolerance e = 5% (Sevilla, Ochave, Regala, & Uriarte, 1984; Tejada, & Punzalan, 2012). This research took three groups, namely: group of: experiment group-1 came to 31 students; experiment group-2 came to 30 students; and control group came to 33 students, each of them was statistically in the same level of critical thinking skills.

Instrument and Procedures

This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design (Fraenkel, Wallen, & Hyun, 2012).

O_1	X_1	O_2
O_1	X_2	O_2
O_1	C	O_2

With: O_1: Pre-test score, O_2: Post-test score, X_1: OR-IPA Model, X_2: PBL Model and C: Conventional Model

Prior to the research, firstly the researchers set up teaching instruments that covered these components: (1) Semester Teaching Plan, (2) Lesson Plan, (3) Student Teaching Materials, (4) Student Worksheet, and (5) Critical Thinking Skills Test of pre-service physics teacher, respectively for the OR-IPA Model and PBL Model. The data were collected by using the research instruments, which consisted of the following components: (1) Teaching Model Implementation Sheet and (2) Student Response Sheet. The validity of those teaching instruments from both OR-IPA Model and PBL Model was then assessed by the physics education experts in terms of the content and construct. In order for the teaching instruments to be able to be implemented, the leaning instruments have to meet the valid and reliable requirements.

The research began by giving the critical thinking skills pre-test (O_1) by using the critical thinking skills test of pre-service physics teacher to each group of students, then providing teaching with different models, namely: OR-IPA Model, PBL Model, and Conventional Model. Finally, after the entire teaching process has been completed, all groups of students are awarded a post-test (O_2) of the critical thinking skills with the same materials and problems as in the pre-test.

Data Analysis

In order to get the validity of contents and construct for the teaching instruments of the OR-IPA Model and PBL Model as well as the research instrument, the assessment of those instruments was done by the physics education expert based on the content and construct validity. Content validity is a description of needs and novelty, while construct validity is a description of the consistency of teaching instruments of OR-IPA Model and PBL Model with theory/empirical and consistency between the instrument components (Plomp, 2013). The data was analyzed by reliability test; each of them was analyzed by using Cohen's Kappa, single measure interrater coefficient correlation (r_α) and Cronbach's alpha (α). The teaching instruments and research instruments are said to be valid if $r_\alpha > r_{table}$ and invalid if $r_\alpha \leq r_{table}$. Meanwhile, the teaching instruments and research instruments are said to be reliable if $.6 \leq \alpha \leq 1.0$ and not reliable if $\alpha < .6$. In order to analyze physics teaching with a more effective teaching model, an "effective" operational definition is required. Physics teaching process with OR-IPA Model, PBL Model and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skills of pre-service physics teachers at $\alpha = 5\%$, (2) the average N-gain at least in moderate category, and (3) students' responses are at least positive. In this research, the pre-test and post-test results were analyzed as follows: when the normality assumption for the achieved score is fulfilled, the Paired t-test will be applied. If it is not fulfilling, non-parametric analysis will be used. In order to get increasing level of student's critical thinking skills score, the calculation was done by using N-gain with equation: N-gain = (Post-test score - Pre-test) / (maximum score - Pre-test) (Hake, 1998). By the criteria of: (1) N-gain > .70 (height); (2) .30 < N-gain < .70 (medium); and (3) N-gain < .30 (low). In order to test whether the improvements on students' critical thinking skills existed or not with the OR-IPA Model, PBL Model, and Conventional Model, Paired t-test against the pre-test score and post-test by using IBM SPSS Statistic 16 software was done. Meanwhile, to get more effective model in improving students' critical thinking skills after being given lessons, researchers compared the effectiveness of the three models by using Independent t-test. In order to see the responses of pre-service physics teachers toward teaching with OR-IPA Model, PBL Model, and Conventional Model, student responses data was analyzed by using qualitative descriptive (Prahani, Winata, & Yuanita, 2015; Riduwan, 2010). With the criteria of: (1) Response ≥ 75% (very positive); (2) 50% ≤ Response < 75% (positive); (3) 25% ≤ Response < 50% (less positive); and (4) Response < 25% (not positive).

Results of Research

Validity of Teaching Instruments and Research Instruments of OR-IPA Model and PBL Model

Before the research is done, teaching instruments and research instruments that have been compiled must meet the requirements of validity and reliability. The validity of teaching instruments of OR-IPA Model and PBL Model, and research instruments were assessed by two physicists of Unesa. The results of the validity assessment of the teaching instruments and research instruments for OR-IPA Model and PBL Model, respectively, are shown in Table 1 and Table 2.

Table 1. The result of teaching instruments and research instruments validity of OR-IPA model.

Components	The Validity of OR-IPA Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	Cohen's kappa	R	r_α	V	α	R
Semester Teaching Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.99	Reliable
Lesson Plan	.87	Reliable	.25	Valid	.97	Reliable	.87	Reliable	.25	Valid	.97	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.96	Reliable	.25	Valid	.99	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.96	Reliable	.25	Valid	.98	Reliable
Critical Thinking Skills Test of Pre-Service Physics Teacher	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes:
r_α = *Single measure interrater coefficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Table 2. The validity of PBL model instruments.

Components	The Validity of PBL Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	*Cohen's kappa*	R	r_α	V	α	R
Semester Teaching Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Lesson Plan	.86	Reliable	.25	Valid	.96	Reliable	.86	Reliable	.25	Valid	.96	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.95	Reliable	.25	Valid	.96	Reliable
Critical Thinking Skills	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Components	The Validity of PBL Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_{α}	V	α	R	*Cohen's kappa*	R	r_{α}	V	α	R
Test of Pre-Service Physics Teacher Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes: r_{α} = *Single measure interrater coefficient correlation;* α = *Cronbach's alpha; R: Reliability; V: Validity*

Table 1 shows that the construct validity of the OR-IPA Model instruments includes: Semester Teaching Plan; Lesson Plan; Students Worksheet; Student Teaching Materials; Critical Thinking Skills Test of pre-service physics teachers, and the research instruments, which includes: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the OR-IPA Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skills; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skills need to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the teaching instruments of the OR-IPA Model in order to be implemented.

Table 2 shows that the construct validity of the PBL Model instruments includes: Semester Teaching Plan; Lesson Plan; Students Activity Sheet; Student Teaching Materials; Student Critical Thinking Skills Test of pre-service physics teacher, and the research instruments, which include: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the PBL Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skills; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skills need to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the teaching instruments of the PBL Model in order to be implemented.

Based on the above description, it can be said that the teaching instruments of OR-IPA Model and PBL Model have fulfilled the content and construct validity requirements to improve the critical thinking of pre-service physics teacher. The teaching instruments of OR-IPA Model and PBL Model can be implemented in the teaching process of basic physics courses.

The critical thinking skills score and N-gain of pre-service physics teachers were obtained by providing the pre-test and post-test of the critical thinking skills. The detailed score of pre-test, post-test, and N-gain of pre-service physics teachers in the OR-IPA Model, PBL Model, and Conventional Model are shown in Figure 1. While the critical thinking skills indicators of group-1: OR-IPA Model, group-2: PBL Model and group-3: Conventional Model is presented in Table 3. Figure 1 shows that prior to the teaching with OR-IPA Model, PBL Model, and Conventional Model, pre-service physics teachers have low average of critical thinking skills. After the implementation of OR-IPA Model and PBL Model, pre-service physics teachers have an increase in the average of critical thinking skills, but in Conventional Model, all pre-service physics teachers still have average of critical thinking skills in low category. In general, the average of critical thinking skills for pre-service physics teachers in post-test with OR-IPA Model, PBL Model, and Conventional Model is in high category (2.67); Medium (2.14); and low (1.00) and the score ranged from 1 - 4. The average N-gain of critical thinking skills owned by pre-service physics teachers for teaching by using OR-IPA Model, PBL Model, and Conventional Model, is in the category of moderate (.63); moderate (.47); and low (.14), from the score range of 0 - 1.

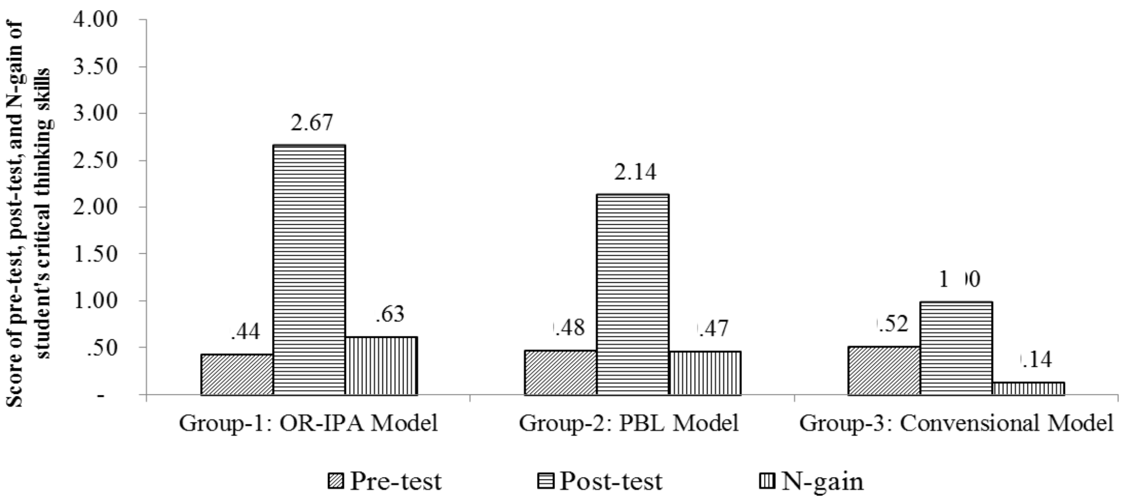

Figure 1: The score of pre-test, post-test, and N-gain of critical thinking skills owned by pre-service physics teachers with OR-IPA model, PBL model, and Conventional Model.

Figure 1 indicates that in order to increase the critical thinking skills of pre-service physics teachers; the OR-IPA Model is better compared to the PBL Model and Conventional Model. While the PBL Model is better when compared to the Conventional Model.

Table 3. The critical thinking skills indicator of group-1: OR-IPA model, group-2: PBL model, and group-3: conventional model.

Group	Score	Indicators of Critical Thinking Skills			
		Analysis	Evaluation	Interpretation	Inference
Group-1: OR-IPA Model	Pre-test	.45	.31	.52	.45
	Post-test	2.91	2.47	3.00	1.96
	N-gain	.69	.59	.71	.43

Group	Score	Indicators of Critical Thinking Skills			
		Analysis	**Evaluation**	**Interpretation**	**Inference**
Group-2: PBL Model	Pre-test	.59	.39	.82	.13
	Post-test	2.36	2.24	2.59	1.39
	N-gain	.52	.51	.56	.33
Group-3: Conventional Model	Pre-test	.49	.32	.71	.58
	Post-test	1.09	.69	1.29	.93
	N-gain	.17	.10	.18	.10

Table 3 shows that the results of critical thinking skills pre-test of pre-service physics teachers for all critical thinking skills indicators were in the low category, whereas after the implementation of teaching with OR-IPA Model, all the critical thinking skills indicators have increased. In general, the average N-gain for critical thinking skills indicator with OR-IPA Model was in medium and high category, with the value was above .43. The result of critical thinking skills pre-test of pre-service physics teachers for all indicators was in low category, while after implementation of teaching with PBL Model, all critical thinking skills indicators have increased. In general, the average N-gain of critical thinking skills indicator with PBL Model was in medium and high category with the value above .33. The result of critical thinking skills pre-test of the pre-service physics teacher for all critical thinking skills indicators was in low category, while after the implementation of teaching with Conventional Model, all critical thinking skills indicators remain in low category. In general, the average N-gain of critical thinking skills indicators with Conventional Model was in low category with value above .10. Meanwhile, the lowest indicator of critical thinking skills in all groups was inference.

Paired T-test of Critical Thinking Skills Owned by Physics Teachers Candidates with OR-IPA Model, PBL Model, and Conventional Model

The existence of critical thinking skills increase in the pre-service physics teachers is measured by testing the average score of Pre-test and the Post-test score by using Paired t-test. Paired t-test is used (for parametric statistical test) because it has fulfilled the requirements: (1) Pre-test score and Post-test data of critical thinking skills of pre-service physics teacher come from normal distributed population, conducted by normality test (Shapiro-Wilk); and (2) the average of Pre-test and Post-test score data is homogeneous when tested by using the two-variance equality test. Paired t-test for the average score of Pre-test and Post-test of critical thinking skills conducted on Group-1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of Paired t-test against Pre-test and Post-test score of critical thinking skills of pre-service physics teachers are presented in Table 4.

Table 4. The results of paired t-test of critical thinking skills owned by pre-service physics teachers in all groups.

Group	N	*Paired t-test*				
		Mean	**Std. error mean**	**t**	**df**	**p**
Group-1: OR-IPA Model	31	-2.25	.13	-17.95	30	< .01
Group-2: PBL Model	30	-1.66	.08	-19.83	29	< .01
Group-3: Conventional Model	33	- .48	.05	-9.24	32	< .01

Table 4 shows that the mean scores of critical thinking skills for groups 1, 2 and 3 respectively for: OR-IPA Model, PBL, and Conventional Teaching Model are -2.25; -1.66; and - .48 with degrees of freedom (df) are 30; 29; 32 and giving t value of -17.95; -19.83; and -9.24. The result of Paired t-test for each group is significant, because $p < .05$. Therefore, t counts the negative value, then clearly there is a significant difference at $\alpha = 5\%$ between the pre-test score with the critical thinking skills Post-test in all groups. For teaching with the OR-IPA Model, PBL Model, and Conventional Model, all of them show higher post-test score compared to the pre-test score, or the mean scores of critical thinking skills of pre-service physics teachers after each teaching process with the OR-IPA Model, PBL Model, and Conventional Model are higher than before.

Independent T-test of Critical Thinking Skills Owned by Pre-Service Physics Teachers with OR-IPA Model, PBL, and Conventional Model

In order to analyze which model is more effective in increasing the critical thinking skills of pre-service physics teachers among Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model, among others, is done by testing the average N-gain of the critical thinking skills by using Independent t-test. Independent t-test is used (for parametric statistical tests) because it meets the requirements of: (1) the average N-gain of critical thinking skills of pre-service physics teachers (Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model) are derived from normally distributed populations, performed by normality test (Shapiro-Wilk); and (2) the average N-gain of critical thinking skills of pre-service physics teachers (Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model) is homogeneous when measured by using multiple-variance test equations. Independent t-test for the average N-gain was performed on Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. Independent t-test results on the average N-gain for all groups are presented in Table 5.

Table 5. Independent t-test results on the average N-gain for all groups.

Group	N	*Independent t-test*				
		Mean Difference	**Std. error mean**	**t**	**df**	**p**
Group 1: OR-IPA Model Group 2: PBL Model	61	.15	.04	3.58	59	< .01
Group 1: OR-IPA Model Group 3: Conventional Model	64	.49	.04	12.5	62	< .01
Group 2: PBL Model Group 3: Conventional Model	63	.34	.03	12.51	61	< .01

Table 5 shows that the mean difference of N-gain of critical thinking skills for groups: 1-2, 1-3, and 2-3 is .15; .49; .34 and respectively have degrees of freedom (df) = 59; 62; 61, gives a value of t = 3.58; 12.50; and 12.51. The score is significant, because $p < .05$. Therefore, $p < .05$, it is clear that there is significant difference in mean of critical thinking skills N-gain in Group-1 that is the OR-IPA Model with Group-2 that is PBL Model, Group-1 that is the OR-IPA Model with Group-3 that is Conventional Model; Group-2 that is PBL Model with Group-3 that is Conventional Model, for each at $\alpha = 5\%$. The results of the above analysis show that the average N-gain of critical thinking skills of pre-service physics teachers was higher after teaching with the OR-IPA Model when compared to PBL Model and Conventional Model. While teaching with PBL Model gave higher average N-gain when compared to the Conventional Model.

The Pre-Service Physics Teachers Response toward the OR-IPA Model, PBL Model, and Conventional Model

The analysis of student's response toward teaching with implemented model is done by giving the Student Response Sheet for pre-service physics teachers after the physics teaching process. The results of the pre-service physics teachers’ responses are presented in Table 6.
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Table 6. The pre-service physics teachers’ response toward the OR-IPA model, PBL model, and Conventional model.

Group	N	Students’ Positive Opinion on the Physics Teaching Process	Category
Group I: OR-IPA Model	31	89 %	Very Positive
Group II: PBL Model	30	89 %	Very Positive
Group III: Conventional Model	33	26 %	Less Positive

Table 6 shows that in general pre-service physics teacher responded very positively to the teaching instruments of the OR-IPA Model and PBL Model. As for the Conventional Model instruments, student responses show less positive.

Discussion

Validity of OR-IPA Model and PBL Model Instruments

The developed teaching instruments’ components include Semester Teaching Plan, Lesson Plan, Student Teaching Materials, Student Worksheet, and Critical Thinking Skills Test of pre-service physics teacher; and the Research Instruments include Teaching Model Implementation Sheet and Student Response Sheet. The assessment of all teaching instruments’ components is done by physics education experts in Unesa and has been declared valid as in Table 1 and Table 2. The implication of the instruments has been declared valid and can be used for the implementation of OR-IPA Model and PBL Model in improving the pre-service physics teachers. In addition, Table 1 and Table 2 also show that all components of the teaching instruments are included reliably, shown by the coefficients of Cohen's Kappa. The result of this validity is supported by the opinion of Plomp (2013) which said that a good product (teaching model) must meet the requirements, namely: validity: the validity of the model can be tested by testing the content and construct validity. Content validity is when there is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge; whereas the validity of constructs (construct validity) is the intervention and is 'logically' designed (Nieveen, McKenney, & Akker, 2007). A valid device (content and construct) has an impact on the improvement of the critical thinking skills owned by the pre-service physics teachers on the significant basic physics material as in Table 3 - 5. The statement is reinforced by the results of research stating that PBL can develop critical thinking skills and analysis and exposes students to exercises to solve problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009). The successful use of this teaching model is determined by the preparation of learning environments and good learning media (Johnson, Rickel, & Lester, 2000) to support each lecturer and student activity (Woolf, 2010) in each stage of the OR-IPA Model and PBL Model syntax. It is a reflection that the developed instruments have been valid and can be implemented to improve the critical thinking skills owned by the pre-service physics teachers.

The individual critical thinking skills score of the pre-service physics teachers is obtained by providing the critical thinking skills test of pre-service physics teachers before the teaching (Pre-test) and after the teaching process is done (Post-test). The data in Figure 1 shows that before the teaching with OR-IPA Model, all students have low critical thinking skills. After the implementation of OR-IPA Model, all students experience increased their critical thinking skills. In general, the critical thinking skills of the pre-service physics teachers in the post-test were in the high category of 2.27 from the range of 1 - 4. The general N-gain scores of pre-service physics teachers with OR-IPA Model were in the medium category of .63. Table 3 shows that all the critical thinking skills indicators in the pre-test are in the low category, whereas after the implementation of teaching with OR-IPA Model, all the critical thinking skills indicators have increased. The general N-gain of critical thinking skills indicators of the OR-IPA Model were in medium and high category with the value was above .43. The results of this research are supported by the work of John Dewey who describes the views of education, with the school as a mirror of the larger society, the class becomes a laboratory for investigation, and solving real-life problems (phase 3). Pedagogy Dewey encourages lecturers to engage students in problem-oriented projects and helps to investigate important social and intellectual issues. Dewey and his followers affirm that teaching in school should be more meaningful, not too abstract (Helterbran, 2010; Loughran, 2013). The vision of purposeful teaching in problem centered is supported by the student's innate desire to explore personal situations for students. The findings of cognitive psychology provide the theoretical foundation for OR-IPA Model. The basic premise in cognitive psychology is that teaching is a process of constructing new knowledge based on current knowledge. Chi, Glaser, & Farr (2014) and Jonassen & Land (2012) assumed that teaching is a constructive process and not an acceptance.

Pre-test, Post-test, and N-gain score of the critical thinking skills owned by pre-service physics teachers in the PBL Model are shown in Figure 1. Based on the data in Figure 1, before the teaching with PBL Model was done, all students have low critical thinking skills. After the implementation of PBL Model, all students' critical thinking skills increase. In general, the pre-service physics teachers gained medium category of 2.14 for their post-test. The general N-gain of pre-service physics teachers by using PBL Model was in the medium category of .47. Table 3 shows that all pre-service physics teachers' pre-test indicators were in the low category, whereas after the implementation of teaching with PBL Model, all the indicators of their critical thinking skills have increased. The general N-gain indicators of critical thinking skills of PBL Model were in medium and high category with value above .33. The results of this research are supported by the characteristics of PBL Model that was designed to assist students in improving the skills of inquiry and problem solving skills, social behavior and skills according to the role of adults, as well as independent learning skills (Arends, 2012: Arizaga, Bahar, Maker, Zimmerman, & Pease , 2016), the PBL Model begins with complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a student-friendly learning environment (Nuninger & Châtelet, 2017), where they acquire complex problem-solving skills in real life and problem situations, student-centered learning environments, and constructivism approaches (Caesar et al., 2016; Chakravarthi, 2010; Kong, Qin, Zhou, Mou, & Gao, 2014). The results of this research are also reinforced by previous research findings that the PBL Model is very useful to improve motivation, self-confidence, self-study skills, creative thinking skills, critical thinking skills, problem-solving skills, assisting in better retention of knowledge and memory skills, and apply meaningful information with real life situations (Ates & Eryilmaz, 2010; Malan, Ndlovu & & Engelbrecht 2014; Myers, 2017; Nilson, 2016).

The pre-test, Post-test, and N-gain scores of the pre-service physics teachers in the Conventional Model are shown in Figure 1. Based on the data in Figure 1, before the teaching process by using the Conventional Model, all students had critical thinking skills in low category. After the implementation of teaching process by using Conventional Model, all students still had critical thinking skills in low category. In general, critical thinking skills of pre-service physics teacher in Post-test were in the medium category of 1.00. The general N-gain for pre-service physics teacher with Conventional Model was in the medium category of .14. Table 3 shows that all critical thinking skills indicators in the pre-test were in low category, whereas after the implementation of teaching with the Conventional Model all critical thinking skills indicators remained in the low category. The general N-gain of critical thinking skills indicators with a Conventional Model was in the low category with values above .10. The low critical thinking skills of pre-service physics teacher are suspected to have something to do with the teaching process that is implemented. The lesson model that is implemented, the Conventional Model is not able to facilitate in developing the critical thinking skills owned by pre-service physics teacher, resulting in low teaching achievement (Hammond et al., 2015; Mann, & Kaitell, 2001).

The result of Paired t-test presented in Table 4 shows that the mean of critical thinking skills for groups 1, 2, and 3 is -2.25; -1.66; - .48. The whole score is significant, because $p <.05$. Since the result of the calculation was negative, it clearly showed that there was a significant difference between the mean of the pre-test score and the post-test score for the critical thinking skills in all groups, the post-test group was higher than the pre-test group. The low critical thinking skills in theory can be caused by: motivation, lack of responsibility, low analytical skills, and lack of discipline in learning (Adebayo, 2014). This can also be due to a lack of ability to organize time, lazy to learn, and less supportive learning environments (Chakravarthi, 2010; Eaton, 2015). The low critical thinking skills of pre-service physics teacher are suspected to have something to do with the teaching process that is implemented. The OR-IPA Model and PBL Model are able to motivate students to investigate and solve problems in real life situations as well as stimulate students to produce a product in improving the critical thinking skills. Problem-based learning can develop critical thinking skills and analysis and expose students to practice solving problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009).

The independent t-test for the average N-gain is performed on Group-1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of the average t-test of the N-gain by using Independent Samples Test is presented in Table 5, shows that the mean difference of critical thinking skills N-gain for groups 1-2, 1-3 groups, and 2-3 groups is .15; .49; .34 and all are significant, because $p < .05$. This clearly indicates that there is a significant difference between the mean N-gain of critical thinking skills in Group-1: OR-IPA Model with Group-2: PBL Model, Group-1: OR-IPA Model with Group-3 Conventional Model; and Group-2: PBL Model with Group-3: Conventional Model. The results of this analysis indicate that the critical thinking skills N-gain of pre-service physics teachers after the teaching process with OR-IPA Model is higher when compared to PBL Model and Conventional Model. The OR-IPA Model is more effective when compared to the PBL Model in improving the critical thinking skills of pre-service physics teachers. The findings are supported by other research that the OR-IPA Model is a multi-representation physics study that can stimulate students in analyzing, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This is also consistent with Ainsworth's research (2008, 1999); Ciais et al. (2005) which stated that multi-representation learning has three main functions, namely: as a complement, interpretation barrier, and build a more comprehensive understanding. The PBL Model has been proven to improve self-study skills and provides a more realistic picture of higher academic challenges, more confidence, improves problem-solving skills, critical thinking skills, and improved communication skills (Benade, 2017, Leong, 2017; Myers, 2017; Zabit, 2010). However, the weakness of the PBL Model is the lack of initiation and timing, lack of student discipline, and more challenging authentic issues (Ates & Eryilmaz, 2010; Thompson et al., 2012). The findings of this research are supported by questionnaire results of the responses from pre-service physics teachers that are presented in Table 6. The data in Table 6 shows that in general the students of pre-service physics teacher give positive responses to the teaching instruments of the OR-IPA Model. While the result of questionnaire response of pre-service physics teacher toward the teaching instruments and Conventional Model generally shows less positive response. The findings are supported by other research that the Conventional Model is less facilitating students in developing their critical thinking skills, so according to Hammond et al (2015) and Mann & Kaitell (2001) this resulted in low learning achievement. The student response data in Table 6 reinforces that the OR-IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model to increase the critical thinking skills of pre-service physics teacher.

The results of previous studies conducted at the State Junior High School in Jember, Indonesia showed that the OR-IPA Model and PBL Model with implemented teaching instruments can significantly improve teaching outcomes with moderate N-gain (Rosyid, Budi, & Supardi, 2013). The OR-IPA Model is a teaching model that has 5 (five) syntaxes and is designed specifically to improve the weakness of the PBL Model in improving student critical thinking skills. The OR-IPA Model is a problem-based teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Therefore, the OR-IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model in improving the critical thinking skills of pre-service physics teachers.

Conclusions

Based on the results of this research and discussion described above, it can be concluded as follows: (1) The teaching instruments of OR-IPA Model and PBL Model to improve the critical thinking skills of pre-service physics teachers has been prepared, including: Semester Teaching Plan, Lesson Plan, Student Learning Materials, Student Worksheet, and Critical Thinking Skills Tests of pre-service physics teacher. The Critical Thinking Skills Tests of pre-service physics teachers have fulfilled the validity requirements ($r_\alpha \sim .26$) and reliability ($\alpha = .96 - .99$) the content and construct can be implemented in the teaching process; (2) Teaching process by using OR-IPA Model and PBL Model is effective, as indicated by: (a) there was a significant increase in critical thinking skills of pre-service physics teachers at $\alpha = 5\%$; (b) the average N-gain of physics teaching by using OR-IPA Model and PBL Model are categorized as: moderate (.60) and moderate (.48); and (c) students' responses in each teaching process were categorized as very positive (89%). Meanwhile, physics teaching process by using the Conventional Model was ineffective, as indicated by: (a) there was a significant increase in students' critical thinking skills at $\alpha = 5\%$, (b) low N-gain (.14) and student responses were less positive (26%); and (3) There is significant difference in mean of critical thinking skills N-gain in Group-1 that is the OR-IPA Model with Group-2 that is PBL Model, Group-1 that is the OR-IPA Model with Group-3 that is Conventional Model; Group-2 that is PBL Model with Group-3 that is Conventional Model, for each at $\alpha = 5\%$. Physics teaching process with OR-IPA Model is more effective in improving student critical thinking skills when compared to PBL Model and Conventional Model. The average N-gain of critical thinking skills of pre-service physics teachers was higher after teaching process with the OR-IPA Model when compared to PBL Model and Conventional Model. Implication of this research is that the OR-IPA

Model can be an innovative solution to improve critical thinking skills, but there is still a need for repetitive research like this.

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Appendix

CRITICAL THINKING SKILLS TEST
BASIC PHYSICS I

Maximum Time: 3 x 50 minutes.

1. Suppose you are a high school physics teacher should buy just one long measuring instrument to teach your students how to measure book thickness (± 70.0 mm). Meanwhile, there are two options: ruler and sliding term. Based on the advantages and disadvantages of each gauge, which measuring tool would you buy? Give reasons!

2. There are several length measuring instruments as shown in Figure 1, namely: screw micrometer, slider term, and ruler. A student wants to measure the "inner diameter" of a pipe that is approximately 50.0 mm. Which measuring tool is the most accurate for that purpose? Give your arguments!

Screw micrometer | Slider term | Ruler

Figure 1: Length measuring tool

3. Suppose you are a physics teacher who are assigning your three students; each of your students is asked to measure the depth of a ± 80.0 mm pipe with a very small diameter, ± 10.0 mm in a measurement laboratory. Within several minutes later, your students get back and say that they are not successful in measuring the depth of the pipe even though the laboratory has a measuring instrument. What is your conclusion about the length measurement problem? Give your reasons!

4. Two cars move straight in the opposite direction as shown in Figure 2. Car I has a speed of 72.0 km / h to the south. After 4 minutes then car II departs with speed 80.0 km / h to the north. If the distance between the two cars is 20.0 km, what will happen after the car I run for 10.0 minutes? Give your reasons!

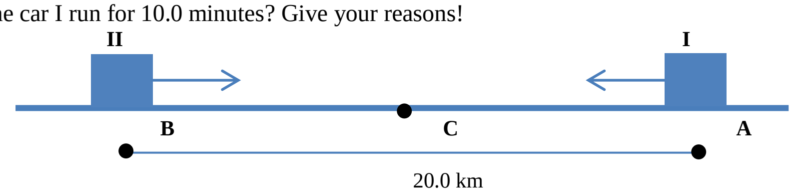

Figure 2: Two cars move straight in the opposite direction

5. An eagle perched on tree limb 19.5 m above the water spots a fish swimming near the surface. The eagle pushed off from the branch and descends toward the water. By adjusting its body in flight, the eagle maintains a constant speed of 3.1 m/s at an angle of 20.0^0 below the horizontal. After 17.0 s flew from the branch into the water, did the eagle catch the fish? Give your arguments!

6 Figure 3 shows position - time graphs for Joszi and Heike paddling canons in a local river; (a) Interpret the position of Joszi against Heike after Heike moves: 0.5 h, 1 h and 1.5 h, (b) What is your conclusion about the rate of the canons.

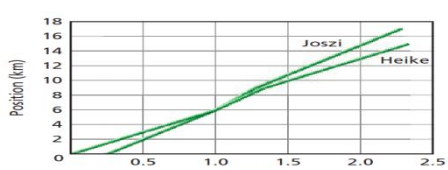

Figure 3: Potition - time graphs for Joszi and Heike
(Source: Zitzewitz, et al. 2005)

7. The archerfish hunts by dislodging an unsuspecting insect from its resting place with a stream of water expelled from the fish's mouth (Figure 4). Suppose the archerfish squirts water with an initial speed of 2.3 m/s at an angle of 19.5^0 above the horizontal. When the stream of water reaches a beetle on a leaf at height 30.0 mm above the water's surface will water wet the beetle's body? Give your reasons!

Figure 4: The archerfish hunts by dislodging an unsuspecting insect
(Source: Zitzewitz, et al. 2005)

8. A park ranger driving on a back country road suddenly sees a deer "frozen" in the headlights. The ranger, who is driving at 11.4 m/s, immediately applies the breaks and slows with an acceleration of 3.8 m/s^2. If the dear is 20.0 m from the ranger's vehicle when the breaks are applied, what will happen with the ranger's vehicle? Give your reasons!

9. Observation at the rate of a running car produces graph in Figure 5. Based on the graph, interpret when is the car accelerated and how fast is the car after traveling 30.0 km? Give your reasons!

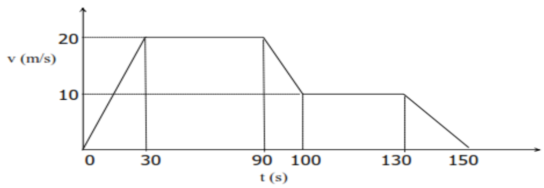

Figure 5: Graph of time - rate for a moving car
(Source: Santoso, 2004)

10. A roadway is banked at proper angle, a car can round a corner without any assistance from friction between the tires and the road. If the angle of the road bend is 26.7°, is the 900-kg car traveling at 20.5 m / s in a turn of the radius of 85.0 m crossing the bend will be safe? Give your reasons!

11. How would you interpret the sprinter's velocity and acceleration as shown in the graph in Figure 6? Give your reasons!

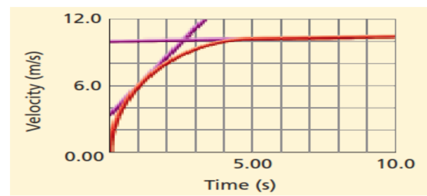

Figure 6: Sprinter's velocity and acceleration
Source: Zitzewitz, et al. 2005

12. A 1200.0 kg car rounds a corner of radius r = 45.0 m. The coefficient of static friction between the tires and the road is 0.8, what can the car run in corner without skidding? Give your reasons!

13. While driving along a country lane with a constant speed of 17.0 m/s, you encounter a dip in the road (Figure 7). The dip can be approximated as a circular arc, with a radius of 65.0 m. If the car seat is only able to withstand 1000.0 N loads, will the car seat be damaged when a mass of 80.0 kg sits in the car seat while the car is at the bottom of the dip as the car's position on the image? Give your reasons!

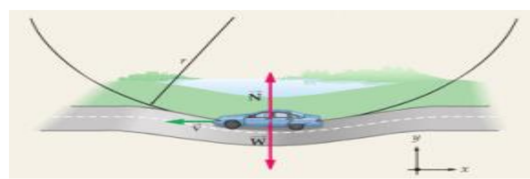

Figure 7: A car crosses the road on a decreasing radius with a radius of 65.0 m depth
(Source: Zitzewitz, et al. 2005)

14. Two youngsters dive off an overhang into a lake. Diver 1 drops straight down, Diver 2 runs off the cliff with an initial horizontal speed v_0. Evaluate the splashdown speed of Diver 2, is **(a)** greater than, **(b)** less than, or **(c)** equal to the splashdown speed of Diver I? Give your arguments!

15. If the height *h* is increased the previous example but the width *w* remains the same, Evaluate the minimum speed needed to cross the crevasse, does it **(a)** increase, **(b)** decrease, **(c)** or stay the same? Give your arguments!

16. From the data indicates that many vehicles are slip when passing a bend in a particular place, what is your conclusion about the path? Give your arguments!

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THE COMPARISON OF OR-IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILLS OF PRE-SERVICE PHYSICS TEACHERS

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Abstract. *Critical thinking skills are one of the 21st century skills that are effectively trained by using the OR-IPA and Problem Based Learning (PBL) Model, therefore this research aims to compare the effectiveness of both. Research design used True Experiment with Randomized Subject Control-group Pre-test and Post-test with 94 pre-service physics teachers. Data collected using the critical thinking skills test and the student response sheet, and then analyzed using t-test and N-gain. The results showed: (1) the teaching instruments of OR-IPA and PBL Model have fulfilled the validity requirements (ra ~ .26) and reliability (α = .96 - .99). (2) Each of OR-IPA, PBL, and Conventional Model can significantly increase critical thinking skills at α = 5%, respectively with average N-gain: medium (.60), medium (.48), and low (.14); with the student response of: very positive, very positive, and less positive. (3) The OR-IPA and PBL Model are effective to improve critical thinking skills, while the Conventional Model is ineffective, and the OR-IPA Model is more effective compared to the PBL Model. Implication of this research is that the OR-IPA Model can be an innovative solution to improve critical thinking skills, but there is still a need for repetitive research like this.*
Keywords: *basic physics, critical thinking skills, OR-IPA model, pre-service physics teachers, and PBL model.*

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Introduction

In this 21st century, education has an important role in producing Human Resources (HR) that has the needed skills to work. Meanwhile, the demands of the curriculum and the development of globalization era require educational institutions to do beneficial innovations for the 21st century skills-based educational world (Griffin & Care, 2015; Turiman, Omar, Daud, & Osman, 2012). Permendikbud No.73 of 2013 on the Indonesian National Qualification Framework in the field of higher education requires universities to prepare curriculum for pre-service physics teacher to have superior competence with various skills that are in line with 21st century demands, among them are: critical thinking skills, skills to utilize Information and Communication Technology (ICT), and skills to solve problems (Griffin & Care, 2015; Jatmiko, Widodo, Martini, Budiyanto, Wicaksono, & Pandiangan, 2016; Kemdikbud, 2013; Pandiangan, Sanjaya, & Jatmiko, 2017). The 21st century educational process requires human resources with competence and the achievement of pre-service physics teachers are directed to skills and learning innovations, among others are: Critical thinking skills, problem solving skills, decision making, creative thinking, responsibility, and ability to learn independently (Griffin & Care, 2015; Pandiangan, Sanjaya, & Jatmiko, 2017; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018).

The development of critical thinking skills is considered as one of the most important goals of education for over a century (Forawi, Almekhlafi, & Al-Mekhlafy, 2012; Geertsen, 2003). Critical thinking has been defined and measured in a number of ways, but it usually involves an individual's ability to identify central issues and assumptions in arguments, recognize important relationships (Mason, 2017, Moon, 2007), make correct conclusions from data, infer provided information or data, interpret whether the conclusion is guaranteed or not based on the data provided (Facione, 2013; Mulnix, 2012). Furthermore, previous researchers explain that critical thinking is cognitive skills, it includes activities of interpretation, analysis, evaluation, inference, explanation, and self-management in problem solving (Bean, 2011; Cheong & Cheung, 2008, Dam & Volman, 2004; Ennis, 2011; Ernst & Monroe 2004; Jenicek, 2006; Marin & Halpern, 2011; Miri, David & Uri 2007; Mundilarto & Ismoyo, 2017; Popil, 2011; Siew & Mapeala, 2016; Snyder & Snyder, 2008; Womack & Jones, 2010). In this research, critical thinking skills is a cognitive process which is carried out as a thinking guide by using reason judgments against evidence, context, standard, method, and conceptual structure by performing concepts, application, synthesis and information obtained from observation, experience, reflection, thinking, or communication as a basis for believing and doing an action and focusing on what to do. The critical thinking skills' indicators in this research are analysis, evaluation, interpretation, and inference based on the results of literature research and preliminary study by the investigator, these indicators are still low and need to be accelerated in pre-service physics teachers.

In connection with the improvement of the teaching process and outcomes quality mentioned above, there are important problems faced by the world of education today, which is how to strive pre-service physics teachers' critical thinking skills through teaching (Krulik & Rudnick, 1996; Marzano, 1993). This needs to be done because there are many students who do not have critical thinking skills (Brookfield, 2017). Critical thinking skills are important thinking skills and should be taught, but there are still many lecturers who do not understand how to teach critical thinking skills. The results of Patrick's, Fallon, Campbell, Cretchley, Devenish, & Tayebjee (2014) and Pithers & Soden (2000) showed that critical thinking skills should be taught, but there are still some lecturers who do not know how to teach critical thinking skills effectively (Brownlee, Walker, Lennox, Exley, & Pearce, 2009; McPeck, 2016).

Martin, Mullis, Foy, & Stanco (2012) showed that most of Indonesian students are only able to recognize a number of basic facts and have not been able to communicate and relate various topics of science, especially in applying complex and abstract concepts. This fact is in line with the results of Rosyid, Jatmiko, & Supardi (2013) research, which indicated that the physics teaching process is still and more emphasized on the process of knowledge transfer, so it has not been able to make students able to construct knowledge. The low critical thinking skills of pre-service physics teachers are suspected to have something to do with the teaching process being implemented (Browne, & Meuti, 1999; Staib, 2003; Wlodkowski, & Ginsberg, 2017). The implemented teaching model, which is the Conventional Teaching Model (i.e. Conventional Model) cannot facilitate in developing students' critical thinking skills, resulting in low learning achievement (Hammond, Barron, Pearson, Schoenfeld, Stage, Zimmerman, & Tilson, 2015; Mann & Kaitell, 2001). Therefore, to improve the quality and facilitate the development of pre-service physics teachers, it is necessary to find out alternative solutions. The alternative solutions include implementing the OR-IPA Teaching Model (i.e. OR-IPA Model) and Problem Based Learning Model (i.e. PBL Model). The results of previous research conducted by Rosyid, Budi, & Supardi (2013) showed that OR-IPA Model and PBL Model with supporting teaching instruments can improve high school students' learning outcomes in Kabupaten Jember, East Java significantly at $\alpha = 5\%$ with moderate N-gain.

The OR-IPA Model is a problem-based teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Multi-representation teaching can stimulate students to perform analysis, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This was also applied to Ainsworth's (2008, 1999) and Ciais, Reichstein, Viovy, Granier, Ogée, Allard & Carrara (2005) studies which suggested that multi-representation learning has three main functions: complementary, interpretive, and can build a more comprehensive understanding. In this research, the OR-IPA Model has five syntaxes, namely: (1) **O**rientation of Problem, (2) **R**epresentation of Problem, (3) **I**nvestigation, (4) **P**resentation, (5) **A**nalysis, Evaluation and Follow-up (Rosyid, Budi, & Supardi, 2013). The interactive tasks in applying this OR-IPA Model to grow up the ability of critical thinking skills are referred to the phases in the syntax, namely: (1) **O**rientation of Problem, which is aimed to attract the students, focus the students, and motivate them to take an active role in the teaching process; (2) **R**epresentation of Problem, which is aimed to assist students in understanding the material and solving the problems that will be discussed through various approaches that can be adapted to the objectives of teaching and the presented material characteristics; (3) **I**nvestigation, which is aimed to collect information with the help of Student Worksheet, then the lecturer guides to carry out step-by-step investigations, explores the explanation, and solutions to build the critical thinking skills which includes (a) formulating the problem; (b) formulating the hypothesis; (c) identifying variables; (d) writing the operational variables definition; (e) writing down the experimental tools and materials; (f) conducting

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experiments; (g) organizing experiment data; (h) analyzing experimental data; and (i) making a conclusion; (4) **P**resentation, which is aimed to guide students in making conclusions and discussion of the investigation results in various representations, and assisting in the planning, preparing and presenting the works; and (5) **A**nalysis, Evaluation and Follow-up, which is aimed to analyze and evaluate the problem-solving process of inquiry and process in various forms of representation, observe the students' work as the learning evidence, and facilitate follow-up learning through the assignment of structured tasks.

The PBL Model has five syntaxes, namely: directing students to problems, organizing students to learn, helping independent and group investigations, developing and presenting artifacts and exhibits, and analyzing and evaluating problem-solving processes (Arends, 2012). Characteristics of the PBL Model are designed to help students improving their inquiry skills and problem-solving skills, social behavior and skills according to the role of adults, as well as independent learning skills for the investigation of everyday life issues (Arends, 2012; Arizaga, Bahar, Maker, Zimmerman, & Pease, 2016; Nilson, 2016). The PBL Model begins with a complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a suitable learning environment for students (Caesar, Jawawi, Matzin, R., Shahrill, Jaidin, & Mundia, 2016; Nuninger & Châtelet, 2017). The PBL Model also regulates a student-centered learning environment that is not viewed as an empty vessel but is capable to bring its own distinct framework and learning (Chakravarthi, 2010; Efendioglu, 2015). The PBL Model can enhance self-study skills and provide a more realistic picture of higher academic challenges, more confidence, better problem-solving skills, critical thinking skills, and provide the improvement of communication skills (Malan, Ndlovu, & Engelbrecht, 2014; Méllesis & Hurren, 2011; Williams, 2005). The application of PBL Model will promote students to have motivation, confidence in learning and able to improve students' ability to solve more complex problems (Caesar et al., 2016; Nilson, 2016; Sern, Salleh, Mohamad, & Yunos, 2015; Tracey & Morrow, 2017). However, the PBL Model is still weak in terms of inquiry orientation components, alternative solutions, and difficult in formulating problems and preparing hypotheses (Ates & Eryilmaz, 2010; Chakravarthi, 2010). Although the research shows that the PBL Model supports self-study and communication skills, critical skills improvement, creative thinking skills and problem-solving skills (Ates & Eryilmaz, 2010; Malan, Ndlovu, & Engelbrecht, 2014; Prahani, Nur, Yuanita, & Limatahu, 2016), however PBL's weaknesses are lack of initiation and timing, lack of student discipline, and more challenging authentic issues are needed (Ates & Eryilmaz, 2010; Thompson, McInerney, Manning, Mapukata-Sondzaba, Chipamaunga, & Maswanganyi, 2012).

The State University of Surabaya (Unesa) as an institution of higher education has facilitated its lecturers with various teaching models that can be integrated with information and communication technology. However, the reality shows that there are still many lecturers who have not conducted the lesson by utilizing the facilities to provide learning experiences for pre-service physics teachers. Most of the lecturer facilities provided by Unesa are only used as teaching tools and have not been utilized to produce teaching models. The teaching models gained through a series of research are less useful and ineffective because they have not been optimally utilized by lecturers at Unesa as it is in other higher education institutions, lecturers should be responsible for developing models, strategies, approaches, methods or instructional techniques in the era of the 21st century (Huba & Freed, 2000; Richards & Rodgers, 2014). OR-IPA Model and PBL Model are very useful to improve lecturers' competence in teaching. This is because the teaching becomes more interesting, more challenging, and better suited to the needs of students. The results of previous research indicate that the OR-IPA Model and PBL Model are effective and practical in improving critical thinking skills of Senior High School students in Jember Regency (Rosyid, Jatmiko, & Supardi, 2013).

Referring to the effectiveness of OR-IPA Model and PBL Model in improving the students' critical thinking skills, it needs to be reviewed and tested for further consistency in improving the critical thinking skills of pre-service physics teacher from Unesa. This research is very important in order to develop models and learning theories that are able to answer the challenges and skills needs in the 21st century. The low critical thinking skills are theoretically caused, among other things, by: poor motivation and responsibility, poor analytical skills, and less discipline in teach (Adebayo, 2014). This is also due to the lack of ability to organize time, lazy to learn, and less supportive learning environment (Chakravarthi, 2010; Eaton, 2015). Therefore, it is necessary to compare the effectiveness between OR-IPA Model and PBL Model in improving student critical thinking skills. In order to be able to compare the effectiveness of the two models, then the preparation of teaching instruction of OR-IPA Model and PBL Model was done firstly which is designed to be able to increase critical thinking skills of pre-service physics teachers.

Problem of Research

The problem of this research is how to analyze the effectiveness of teaching in the basic physics course with the OR-IPA Model and PBL Model to get more effective teaching model to improve the critical thinking skills of pre-service physics teacher. In addition, also how to get examples of teaching instruments that are valid and reliable with an effective teaching model in improving the critical thinking skills of pre-service physics teachers. In detail, the focuses of this research were: (1) how is the validity and reliability of teaching instruments in basic physics course with OR-IPA Model and PBL Model to improve the critical thinking skills of pre-service physics teachers, which includes: Semester Teaching Plan, Lesson Plan, Student Teaching Materials, Student Worksheet, and Student Critical Thinking Skills Test of pre-service physics teachers? (2) how is the effectiveness of teaching process with OR-IPA Model, PBL Model, and Conventional Model in improving the critical thinking skills of pre-service physics teachers? and (3) which teaching model is the most effective to improve the critical thinking skills of pre-service physics teachers?

Research Focus

During this time, the way to get the student's critical thinking skills is done by teaching with PBL Model, but the previous research conducted on senior high school students in Jember, Indonesia by using teaching with OR-IPA Model, which is a correction of the PBL Model to improve students' critical thinking skills showed results that are also effective and practical (can be applied). On the other hand, many students do not have critical thinking skills, so there are many lecturers who still do not understand how to teach critical thinking skills effectively to the pre-service physics teachers. The focus of this research was to compare the effectiveness of teaching in basic physics courses with OR-IPA Model and PBL Model in improving the critical thinking skills of pre-service physics teacher. This research used control variables; it was the Conventional Model.

Methodology of Research

General Background

This research was conducted at State University of Surabaya in June - December 2017. The scope of this research is the first-year students who took Basic Physics course in academic year 2017/2018. This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design. This research is emphasized on the analysis of the OR-IPA Model, PBL Model, and Conventional Model effectiveness by analyzing the increase of critical thinking skills of pre-service physics teachers before and after following the process of physics teaching with CRBT model. The Conventional Model in this research was lecturer-centered teaching model, which includes lecture, presentation, and discussion. The teaching instruments and research instruments are said to be valid if $r_a >$ r table and invalid if $r_a \leq$ r table. Physics teaching process with OR-IPA Model, PBL Model, and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skills of pre-service physics teachers at $\alpha = 5\%$, (2) the minimum N-gain is categorized as moderate, and (3) students' responses are at least positive.

Sample

The research was conducted to 94 students of Physics Education Study Program, Unesa, Indonesia, which came from a population of 123 students in three groups (experimental group-1 / OR-IPA Model, experimental group-2 / PBL Model, and control group / Conventional Model). The calculation of the sample number was based on the Slovin formula, that was the sample = [population / (1 + $e^2 \times$ population)] with error tolerance e = 5% (Sevilla, Ochave, Regala, & Uriarte, 1984; Tejada, & Punzalan, 2012). This research took three groups, namely: group of: experiment group-1 came to 31 students; experiment group-2 came to 30 students; and control group came to 33 students, each of them was statistically in the same level of critical thinking skills.

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Instrument and Procedures

This research is True Experiment with Randomized Subject Control-group Pre-test and Post-test Design (Fraenkel, Wallen, & Hyun, 2012).

O_1	X_1	O_2
O_1	X_2	O_2
O_1	C	O_2

With: O_1: Pre-test score, O_2: Post-test score, X_1: OR-IPA Model, X_2: PBL Model and C: Conventional Model

Prior to the research, firstly the researchers set up teaching instruments that covered these components: (1) Semester Teaching Plan, (2) Lesson Plan, (3) Student Teaching Materials, (4) Student Worksheet, and (5) Critical Thinking Skills Test of pre-service physics teacher, respectively for the OR-IPA Model and PBL Model. The data were collected by using the research instruments, which consisted of the following components: (1) Teaching Model Implementation Sheet and (2) Student Response Sheet. The validity of those teaching instruments from both OR-IPA Model and PBL Model was then assessed by the physics education experts in terms of the content and construct. In order for the teaching instruments to be able to be implemented, the leaning instruments have to meet the valid and reliable requirements.

The research began by giving the critical thinking skills pre-test (O_1) by using the critical thinking skills test of pre-service physics teacher to each group of students, then providing teaching with different models, namely: OR-IPA Model, PBL Model, and Conventional Model. Finally, after the entire teaching process has been completed, all groups of students are awarded a post-test (O_2) of the critical thinking skills with the same materials and problems as in the pre-test.

Data Analysis

In order to get the validity of contents and construct for the teaching instruments of the OR-IPA Model and PBL Model as well as the research instrument, the assessment of those instruments was done by the physics education expert based on the content and construct validity. Content validity is a description of needs and novelty, while construct validity is a description of the consistency of teaching instruments of OR-IPA Model and PBL Model with theory/empirical and consistency between the instrument components (Plomp, 2013). The data was analyzed by reliability test; each of them was analyzed by using Cohen's Kappa, single measure interrater coefficient correlation (r_a) and Cronbach's alpha (a). The teaching instruments and research instruments are said to be valid if $r_a > r_{table}$ and invalid if $r_a \leq r_{table}$. Meanwhile, the teaching instruments and research instruments are said to be reliable if $.6 \leq \alpha \leq 1.0$ and not reliable if $\alpha < .6$. In order to analyze physics teaching with a more effective teaching model, an "effective" operational definition is required. Physics teaching process with OR-IPA Model, PBL Model and Conventional Model are said to be effective if: (1) there is a significant increase of critical thinking skills of pre-service physics teachers at $\alpha = 5\%$, (2) the average N-gain at least in moderate category, and (3) students' responses are at least positive. In this research, the pre-test and post-test results were analyzed as follows: when the normality assumption for the achieved score is fulfilled, the Paired t-test will be applied. If it is not fulfilling, non-parametric analysis will be used. In order to get increasing level of student's critical thinking skills score, the calculation was done by using N-gain with equation: N-gain = (Post-test score - Pre-test) / (maximum score - Pre-test) (Hake, 1998). By the criteria of: (1) N-gain > .70 (height); (2) .30 < N-gain < .70 (medium); and (3) N-gain < .30 (low). In order to test whether the improvements on students' critical thinking skills existed or not with the OR-IPA Model, PBL Model, and Conventional Model, Paired t-test against the pre-test score and post-test by using IBM SPSS Statistic 16 software was done. Meanwhile, to get more effective model in improving students' critical thinking skills after being given lessons, researchers compared the effectiveness of the three models by using Independent t-test. In order to see the responses of pre-service physics teachers toward teaching with OR-IPA Model, PBL Model, and Conventional Model, student responses data was analyzed by using qualitative descriptive (Prahani, Winata, & Yuanita, 2015; Riduwan, 2010). With the criteria of: (1) Response ≥ 75% (very positive); (2) 50% ≤ Response < 75% (positive); (3) 25% ≤ Response < 50% (less positive); and (4) Response < 25% (not positive).

Results of Research

Validity of Teaching Instruments and Research Instruments of OR-IPA Model and PBL Model

Before the research is done, teaching instruments and research instruments that have been compiled must meet the requirements of validity and reliability. The validity of teaching instruments of OR-IPA Model and PBL Model, and research instruments were assessed by two physicists of Unesa. The results of the validity assessment of the teaching instruments and research instruments for OR-IPA Model and PBL Model, respectively, are shown in Table 1 and Table 2.

Table 1. The result of teaching instruments and research instruments validity of OR-IPA model.

Components	The Validity of OR-IPA Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	Cohen's kappa	R	r_α	V	α	R
Semester Teaching Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.99	Reliable
Lesson Plan	.87	Reliable	.25	Valid	.97	Reliable	.87	Reliable	.25	Valid	.97	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.96	Reliable	.25	Valid	.99	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.96	Reliable	.25	Valid	.98	Reliable
Critical Thinking Skills Test of Pre-Service Physics Teacher	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes: r_α = Single measure interrater coefficient correlation; α = Cronbach's alpha; R: Reliability; V: Validity

Table 2. The validity of PBL model instruments.

Components	The Validity of PBL Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	Cohen's kappa	R	r_α	V	α	R
Semester Teaching Plan	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Lesson Plan	.86	Reliable	.25	Valid	.96	Reliable	.86	Reliable	.25	Valid	.96	Reliable
Student Worksheet	1.00	Reliable	.26	Valid	.99	Reliable	.97	Reliable	.26	Valid	.97	Reliable
Student Teaching Materials	.96	Reliable	.25	Valid	.97	Reliable	.95	Reliable	.25	Valid	.96	Reliable

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Components	The Validity of PBL Model Instruments											
	Construct Validity						Content Validity					
	Cohen's kappa	R	r_α	V	α	R	Cohen's kappa	R	r_α	V	α	R
Critical Thinking Skills Test of Pre-Service Physics Teacher	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Teaching Model Implementation Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable
Student Response Sheet	1.00	Reliable	.26	Valid	.99	Reliable	1.00	Reliable	.26	Valid	.99	Reliable

Notes: r_α = Single measure interrater coefficient correlation; α = Cronbach's alpha; R: Reliability; V: Validity

Table 1 shows that the construct validity of the OR-IPA Model instruments includes: Semester Teaching Plan; Lesson Plan; Students Worksheet; Student Teaching Materials; Critical Thinking Skills Test of pre-service physics teachers, and the research instruments, which includes: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the OR-IPA Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skills; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skills need to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the teaching instruments of the OR-IPA Model in order to be implemented.

Table 2 shows that the construct validity of the PBL Model instruments includes: Semester Teaching Plan; Lesson Plan; Students Activity Sheet; Student Teaching Materials; Student Critical Thinking Skills Test of pre-service physics teacher, and the research instruments, which include: Teaching Model Implementation Sheet and Student Response Sheet. All of them have a minimum value of .25 that is greater than r table (.16). All of the components are valid. Otherwise for the reliability are measured by the α value, which are all between the value of .6 and 1, so that all components are reliable. In addition to provide the valid and reliable judgments on the construct validity and the content validity of the PBL Model instruments, the validator also provides several suggestions, namely: (1) Problems should be authentic issues not academic problems; (2) Multi-representation activities shall be designed to train the critical thinking skills; (3) Problems for indicators of evaluation still need to be added one step further; (4) The size of the letters in the Student Teaching Materials should be smaller and not too large; (5) Guidance should be decreased for each student worksheet 1 to student worksheet 4; (6) Consistency of writing scientific terms and symbols of physics; (7) The critical thinking skills need to be provided to the student worksheet for further student training. The suggestion from the validator is used as the reference for revision process of the teaching instruments of the PBL Model in order to be implemented.

Based on the above description, it can be said that the teaching instruments of OR-IPA Model and PBL Model have fulfilled the content and construct validity requirements to improve the critical thinking of pre-service physics teacher. The teaching instruments of OR-IPA Model and PBL Model can be implemented in the teaching process of basic physics courses.

The Effectiveness of OR-IPA Model, PBL Model and Conventional Model for Critical Thinking Skills of Pre-Service Physics Teachers

The critical thinking skills score and N-gain of pre-service physics teachers were obtained by providing the pre-test and post-test of the critical thinking skills. The detailed score of pre-test, post-test, and N-gain of pre-service physics teachers in the OR-IPA Model, PBL Model, and Conventional Model are shown in Figure 1. While the critical thinking skills indicators of group-1: OR-IPA Model, group-2: PBL Model and group-3: Conventional Model is presented in Table 3. Figure 1 shows that prior to the teaching with OR-IPA Model, PBL Model, and Conventional Model, pre-service physics teachers have low average of critical thinking skills. After the implementation of OR-IPA Model and PBL Model, pre-service physics teachers have an increase in the average of critical thinking skills, but in Conventional Model, all pre-service physics teachers still have average of critical thinking skills in low category. In general, the average of critical thinking skills for pre-service physics teachers in post-test with OR-IPA Model, PBL Model, and Conventional Model is in high category (2.67); Medium (2.14); and low (1.00) and the score ranged from 1 - 4. The average N-gain of critical thinking skills owned by pre-service physics teachers for teaching by using OR-IPA Model, PBL Model, and Conventional Model, is in the category of moderate (.63); moderate (.47); and low (.14), from the score range of 0 - 1.

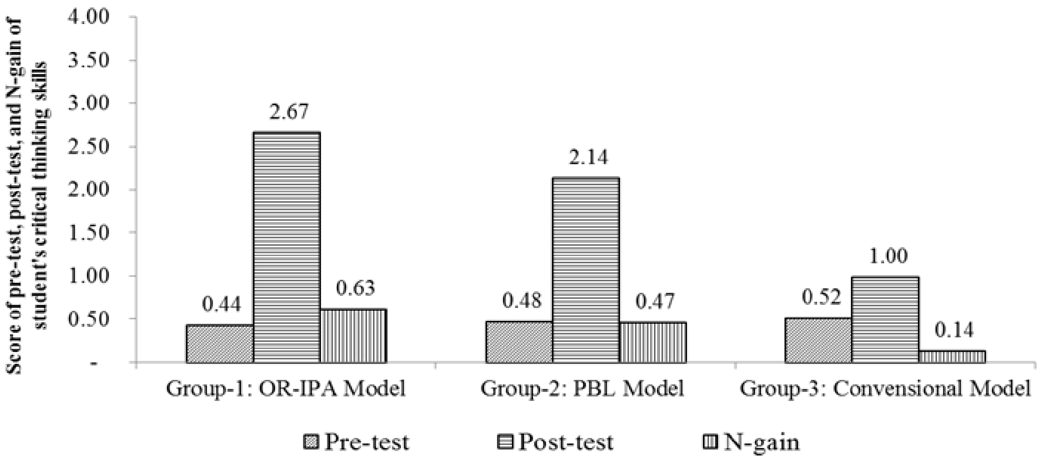

Figure 1: The score of pre-test, post-test, and N-gain of critical thinking skills owned by pre-service physics teachers with OR-IPA model, PBL model, and Conventional Model.

Figure 1 indicates that in order to increase the critical thinking skills of pre-service physics teachers; the OR-IPA Model is better compared to the PBL Model and Conventional Model. While the PBL Model is better when compared to the Conventional Model.

Table 3. The critical thinking skills indicator of group-1: OR-IPA model, group-2: PBL model, and group-3: conventional model.

Group	Score	Indicators of Critical Thinking Skills			
		Analysis	Evaluation	Interpretation	Inference
Group-1: OR-IPA Model	Pre-test	.45	.31	.52	.45
	Post-test	2.91	2.47	3.00	1.96
	N-gain	.69	.59	.71	.43
Group-2: PBL Model	Pre-test	.59	.39	.82	.13
	Post-test	2.36	2.24	2.59	1.39
	N-gain	.52	.51	.56	.33

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Group	Score	Indicators of Critical Thinking Skills			
		Analysis	Evaluation	Interpretation	Inference
Group-3: Conventional Model	Pre-test	.49	.32	.71	.58
	Post-test	1.09	.69	1.29	.93
	N-gain	.17	.10	.18	.10

Table 3 shows that the results of critical thinking skills pre-test of pre-service physics teachers for all critical thinking skills indicators were in the low category, whereas after the implementation of teaching with OR-IPA Model, all the critical thinking skills indicators have increased. In general, the average N-gain for critical thinking skills indicator with OR-IPA Model was in medium and high category, with the value was above .43. The result of critical thinking skills pre-test of pre-service physics teachers for all indicators was in low category, while after implementation of teaching with PBL Model, all critical thinking skills indicators have increased. In general, the average N-gain of critical thinking skills indicator with PBL Model was in medium and high category with the value above .33. The result of critical thinking skills pre-test of the pre-service physics teacher for all critical thinking skills indicators was in low category, while after the implementation of teaching with Conventional Model, all critical thinking skills indicators remain in low category. In general, the average N-gain of critical thinking skills indicators with Conventional Model was in low category with value above .10. Meanwhile, the lowest indicator of critical thinking skills in all groups was inference.

Paired T-test of Critical Thinking Skills Owned by Physics Teachers Candidates with OR-IPA Model, PBL Model, and Conventional Model

The existence of critical thinking skills increase in the pre-service physics teachers is measured by testing the average score of Pre-test and the Post-test score by using Paired t-test. Paired t-test is used (for parametric statistical test) because it has fulfilled the requirements: (1) Pre-test score and Post-test data of critical thinking skills of pre-service physics teacher come from normal distributed population, conducted by normality test (Shapiro-Wilk); and (2) the average of Pre-test and Post-test score data is homogeneous when tested by using the two-variance equality test. Paired t-test for the average score of Pre-test and Post-test of critical thinking skills conducted on Group-1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of Paired t-test against Pre-test and Post-test score of critical thinking skills of pre-service physics teachers are presented in Table 4.

Table 4. The results of paired t-test of critical thinking skills owned by pre-service physics teachers in all groups.

Group	N	Paired t-test				
		Mean	Std. error mean	t	df	p
Group-1: OR-IPA Model	31	-2.25	.13	-17.95	30	< .01
Group-2: PBL Model	30	-1.66	.08	-19.83	29	< .01
Group-3: Conventional Model	33	- .48	.05	-9.24	32	< .01

Table 4 shows that the mean scores of critical thinking skills for groups 1, 2 and 3 respectively for: OR-IPA Model, PBL, and Conventional Teaching Model are -2.25; -1.66; and - .48 with degrees of freedom (df) are 30; 29; 32 and giving t value of -17.95; -19.83; and -9.24. The result of Paired t-test for each group is significant, because $p < .05$. Therefore, t counts the negative value, then clearly there is a significant difference at $\alpha = 5\%$ between the pre-test score with the critical thinking skills Post-test in all groups. For teaching with the OR-IPA Model, PBL Model, and Conventional Model, all of them show higher post-test score compared to the pre-test score, or the mean scores of critical thinking skills of pre-service physics teachers after each teaching process with the OR-IPA Model, PBL Model, and Conventional Model are higher than before.

Independent T-test of Critical Thinking Skills Owned by Pre-Service Physics Teachers with OR-IPA Model, PBL, and Conventional Model

In order to analyze which model is more effective in increasing the critical thinking skills of pre-service physics teachers among Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Teaching Model, among others, is done by testing the average N-gain of the critical thinking skills by using Independent t-test. Independent t-test is used (for parametric statistical tests) because it meets the requirements of: (1) the average N-gain of critical thinking skills of pre-service physics teachers (Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model) are derived from normally distributed populations, performed by normality test (Shapiro-Wilk); and (2) the average N-gain of critical thinking skills of pre-service physics teachers (Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model) is homogeneous when measured by using multiple-variance test equations. Independent t-test for the average N-gain was performed on Group 1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. Independent t-test results on the average N-gain for all groups are presented in Table 5.

Table 5. Independent t-test results on the average N-gain for all groups.

Group	N	Independent t-test				
		Mean Difference	Std. error mean	t	df	p
Group 1: OR-IPA Model Group 2: PBL Model	61	.15	.04	3.58	59	< .01
Group 1: OR-IPA Model Group 3: Conventional Model	64	.49	.04	12.5	62	< .01
Group 2: PBL Model Group 3: Conventional Model	63	.34	.03	12.51	61	< .01

Table 5 shows that the mean difference of N-gain of critical thinking skills for groups: 1-2, 1-3, and 2-3 is .15; .49; .34 and respectively have degrees of freedom (df) = 59; 62; 61, gives a value of t = 3.58; 12.50; and 12.51. The score is significant, because $p < .05$. Therefore, $p < .05$, it is clear that there is significant difference in mean of critical thinking skills N-gain in Group-1 that is the OR-IPA Model with Group-2 that is PBL Model, Group-1 that is the OR-IPA Model with Group-3 that is Conventional Model; Group-2 that is PBL Model with Group-3 that is Conventional Model, for each at $\alpha = 5\%$. The results of the above analysis show that the average N-gain of critical thinking skills of pre-service physics teachers was higher after teaching with the OR-IPA Model when compared to PBL Model and Conventional Model. While teaching with PBL Model gave higher average N-gain when compared to the Conventional Model.

The Pre-Service Physics Teachers Response toward the OR-IPA Model, PBL Model, and Conventional Model

The analysis of student's response toward teaching with implemented model is done by giving the Student Response Sheet for pre-service physics teachers after the physics teaching process. The results of the pre-service physics teachers' responses are presented in Table 6.

Table 6. The pre-service physics teachers' response toward the OR-IPA model, PBL model, and Conventional model.

Group	N	Students' Positive Opinion on the Physics Teaching Process	Category
Group I: OR-IPA Model	31	89 %	Very Positive
Group II: PBL Model	30	89 %	Very Positive
Group III: Conventional Model	33	26 %	Less Positive

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Table 6 shows that in general pre-service physics teacher responded very positively to the teaching instruments of the OR-IPA Model and PBL Model. As for the Conventional Model instruments, student responses show less positive.

Discussion

Validity of OR-IPA Model and PBL Model Instruments

The developed teaching instruments' components include Semester Teaching Plan, Lesson Plan, Student Teaching Materials, Student Worksheet, and Critical Thinking Skills Test of pre-service physics teacher; and the Research Instruments include Teaching Model Implementation Sheet and Student Response Sheet. The assessment of all teaching instruments' components is done by physics education experts in Unesa and has been declared valid as in Table 1 and Table 2. The implication of the instruments has been declared valid and can be used for the implementation of OR-IPA Model and PBL Model in improving the pre-service physics teachers. In addition, Table 1 and Table 2 also show that all components of the teaching instruments are included reliably, shown by the coefficients of Cohen's Kappa. The result of this validity is supported by the opinion of Plomp (2013) which said that a good product (teaching model) must meet the requirements, namely: validity: the validity of the model can be tested by testing the content and construct validity. Content validity is when there is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge; whereas the validity of constructs (construct validity) is the intervention and is 'logically' designed (Nieveen, McKenney, & Akker, 2007). A valid device (content and construct) has an impact on the improvement of the critical thinking skills owned by the pre-service physics teachers on the significant basic physics material as in Table 3 - 5. The statement is reinforced by the results of research stating that PBL can develop critical thinking skills and analysis and exposes students to exercises to solve problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009). The successful use of this teaching model is determined by the preparation of learning environments and good learning media (Johnson, Rickel, & Lester, 2000) to support each lecturer and student activity (Woolf, 2010) in each stage of the OR-IPA Model and PBL Model syntax. It is a reflection that the developed instruments have been valid and can be implemented to improve the critical thinking skills owned by the pre-service physics teachers.

The Effectiveness of OR-IPA Model, PBL Model, and Conventional Model to Improve the Critical Thinking Skills Owned by the Pre-service Physics Teachers

The individual critical thinking skills score of the pre-service physics teachers is obtained by providing the critical thinking skills test of pre-service physics teachers before the teaching (Pre-test) and after the teaching process is done (Post-test). The data in Figure 1 shows that before the teaching with OR-IPA Model, all students have low critical thinking skills. After the implementation of OR-IPA Model, all students experience increased their critical thinking skills. In general, the critical thinking skills of the pre-service physics teachers in the post-test were in the high category of 2.27 from the range of 1 - 4. The general N-gain scores of pre-service physics teachers with OR-IPA Model were in the medium category of .63. Table 3 shows that all the critical thinking skills indicators in the pre-test are in the low category, whereas after the implementation of teaching with OR-IPA Model, all the critical thinking skills indicators have increased. The general N-gain of critical thinking skills indicators of the OR-IPA Model were in medium and high category with the value was above .43. The results of this research are supported by the work of John Dewey who describes the views of education, with the school as a mirror of the larger society, the class becomes a laboratory for investigation, and solving real-life problems (phase 3). Pedagogy Dewey encourages lecturers to engage students in problem-oriented projects and helps to investigate important social and intellectual issues. Dewey and his followers affirm that teaching in school should be more meaningful, not too abstract (Helterbran, 2010; Loughran, 2013). The vision of purposeful teaching in problem centered is supported by the student's innate desire to explore personal situations for students. The findings of cognitive psychology provide the theoretical foundation for OR-IPA Model. The basic premise in cognitive psychology is that teaching is a process of constructing new knowledge based on current knowledge. Chi, Glaser, & Farr (2014) and Jonassen & Land (2012) assumed that teaching is a constructive process and not an acceptance.

Pre-test, Post-test, and N-gain score of the critical thinking skills owned by pre-service physics teachers in the PBL Model are shown in Figure 1. Based on the data in Figure 1, before the teaching with PBL Model was done, all students have low critical thinking skills. After the implementation of PBL Model, all students' critical thinking skills increase. In general, the pre-service physics teachers gained medium category of 2.14 for their post-test. The general N-gain of pre-service physics teachers by using PBL Model was in the medium category of .47. Table 3 shows that all pre-service physics teachers' pre-test indicators were in the low category, whereas after the implementation of teaching with PBL Model, all the indicators of their critical thinking skills have increased. The general N-gain indicators of critical thinking skills of PBL Model were in medium and high category with value above .33. The results of this research are supported by the characteristics of PBL Model that was designed to assist students in improving the skills of inquiry and problem solving skills, social behavior and skills according to the role of adults, as well as independent learning skills (Arends, 2012: Arizaga, Bahar, Maker, Zimmerman, & Pease , 2016), the PBL Model begins with complex real life (Ledesma, 2016), unstructured, and involves interdisciplinary content (Loucky, 2017), engages in collaborative teaching to manage an increasingly diverse student population (Guilherme, Faria, & Boaventura, 2016; Kang, Kim, & Lee, 2015). PBL is an important practice that provides a student-friendly learning environment (Nuninger & Châtelet, 2017), where they acquire complex problem-solving skills in real life and problem situations, student-centered learning environments, and constructivism approaches (Caesar et al., 2016; Chakravarthi, 2010; Kong, Qin, Zhou, Mou, & Gao, 2014). The results of this research are also reinforced by previous research findings that the PBL Model is very useful to improve motivation, self-confidence, self-study skills, creative thinking skills, critical thinking skills, problem-solving skills, assisting in better retention of knowledge and memory skills, and apply meaningful information with real life situations (Ates & Eryilmaz, 2010; Malan, Ndlovu & & Engelbrecht 2014; Myers, 2017; Nilson, 2016).

The pre-test, Post-test, and N-gain scores of the pre-service physics teachers in the Conventional Model are shown in Figure 1. Based on the data in Figure 1, before the teaching process by using the Conventional Model, all students had critical thinking skills in low category. After the implementation of teaching process by using Conventional Model, all students still had critical thinking skills in low category. In general, critical thinking skills of pre-service physics teacher in Post-test were in the medium category of 1.00. The general N-gain for pre-service physics teacher with Conventional Model was in the medium category of .14. Table 3 shows that all critical thinking skills indicators in the pre-test were in low category, whereas after the implementation of teaching with the Conventional Model all critical thinking skills indicators remained in the low category. The general N-gain of critical thinking skills indicators with a Conventional Model was in the low category with values above .10. The low critical thinking skills of pre-service physics teacher are suspected to have something to do with the teaching process that is implemented. The lesson model that is implemented, the Conventional Model is not able to facilitate in developing the critical thinking skills owned by pre-service physics teacher, resulting in low teaching achievement (Hammond et al., 2015; Mann, & Kaitell, 2001).

The result of Paired t-test presented in Table 4 shows that the mean of critical thinking skills for groups 1, 2, and 3 is -2.25; -1.66; - .48. The whole score is significant, because $p < .05$. Since the result of the calculation was negative, it clearly showed that there was a significant difference between the mean of the pre-test score and the post-test score for the critical thinking skills in all groups, the post-test group was higher than the pre-test group. The low critical thinking skills in theory can be caused by: motivation, lack of responsibility, low analytical skills, and lack of discipline in learning (Adebayo, 2014). This can also be due to a lack of ability to organize time, lazy to learn, and less supportive learning environments (Chakravarthi, 2010; Eaton, 2015). The low critical thinking skills of pre-service physics teacher are suspected to have something to do with the teaching process that is implemented. The OR-IPA Model and PBL Model are able to motivate students to investigate and solve problems in real life situations as well as stimulate students to produce a product in improving the critical thinking skills. Problem-based learning can develop critical thinking skills and analysis and expose students to practice solving problems (Klegeris & Hurren, 2011; Şendağ & Odabaşı, 2009).

The independent t-test for the average N-gain is performed on Group-1: OR-IPA Model, Group-2: PBL Model, and Group-3: Conventional Model. The result of the average t-test of the N-gain by using Independent Samples Test is presented in Table 5, shows that the mean difference of critical thinking skills N-gain for groups 1-2, 1-3 groups, and 2-3 groups is .15; .49; .34 and all are significant, because $p < .05$. This clearly indicates that there is a significant difference between the mean N-gain of critical thinking skills in Group-1: OR-IPA Model with Group-2: PBL Model, Group-1: OR-IPA Model with Group-3 Conventional Model; and Group-2: PBL Model with Group-3: Conventional Model. The results of this analysis indicate that the critical thinking skills N-gain of pre-service physics teachers after the teaching process with OR-IPA Model is higher when compared to PBL Model and Conventional Model. The OR-IPA Model is more effective when compared to the PBL Model in improving the critical thinking skills of pre-service

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physics teachers. The findings are supported by other research that the OR-IPA Model is a multi-representation physics study that can stimulate students in analyzing, synthesis, and evaluation, so that students can build their own understanding (Damon, 2015, Maor, 2001). This is also consistent with Ainsworth's research (2008, 1999); Ciais et al. (2005) which stated that multi-representation learning has three main functions, namely: as a complement, interpretation barrier, and build a more comprehensive understanding. The PBL Model has been proven to improve self-study skills and provides a more realistic picture of higher academic challenges, more confidence, improves problem-solving skills, critical thinking skills, and improved communication skills (Benade, 2017, Leong, 2017; Myers, 2017; Zabit, 2010). However, the weakness of the PBL Model is the lack of initiation and timing, lack of student discipline, and more challenging authentic issues (Ates & Eryilmaz, 2010; Thompson et al., 2012). The findings of this research are supported by questionnaire results of the responses from pre-service physics teachers that are presented in Table 6. The data in Table 6 shows that in general the students of pre-service physics teacher give positive responses to the teaching instruments of the OR-IPA Model. While the result of questionnaire response of pre-service physics teacher toward the teaching instruments and Conventional Model generally shows less positive response. The findings are supported by other research that the Conventional Model is less facilitating students in developing their critical thinking skills, so according to Hammond et al (2015) and Mann & Kaitell (2001) this resulted in low learning achievement. The student response data in Table 6 reinforces that the OR-IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model to increase the critical thinking skills of pre-service physics teacher.

The results of previous studies conducted at the State Junior High School in Jember, Indonesia showed that the OR-IPA Model and PBL Model with implemented teaching instruments can significantly improve teaching outcomes with moderate N-gain (Rosyid, Budi, & Supardi, 2013). The OR-IPA Model is a teaching model that has 5 (five) syntaxes and is designed specifically to improve the weakness of the PBL Model in improving student critical thinking skills. The OR-IPA Model is a problem-based teaching model through a multi-representation approach based on the theory of multiple intelligences, constructivist theory, cognitive theory, and multi-representation theory. Therefore, the OR-IPA Model is theoretically and empirically proven to be better than the PBL Model and Conventional Model in improving the critical thinking skills of pre-service physics teachers.

Conclusions

Based on the results of this research and discussion described above, it can be concluded as follows: (1) The teaching instruments of OR-IPA Model and PBL Model to improve the critical thinking skills of pre-service physics teachers has been prepared, including: Semester Teaching Plan, Lesson Plan, Student Learning Materials, Student Worksheet, and Critical Thinking Skills Tests of pre-service physics teacher. The Critical Thinking Skills Tests of pre-service physics teachers have fulfilled the validity requirements ($r_{\alpha} \sim .26$) and reliability ($\alpha = .96 - .99$) the content and construct can be implemented in the teaching process; (2) Teaching process by using OR-IPA Model and PBL Model is effective, as indicated by: (a) there was a significant increase in critical thinking skills of pre-service physics teachers at $\alpha = 5\%$; (b) the average N-gain of physics teaching by using OR-IPA Model and PBL Model are categorized as: moderate (.60) and moderate (.48); and (c) students' responses in each teaching process were categorized as very positive (89%). Meanwhile, physics teaching process by using the Conventional Model was ineffective, as indicated by: (a) there was a significant increase in students' critical thinking skills at $\alpha = 5\%$, (b) low N-gain (.14) and student responses were less positive (26%); and (3) There is significant difference in mean of critical thinking skills N-gain in Group-1 that is the OR-IPA Model with Group-2 that is PBL Model, Group-1 that is the OR-IPA Model with Group-3 that is Conventional Model; Group-2 that is PBL Model with Group-3 that is Conventional Model, for each at $\alpha = 5\%$. Physics teaching process with OR-IPA Model is more effective in improving student critical thinking skills when compared to PBL Model and Conventional Model. The average N-gain of critical thinking skills of pre-service physics teachers was higher after teaching process with the OR-IPA Model when compared to PBL Model and Conventional Model. Implication of this research is that the OR-IPA Model can be an innovative solution to improve critical thinking skills, but there is still a need for repetitive research like this.

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Appendix

CRITICAL THINKING SKILLS TEST
BASIC PHYSICS I

Maximum Time: 3 x 50 minutes.

1. Suppose you are a high school physics teacher should buy just one long measuring instrument to teach your students how to measure book thickness (± 70.0 mm). Meanwhile, there are two options: ruler and sliding term. Based on the advantages and disadvantages of each gauge, which measuring tool would you buy? Give reasons!
2. There are several length measuring instruments as shown in Figure 1, namely: screw micrometer, slider term, and ruler. A student wants to measure the "inner diameter" of a pipe that is approximately 50.0 mm. Which measuring tool is the most accurate for that purpose? Give your arguments!



Screw micrometer　　Slider term　　Ruler

Figure 1: Length measuring tool

3. Suppose you are a physics teacher who are assigning your three students; each of your students is asked to measure the depth of a ± 80.0 mm pipe with a very small diameter, ± 10.0 mm in a measurement laboratory. Within several minutes later, your students get back and say that they are not successful in measuring the depth of the pipe even though the laboratory has a measuring instrument. What is your conclusion about the length measurement problem? Give your reasons!
4. Two cars move straight in the opposite direction as shown in Figure 2. Car I has a speed of 72.0 km / h to the south. After 4 minutes then car II departs with speed 80.0 km / h to the north. If the distance between the two cars is 20.0 km, what will happen after the car I run for 10.0 minutes? Give your reasons!

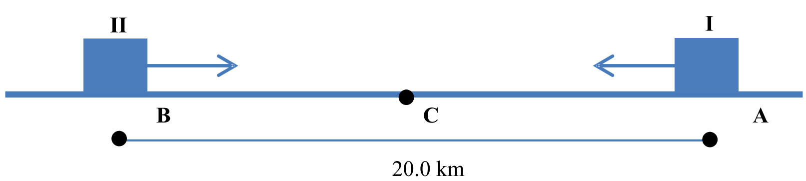

Figure 2: Two cars move straight in the opposite direction

5. An eagle perched on tree limb 19.5 m above the water spots a fish swimming near the surface. The eagle pushed off from the branch and descends toward the water. By adjusting its body in flight, the eagle maintains a constant speed of 3.1 m/s at an angle of 20.0^0 below the horizontal. After 17.0 s flew from the branch into the water, did the eagle catch the fish? Give your arguments!
6. Figure 3 shows position - time graphs for Joszi and Heike paddling canons in a local river; (a) Interpret the position of Joszi against Heike after Heike moves: 0.5 h, 1 h and 1.5 h, (b) What is your conclusion about the rate of the canons.

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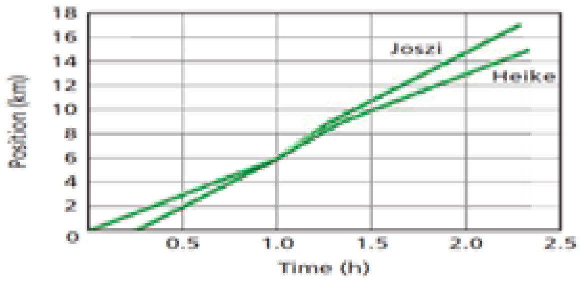

Figure 3: Position - time graphs for Joszi and Heike

(Source: Zitzewitz, et al. 2005)

7. The archerfish hunts by dislodging an unsuspecting insect from its resting place with a stream of water expelled from the fish's mouth (Figure 4). Suppose the archerfish squirts water with an initial speed of 2.3 m/s at an angle of 19.5^0 above the horizontal. When the stream of water reaches a beetle on a leaf at height 30.0 mm above the water's surface will water wet the beetle's body? Give your reasons!

Figure 4: The archerfish hunts by dislodging an unsuspecting insect

(Source: Zitzewitz, et al. 2005)

8. A park ranger driving on a back country road suddenly sees a deer "frozen" in the headlights. The ranger, who is driving at 11.4 m/s, immediately applies the breaks and slows with an acceleration of 3.8 m/s^2. If the dear is 20.0 m from the ranger's vehicle when the breaks are applied, what will happen with the ranger's vehicle? Give your reasons!
9. Observation at the rate of a running car produces graph in Figure 5. Based on the graph, interpret when is the car accelerated and how fast is the car after traveling 30.0 km? Give your reasons!

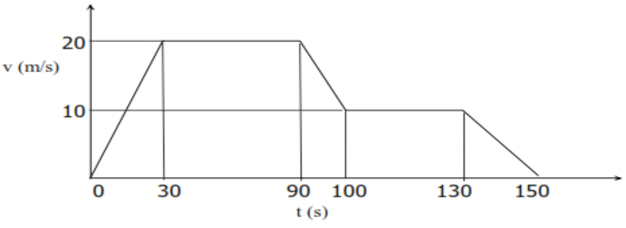

Figure 5: Graph of time - rate for a moving car

(Source: Santoso, 2004)

10. A roadway is banked at proper angle, a car can round a corner without any assistance from friction between the tires and the road. If the angle of the road bend is 26.7^o, is the 900-kg car traveling at 20.5 m / s in a turn of the radius of 85.0 m crossing the bend will be safe? Give your reasons!
11. How would you interpret the sprinter's velocity and acceleration as shown in the graph in Figure 6? Give your reasons!

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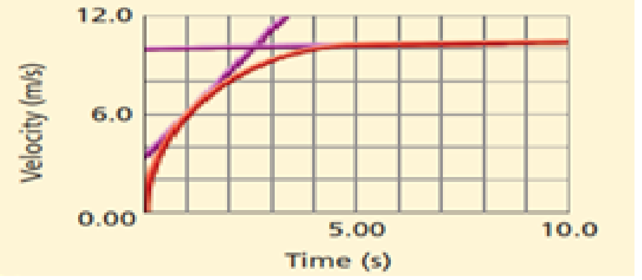

Figure 6: Sprinter's velocity and acceleration

Source: Zitzewitz, et al. 2005

12. A 1200.0 kg car rounds a corner of radius r = 45.0 m. The coefficient of static friction between the tires and the road is 0.8, what can the car run in corner without skidding? Give your reasons!
13. While driving along a country lane with a constant speed of 17.0 m/s, you encounter a dip in the road (Figure 7). The dip can be approximated as a circular arc, with a radius of 65.0 m. If the car seat is only able to withstand 1000.0 N loads, will the car seat be damaged when a mass of 80.0 kg sits in the car seat while the car is at the bottom of the dip as the car's position on the image? Give your reasons!

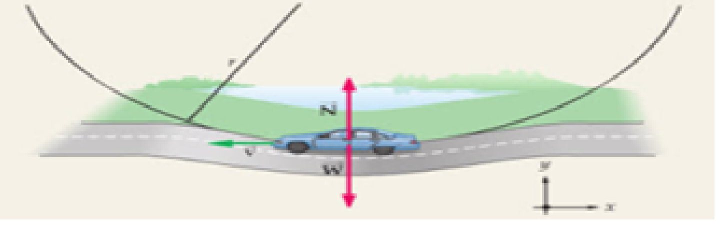

Figure 7: A car crosses the road on a decreasing radius with a radius of 65.0 m depth

(Source: Zitzewitz, et al. 2005)

14. Two youngsters dive off an overhang into a lake. Diver 1 drops straight down, Diver 2 runs off the cliff with an initial horizontal speed v_0. Evaluate the splashdown speed of Diver 2, is **(a)** greater than, **(b)** less than, or **(c)** equal to the splashdown speed of Diver I? Give your arguments!
15. If the height *h* is increased the previous example but the width *w* remains the same, Evaluate the minimum speed needed to cross the crevasse, does it **(a)** increase, **(b)** decrease, **(c)** or stay the same? Give your arguments!
16. From the data indicates that many vehicles are slip when passing a bend in a particular place, what is your conclusion about the path? Give your arguments!

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Re: Paper submission from

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Submitted on Sunday, December 17, 2017 - 03:41

Budi Jatmiko . <budijatmiko@unesa.ac.id> Tue, Jan 23, 2018, 6:51 AM

to Journal

Dear Editor,

On December 19, 2017 I have submitted an emal with the title: THE COMPARISON OF ORIENTATION IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILL OF PHYSICS TEACHER CANDIDATES, but until now I have not received the review results from JBSE, what should I do?

Regards,
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Budi Jatmiko . <budijatmiko@unesa.ac.id> Fri, Feb 2, 2018, 9:57 PM

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On December 19, 2017 I have submitted an manuscipt with the title: THE COMPARISON OF ORIENTATION IPA TEACHING MODEL AND PROBLEM BASED LEARNING MODEL EFFECTIVENESS TO IMPROVE CRITICAL THINKING SKILL OF PHYSICS TEACHER CANDIDATES, but until now I have not received the review results from JBSE, While on January 7, 2018 I have sent a second manuscipt with the title "THE PRACTICALITY AND EFFECTIVENESS ...." On this day of February 2, 2018 I have received the revised manuscript. What should I do with manuscript with the title "The Comparation ...."? Should I send it again?

Journal of Baltic Science Education <mail.jbse@gmail.com> Fri, Feb 2, 2018, 10:00 PM

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Paper after the review process. Corrections are needed

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Dear author (s),

We send to you your manuscript with some remarks after the review process. Please make all corrections asap, but not later than **20 February 2018**. If you want to reject this paper please inform us asap. Your explanation / rebuttal letter should be added (Each comment from the referee, the author (s) should explicitly state whether they made a requested change or, if not, they must explain their reasons in detail).
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2 Attachments

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Many thanks.

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Journal of Baltic Science Education <mail.jbse@gmail.com> Mar 30, 2018, 3:37 PM

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Sincerely,

Editor

--

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Attachments area

Budi Jatmiko . <budijatmiko@unesa.ac.id> Apr 3, 2018, 1:50 PM

to Journal

Dear Editor,

I have submitted a pre-final manuscript entitled "THE COMPARISON OF OR-IPA ...." which we have revised. Hopefully this revised result is in line with your expectations.

Sincerely,
Budi Jatmiko - Author

Attachments area