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The Validity and Practicality of The PEPSA Teaching Model to Improve Critical Thinking Skills through Online Tutorials in Open and Distance Education

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Abstract

A PEPSA teaching model consists of five steps has been developed through an innovative research and development activity. The five steps are Purpose, Explanation, Problem Solving, Summary, and Advance Drills. Every step of the five syntaxes of the PEPSA teaching model is supported both theoretically and empirically by modern education experts and observers. The aim of this research was to analyse the validity and practicality of the PEPSA teaching model in distance education which is expected to improve the critical thinking skills of physics education students, especially in learning quantum physics courses. This research was conducted using Focus Group Discussion (FGD) by inviting three experts and practitioners of the teaching model to have a focused discussion on analysing the validity of the PEPSA teaching model while analysing the practicality of the PEPSA teaching model; a limited trial was conducted in three meetings with four groups of students, each group consists of five students. While using the PEPSA teaching model, the following materials are given: the basics of quantum physics to groups of students who are considered to have the same level of ability. The data collected from FGD is then further analysed by means of validity coefficient using a single measure interrater coefficient correlation ($r\alpha$) and Cronbach's alpha (α). The results showed $r\alpha$ = 0.813 and 0.917 for content validity; $r\alpha$ = 0.827 and 0.962 for construct validity, so the PEPSA teaching model is included in the very valid and reliable category. In addition, the PEPSA teaching model is categorized as very practical to use. This is shown from the results of implementing each step in the PEPSA teaching model syntax that is easy to implement, very high student activity, and there are no significant obstacles during the learning process for all groups of students.

Keywords: *PEPSA Teaching Model, Validity of PEPSA Teaching Model, Practicality of PEPSA Teaching Model, Critical Thinking Skills, Distance Learning, Basics of Quantum Physics.*

INTRODUCTION

The Covid-19 outbreak that hit China, especially the Wuhan Province, in November 2019 quickly became an epidemic in all provinces in China and throughout the world, including Indonesia. The Covid-19 outbreak was first discovered in two Indonesian citizens who have been domiciled in Depok City since March 2020 and spread so quickly to all provinces in Indonesia. The rapid transmission of Covid-19 has forced the government to organize education, which was previously carried out through face-to-face learning, but finally carried out online learning.

In 21st century learning, the demands of the curriculum in the era of globalization and the Covid-19 pandemic require all educational institutions to carry out ICT-based innovations (Qian & Clark, 2016). Regulation of the Minister of Education and Culture of the Republic of Indonesia No. 73 of 2013 concerning the Indonesian National Qualifications Framework (NQF) requires universities to develop an appropriate curriculum so that students have the competence and critical thinking skills and mastery of Information and Communication Technology (Ministry of Education and Culture of the Republic of Indonesia, 2013; O'Sullivan, & Dallas, 2017). Based on these

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competencies, Universitas Terbuka (UT) has a very important role in pursuing the quality of learning processes and outcomes through the development of practical and effective online learning models, especially in Open and Distance Education (ODE).

LITERATURE REVIEW

Critical thinking skills can be possessed by students if a validity, practicality, and effective learning model are designed so that the teaching model can be used as a guide in planning, implementing, and evaluating learning either through online tutorials or face-to-face tutorials (Pandiangan, Sanjaya, & Jatmiko, 2017). As a material for operationalizing the teaching model, a learning device must be designed in the form of a syllabus, teaching materials, student worksheets, and evaluation instruments so that it is expected to be used in improving students' critical thinking skills in ODE. Pithers & Soden (2000) stated that to train students' critical thinking skills, a suitable and appropriate teaching model must be developed so that students are expected to have a high enthusiasm for learning and contribute to improving student learning outcomes.

The low critical thinking skills of students have something to do with the learning process that occurs. The teaching model used is the conventional teaching model, which does not facilitate students in developing critical thinking skills, which results in low student learning outcomes (Darling-Hammond et al., 2015). Therefore, to improve the learning of physics, especially in quantum physics concepts, it is necessary to find alternative solutions to developing the PEPSA teaching model (Purpose, Explanation, Problem-Solving, Summary, Advance Drills). The PEPSA teaching model is an explanation-based teaching model through the Easy Java Simulation (EJS) approach based on multiple intelligence theory, constructivist theory, cognitive theory, and andragogy theory that are practical and effective in teaching physics especially quantum physics problems. The PEPSA teaching model, as the name suggests, has five syntaxes; those are (1) purpose, (2) explanation, (3) problem-solving, (4) summary, and (5) advance drills.

The PEPSA teaching model is believed to inspire students to find and solve problems in real life and to inspire students to create products to improve critical thinking skills. Authentic problem-based learning can develop critical thinking and analytical skills and direct students to exercises so that they are able to solve problems (Klegeris & Hurren, 2011). Pandiangan, Sanjaya, & Jatmiko (2017) reported that the PEPSA teaching model could significantly improve students' physics problem-solving skills and self-directed learning skills with normalized gain in the medium category in the small trial and high category in the wide trial.

UT, as a higher education institution that organizes distance education, has facilitated students with various learning materials and teaching models that can be integrated with appropriate ICT. However, almost all existing textbooks do not mention a teaching model to provide a learning experience for students of in-service teachers. Almost all learning materials provided by UT are only used as teaching tools and have not been used as teaching models. Teaching models obtained through research have not been maximal and effective because they are not used optimally. The PEPSA teaching model is very useful for improving the competence of tutors and students' skills in designing, implementing, and evaluating learning in open and distance learning. The Learning process becomes more interesting, more challenging, and more suitable to students' needs when using the PEPSA teaching model, which is assumed to be valid, practical, and effective in improving students' critical thinking skills.

Referring to existing learning needs and novelty, it is necessary to develop other teaching models to improve students' critical thinking skills in open and distance education through online learning. This research is very important in the context of developing new learning models and theories to be able to answer the skills needs of the 21st century. The low critical thinking skills of students are theoretically caused by low motivation (Kim, Sharma, Land, & Furlong, 2013), lack of responsibility (Brookfield, 2017), and low analytical skills (Paans, Sermeus, Nieweg, & Van der

Schans, 2010), and lack of discipline in learning (Nilson, 2016). Therefore, the purpose of this research is to develop a valid and practical PEPSA learning model, and it is hoped that it can be used to improve students' critical thinking skills through online learning in open and distance education.

The problem in this research is how to analyse the validity and practicality of the PEPSA teaching model on the basics of quantum physics to improve students' critical thinking skills through online tutorials in open and distance education? The PEPSA teaching model is categorized as good when the content validity and construct validity are valid and reliable. The validity of the PEPSA teaching model is determined based on the validity formula r_α = [(Mean Square people - Mean Square residual)/ (Mean Square people + (k-1) Mean Square residual)] and Cronbach's alpha α = k r_α/ [1+(k- 1) r_α]. The criteria for validity and reliability of the PEPSA teaching model refer to Leech, Barret, & Morgan (2005) and Malhotra, & Birks (2010), as shown in Table 1.

Table1
Criteria for validity and reliability of the PEPSA teaching model and PEPSA learning tools

No.	Check	Scale Statistics	Criteria	Category
1	PEPSA Teaching Model Validity (r_α)	Single Measures ICC	$r_\alpha \leq$ r table	Invalid
			$r_\alpha >$ r table	Valid
2	PEPSA Teaching Model Tool Validity (r_α)	Single Measures ICC	$r_\alpha \leq$ r table	Invalid
			$r_\alpha >$ r table	Valid
3	PEPSA Teaching Model Reliability (α)	Cronbach's alpha/Average Measures ICC	$\alpha < 0.6$	Unreliable
			$0.6 \leq \alpha \leq 1.0$	Reliable
4	PEPSA Teaching Model Tool Reliability (α)	Cronbach's alpha/Average Measures ICC	$\alpha < 0.6$	Unreliable
			$0.6 \leq \alpha \leq 1.0$	Reliable

The PEPSA teaching model is practical if it meets the following requirements: (1) every step of the PEPSA teaching model syntax can be used and is easy to apply in every learning process; (2) every student has a good activity during the learning process; and (3) there are alternative solutions if there are obstacles obtained during the learning process.

The focus of this research is to analyse the validity and practicality of the PEPSA teaching model so that it can be used as a quantum physics teaching model that can improve critical thinking skills through online tutorials in open and distance education. The problems include: (1) is the PEPSA teaching model developed valid both in content validity and construct validity? (2) is the syntax of the PEPSA teaching model usable and easy to apply at every step of learning quantum physics? (3) are students active during the quantum physics learning process using the PEPSA teaching model? and (4) are there any obstacles and difficulties in implementing the PEPSA teaching model?

RESEARCH METHOD

General Research Background

This research focused on analysing the validity and practicality of the PEPSA teaching model. The PEPSA teaching model is specifically designed to improve students' critical thinking skills through online tutorials in open and distance education before and after using the PEPSA teaching model. The validity of the PEPSA teaching model is determined based on the difference between the mean square people score and the mean square residual score, while the reliability of the PEPSA teaching model is determined based on Cronbach's alpha. Likewise, the practicality of the PEPSA

teaching model is determined based on significant scores for the three practicality indicators of the PEPSA teaching model.

Research Sample

This research uses a Focus Group Discussion (FGD) by presenting experts and practitioners of teaching models. FGDs were conducted for discussions that focused on analysing the validity of the PEPSA teaching model, while to analyse the practicality of the PEPSA teaching model, a limited trial was conducted on sixty students participating in an online tutorial for an introductory quantum physics course from all over Indonesia in three meetings with four groups of students, each the group consists of five students with the same level of critical thinking skills in understanding the basics of quantum physics.

Research Instruments and Procedures

This research is classified as quasi-experimental research using one group pre-test and post-test design, namely: O1 X O2 (Frankel, Wallen, & Hyun, 2012). The PEPSA teaching model (X) was first validated by three physics education experts until the model was declared valid and reliable. Furthermore, the PEPSA teaching model that is already valid and reliable based on the expert is used in physics learning for the basics of quantum physics. The research was conducted by giving a pre-test (O1) to a group of students with material on the basics of quantum physics-based on indicators of critical thinking skills, then giving learning using the PEPSA teaching model (X) to a group of students.

The validation process of the PEPSA teaching model was carried out through FGDs by presenting three experts. Prior to the implementation of the FGD, the researcher sent materials to be validated by experts in the form of a Learning Process Design, a prototype of the PEPSA teaching model, a prototype of learning materials for the basics of quantum physics based on the PEPSA teaching model, student activity sheets, observation instrument sheets, response and interview instrument sheets, pre-test and post-test of critical thinking skills, as well as model validation instrument sheets and PEPSA teaching model tools to be studied before the FGD. The FGD aims to validate the PEPSA teaching model with learning experts. The result of this FGD is to obtain validity PEPSA teaching model validation results and some very useful inputs.

The limited trial process was carried out using the PEPSA teaching model, including syllabus, lesson plans, modules for students, and student worksheets. Based on the experts, the PEPSA teaching model and the PEPSA teaching model tools have been validated in terms of content validity, construct validity, and determining reliability. The learning process applied in the limited trial research is using the PEPSA teaching model with the following steps: (1) Purpose, (2) Explanation, (3) Problem-Solving, (4) Summary, and (5) Advance-Drill. Finally, after the learning process, the four groups were asked to do a post-test with the same material as the pre-test.

Research Data Analysis.

The PEPSA teaching model was validated by experts based on content validity and construct validity. Content validity is a description of the need and novelty, while construct validity is a description of the consistency between the PEPSA teaching model with theory, empirical, and consistency between model components (Plomp, & Nieveen, 2007). To analyse the validity and reliability of the PEPSA teaching model, each uses the single measures Interrater Coefficient Correlation (ICC) and Cronbach's Alpha. Meanwhile, to analyse the practicality of the model, both the implementation of the syntax, student activities, and alternative barrier solutions were carried out using triangulation, inferential statistical tests, Cronbach Alpha, and qualitative

descriptive. The method of analysing research data for the validity and practicality of the PEPSA teaching model is shown in Table 2.

Table 2
Research Methods and Data Analysis for the validity and practicality of the PEPSA teaching model

Variable	Data	Data Analysis Methods
The validity of the PEPSA teaching model	Expert validation results on the PEPSA teaching model	▪ Triangulation ▪ Inferential statistical test (interrater correlation coefficient and Cronbach Alpha) ▪ Qualitative descriptive
	Expert validation results on the PEPSA learning model instrument	▪ Triangulation ▪ Inferential statistical test (interrater correlation coefficient and Cronbach Alpha) ▪ Qualitative descriptive
The practicality of the PEPSA teaching model	The results of observations on the implementation of syntax, reaction principles, and social systems	▪ Triangulation ▪ Inferential statistical test (interrater correlation coefficient and Cronbach Alpha) ▪ Qualitative descriptive
	Student activity observations	▪ Triangulation ▪ Inferential statistical test (interrater correlation coefficient and Cronbach Alpha) ▪ Qualitative descriptive
	Observation results on existing obstacles	▪ Triangulation ▪ Inferential statistical test (interrater correlation coefficient and Cronbach Alpha) ▪ Qualitative descriptive

FINDINGS AND DISCUSSION

Characteristics of the PEPSA Teaching Model

PEPSA teaching model is a physics teaching model designed based on explanation and problem-solving. PEPSA teaching model is based on the results of studies and preliminary studies so that it can train students' critical thinking skills in Open and Distance Education (ODE). According to Arends (2014), there are four characteristics of the teaching model that must be developed so that it is effectively used; those are (1) logical theoretical rationale from its design, (2) components and activities of students/tutors in teaching so that learning can be carried out well, and (3) a supportive learning environment to achieve learning objectives. Furthermore, the characteristics of the developed PEPSA teaching model can be explained as follows.

1. Rationalization of the PEPSA Teaching Model

The physics teaching model developed in this research was specifically to train students' critical thinking skills in ODE (Marin & Halpern, 2011). Students' critical thinking skills in learning physics are based on the characteristics of abstract physics material and are considered relatively difficult and complex (Ersoy & Güner, 2015), and although students show reasonable abilities in problem-solving skills, there is evidence that conceptual understanding and critical thinking skills

most students are still very weak (Jennifer, Strand, Mestre, & Ross, 2015; Pandiangan, Jatmiko, & Sanjaya, 2015).

The PEPSA teaching model, which was developed to train critical thinking skills, is based on the flow of critical thinking skills, according to Ennis (2011). Ennis suggests that critical thinking is a process consisting of (1) analysis, (2) assessing, and (3) improving. Through the PEPSA teaching model developed, it is hoped that students can build initiative and persistence in the learning process to think critically, independently, and actively build their independence in learning physics from their personal experiences with other people, as well as with the surrounding environment. The PEPSA teaching model is expected to be able to develop students' critical thinking processes and skills in applying the view of cognitive constructivism, namely the disequilibrium condition of student thinking to foster learning motivation, the importance of the availability of a learning environment, and the availability of materials and tasks that stimulate the development of creativity in the learning process (Moreno, 2010). The developed PEPSA teaching model is specifically designed to improve students' critical thinking skills in ODE, which is supported by the latest learning theories, which are: (1) motivational learning theory; (2) behavioural learning theory; (3) constructivism learning theory; (4) cognitive psychology learning theory; (5) learning theory of information processing; and (6) learning theory of andragogy.

The rationale for the sequence of each syntax in the PEPSA teaching model developed is based on theoretical studies and empirical studies, as described in Figure 1.

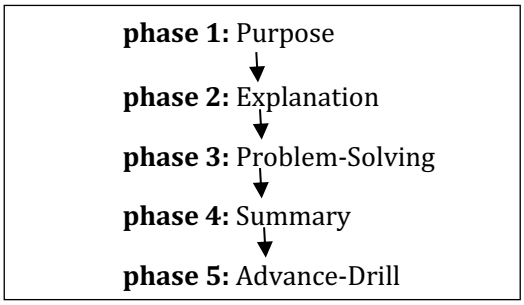

Figure 1. The syntax of the PEPSA teaching model

2. Components and Activities of Students/Tutors in the PEPSA Teaching Model

The factors that influence the success of the teaching model consist of five components; those are: (a) syntax of the teaching model, (b) social system, (3) reaction principle, (4) support system, (5) instructional and accompaniment impact (Joyce & Weil, 2003). The teaching components developed are contained in the components of the PEPSA teaching model, which can be described as follows.

a) Syntax

The syntax, tutor activities, and student activities in the PEPSA teaching model consist of five phases, as described in Table 3.

Table 3
The syntax, tutor activities, and student activities in the PEPSA teaching model

syntax	student activities	tutor activities
1. Purpose	1. Students independently listen, pay attention, observe, predict,	1. Tutor Generating student initiation by facilitating and presenting authentic

syntax	student activities	tutor activities
	and try what will happen so that they are expected to generate initiation in themselves. 2. Students independently develop general learning outcomes. 3. Students independently develop specific learning outcomes.	problems so that they are expected to be able to independently observe, predict, and try what will happen. 2. Tutor Motivates students to be able to independently develop general learning outcomes. 3. Tutor Facilitates students to be able to independently develop specific learning outcomes.
2. Explanation	1. Students with tutor direction form groups consisting of 5 members. 2. Receive Student Worksheets and necessary equipment from tutors/instructors. 3. Students independently take responsibility for studying the description of the material provided.	1. The tutor facilitates students to form groups of 5 members per group. 2. The tutor distributes the LKM and the necessary equipment to each group. 3. The tutor motivates students to be able to take responsibility for studying the description of the material given.
3. Problem-Solving	1. Students independently try to practice the given exercise. 2. Students match the answers made by students with the answer signs provided. 3. Students reflect and review concepts that are not well understood.	1. The tutor motivates students to try to practice the given exercises. 2. The tutor facilitates students to match the answers made by students with the answer signs provided. 3. Tutors facilitate students to reflect and review concepts that have not been well understood.
6. Summary	1. Students independently make reinforcement in the form of summaries and conclusions. 2. Students collect individual work in the form of Student Worksheets. 3. Students receive and record further evaluation assignments from tutors.	1. Tutors facilitate students independently to make reinforcement in the form of summaries and conclusions. 2. The tutor receives and collects the results of individual student work on the Student Worksheet. 3. Tutors give further evaluation tasks to students.
5. Advance-Drill	1. Students independently work on the formative tests given. 2. Students match the answers made by students with the answer signs provided.	1. The tutor motivates students to take the given formative test. 2. The tutor facilitates students to match the answers made by students with the answer signs provided.

syntax	student activities	tutor activities
	3. Students reflect and review concepts that have not been well understood.	3. Tutors facilitate students to reflect and review concepts that have not been well understood.

b) Social system

The social system states that the role of tutors and students in the PEPSA teaching model must be reflected in the learning syntax in the form of student and tutor activities, namely:

1. Students take the initiative and responsibility in learning activities by contributing to the critical thinking process both individually and in groups in their work teams.
2. Tutors act as facilitators, motivators, and mediators in the learning process to improve student's critical thinking skills, both individually and in groups.

c) Reaction principle

The principle of reaction relates to how the tutor pays attention and responds to students; the tutor responds to questions, answers, and responses to what students do. In this PEPSA teaching model, the way that tutors should pay attention and respond to students is as follows.

1. Tutors motivate students so that students can take the initiative and gradually take responsibility for the learning process independently.
2. Tutors can facilitate students in the learning process and become mediators for students when students need help.
3. Tutors provide feedback, appreciation, and opportunities for students to express opinions, ask questions, and provide criticism and suggestions to improve critical thinking skills.

d) Support system

The support system for a learning model is all the tools, materials, and tools needed to implement the PEPSA learning model. Learning resources and tools needed to implement the PEPSA learning model consist of Syllabus and Tutorial Activity Design (RAT), Tutorial Activity Unit (SAT), Student Worksheets (LKM), student textbooks, learning media in the form of Phet simulations, computers, or laptops, and evaluation instruments.

e) The instructional and the accompaniment impact of the PEPSA teaching model

The instructional impact is a learning outcome that is achieved directly by directing students to the expected goals, which are: students can improve critical thinking skills. While the impact of the accompaniment is the learning result produced through a learning process as a result of creating a learning atmosphere experienced directly by students without tutor guidance, namely:

1) Students can generate learning motivation which is indicated by a positive response to the implementation of learning.
2) Students can develop social interaction by developing social skills in the problem-solving process.
3) Students can develop independent learning skills, problem-solving, creative thinking, communication, collaboration, and metacognition.
4) Students can develop and build mental models through multiple representations.

3. Supportive Learning Environment

One of the important factors that can maximize learning is the existence of a supportive and conducive learning environment. The learning environment, in this case, is everything related to the place of the learning process and a conducive situation that is in accordance with the PEPSA teaching model. The learning environment is created in such a way with a student grouping system and proper seating arrangements to facilitate students in the learning process. The student grouping system is based on heterogeneity, with 5 students in each group, respectively. Student seating arrangements are made in a circle and face each other. The learning environment in each PEPSA teaching model syntax was developed in order to improve students' critical thinking skills in ODE.

Management of the learning environment PEPSA teaching model focuses on improving social skills, effective cooperation, and mutual respect, using all resources that can improve critical thinking skills of open and distance education students, problem-solving, creative thinking, communication skills, multi-representation abilities, and metacognition abilities.

PEPSA Teaching Model and Device Validity

The validation of the PEPSA teaching model and PEPSA teaching device was carried out through a series of FGD activities by presenting three physics education experts as validators. The details of the validity and reliability scores for each component item of the PEPSA teaching model and the PEPSA teaching devices are shown in Table 4.

Table 4
Validity and Reliability of PEPSA Teaching Models and PEPSA Teaching Devices

No.	Items	Content validity				Construct validity			
		validity (r_α)		Cronbach's alpha (α)		validity (r_α)		Cronbach's alpha (α)	
1	PEPSA teaching model	0.979	valid	0.986	reliable	0.972	valid	0.982	reliable
2	PEPSA teaching device	0.980	valid	0.986	reliable	0.969	valid	0.979	reliable

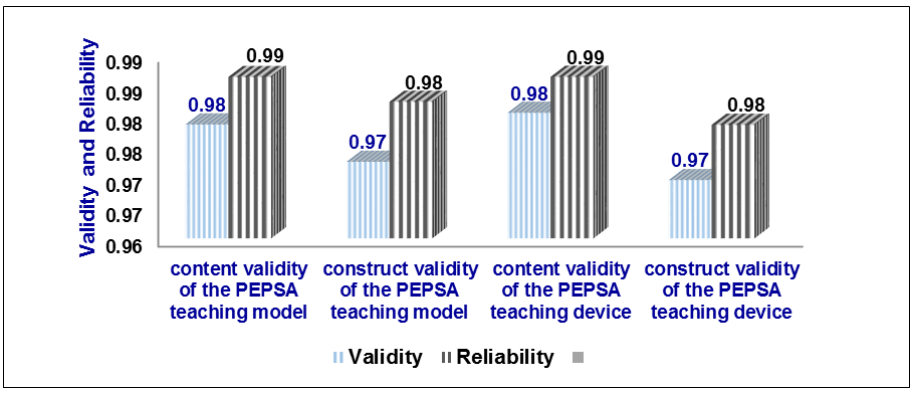

Figure 2. Validity and reliability of the PEPSA teaching model and PEPSA teaching device

Based on Table 4 and Figure 2 shows that the validity, both content validity and construct validity, and the reliability of the PEPSA teaching model are included in the valid and reliable categories. Likewise, the validity and reliability of PEPSA teaching devices consisting of the syllabus, tutorial activity units, books for students, student worksheets, critical thinking skills tests, tutor activity observation sheets, student activity observation sheets, and student responses are included in the validity and reliable categories. Based on this, the PEPSA teaching model and PEPSA teaching devices meet the criteria for a good teaching model, which are: (1) PEPSA teaching models and tools according to needs, (2) there is a novelty in model development, (3) model development is supported by the foundation strong theory and empirical, (4) has a consistency between the components that make up the model, (5) has good readability. The results of this study indicate that the PEPSA learning model developed is feasible to be used as a learning model for the basics of quantum physics to improve critical thinking skills in open and distance education.

The validation of the PEPSA teaching model and the PEPSA teaching device is in line with the research results of Armenteros, Ruiz, & Zamora (2012), which state that the validation of a product can be done through FGD activities by experts; both face to face and online. Based on the consideration of the availability of available facilities and infrastructure, the validation of the PEPSA teaching model and the PEPSA teaching device was carried out online through a Zoom meeting involving three ODE experts. The results of the FGD activities showed that the PEPSA teaching model and the PEPSA teaching device consisted of rational models, theoretical and empirical support, model syntax, social systems, reaction principles, support systems, and instructional impacts & accompaniment impacts were all included in the validity and reliable categories. Malhotra & Birks (2010) state that a product is said to be valid if it has a single measure inter-correlation coefficient of $r_{\alpha} = 0.754 > r_{table}$. In this research, the following results were obtained.

(1) The PEPSA teaching model obtained $r_{\alpha} = 0.979 > r_{table}$ for content validity and $r_{\alpha} = 0.972 > r_{table}$ for construct validity, meaning that the PEPSA teaching model developed has high content and construct validity.
(2) The PEPSA teaching device is obtained $r_{\alpha} = 0.980 > r_{table}$ for content validity and $r_{\alpha} = 0.969 > r_{table}$ for construct validity, meaning that the PEPSA teaching devices developed are all valid and reliable.

This is in line with the research result of Plomp & Nieveen (2007) and Plomp (2013), which state that a product has good quality if it is based on valid content validity and construct validity and can describe needs, novelty, consistency between model components, and supported by theory and empirical.

The PEPSA teaching model is already valid; both content validity and construct validity must be tested for consistency so that the model is stable and can be used consistently. According to Sarstedt & Mooi (2014), the reliability of a product can be stable if it meets the requirements, which are: stability of the measurement, internal consistency reliability, and inter-rater reliability. The PEPSA teaching model is said to be reliable if Cronbach's alpha coefficient (α) and Cronbach's alpha if the item deleted$\geq$ 0.60 (Leech, Barret, & Morga, 2005; Malhotra & Birks, 2010). Based on the FGD results, it was found that the reliability of internal consistency and reliability between PEPSA teaching model assessors are all reliable, as shown in Table 2 with Cronbach's alpha of 0.986 for content validity and 0.982 for construct validity. Internal consistency reliability is indicated by Cronbach's alpha if the item deleted each component starts from 0.981-0.989 for content validity and 0.979-0.999 for construct validity; this indicates that the PEPSA teaching model developed has high reliability.

Likewise, the PEPSA teaching devices developed to consist of: "syllabus, tutorial activity units, student books, student worksheets, critical thinking skills tests, tutor activity observation sheets,

student activity observation sheets, and student responses" are PEPSA teaching devices that are suitable for use to implement the PEPSA teaching model so that it fits the needs, has novelty, is supported by a strong theoretical and empirical basis, has a consistency between components, has good readability, and is suitable for use as a learning plan for the PEPSA teaching model to improve students' critical thinking skills in ODE (Nieveen & Plomp, 2007; Gugliolmino & Gugliolmino, 2011).

The results of this research are in line with the research of Seechaliao, Natakutoong, & Wannasuphoprasit (2012), which states that a valid teaching model is very helpful for researchers and practitioners in designing teaching based on understood learning principles. A valid teaching model can be used as a guide for academics and practitioners in planning a learning program (Kimbell & Stables (2007). A valid teaching model is suitable for use in physics learning that involves science processes and products so that it can be used to improve critical thinking skills, physics problem-solving skills, and self-directed learning skills (Pandiangan, Jatmiko, Sanjaya, 2017); Teal, Vess, & Ambrose, 2015).

PEPSA Learning Model Practicality

The practicality test of the PEPSA teaching model was carried out in a limited trial four times in cycles in four test groups of twenty students, each group consisting of five students, respectively. The results of the practical trial of the PEPSA teaching model are shown in Table 5.

Table 5
The practicality of PEPSA Learning Model in Limited Trial

Syntax	Results of observations and interviews	
	Tutor activity	**Student activities**
1. Purpose	Tutors have facilitated students well to initiate students, conduct and try simulations to generate student persistence, and motivate students to determine experimental goals.	Students pay attention and listen to the tutor's explanation enthusiastically about the basics of quantum physics, pay attention and try to simulate physical phenomena to generate motivation and self-initiative, students listen to the tutor's explanation and try to understand the learning objectives well.
2. Explanation	Tutors have facilitated students well to arouse students' curiosity so that they can formulate problems, identify variables, and create hypotheses.	Students can formulate problems, identify variables, and make hypotheses.
3. Problem-solving	Tutors have facilitated students to try to practice solving some important problems, matching the answers they did with the answer signs provided, reflecting and reviewing concepts that were not well understood.	Students can try to practice solving some important problems, be able to match the answers that are done with the answer signs provided, reflect, and review concepts that are not well understood.
6. Summary	Tutors have facilitated students to make reinforcement in the form of summaries and conclusions, receive and collect individual work results on student activity sheets, and provide further evaluation tasks to students.	Students can make reinforcement in the form of summaries and conclusions, receive and collect the results of individual student work on student worksheets, and receive further evaluation assignments from tutors.

Syntax	Results of observations and interviews	
	Tutor activity	**Student activities**
5. Advance-drill	Tutors have motivated students to take formative tests, match answers made by students with the answer signs provided, reflect, and review concepts that have not been well understood.	Students can take formative tests, can match answers made by students with the answer signs provided, reflect, and review concepts that have not been well understood.

Table 5 shows that the implementation of the PEPSA teaching model can be done well, student activities that are relevant to the learning material are very high, and some of the existing obstacles can be overcome so that the PEPSA teaching model is practically used in the learning process.

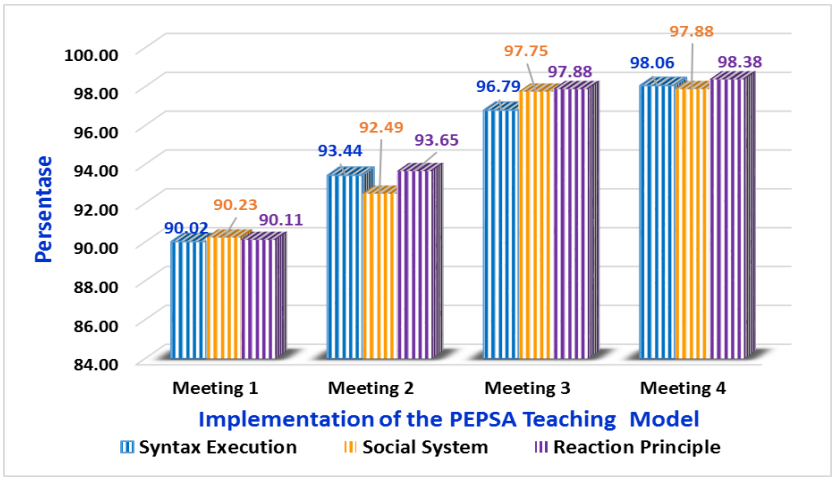

Figure 3. Implementation of the PEPSA Teaching Model

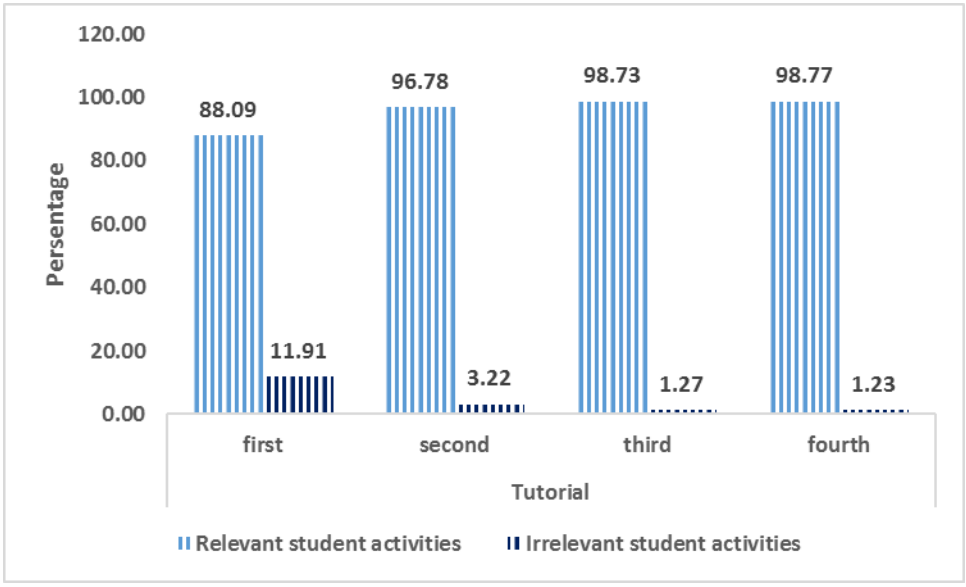

Figure 4. Student Activities Using the PEPSA Teaching Model

Based on Figure 3 and Figure 4, shows that the implementation of syntax, social systems, and reaction principles for each aspect of learning in all meetings is included in the very good category

with an achievement percentage of 90.02 – 98.38, and student activities for each aspect in the entire class are included in a very high category with the achievement of the percentage of the frequency of relevant student activities reached 88.09% - 98.77%. At the same time, the obstacles that exist in the PEPSA teaching model during the implementation of learning can be overcome properly. Based on the results and descriptions, it can be concluded that the PEPSA teaching model is practically used and implemented very well.

Based on the data on the implementation of the syntax of the PEPSA teaching model, it shows that the implementation of the syntax of each phase of the PEPSA teaching model at meeting 1 is categorized as good. However, at the 2nd to 4th meetings, the implementation of the syntax for each phase of the PEPSA teaching model was categorized as very good, and the students' ability to do the assigned tasks was categorized as very good. These findings are in accordance with the results of observations and interviews conducted with tutors in the learning process using the PEPSA teaching model. These findings are also in accordance with empirical data, which states that: providing problem orientation can significantly increase student motivation, and students gain satisfaction in participating in the learning process in the classroom (Kim, 2014; Brookfield, 2017); tutors who are able to encourage students to be involved in identifying problems can increase students' internal motivation and enthusiasm for learning so that they have a high initiative to learn (Yilmaz, 2017).

The results of this research are also supported by several learning theories, including ARCS motivation theory (Attention, Relevance, Confidence, Satisfaction) which states that a person will be motivated if what he does attracts students' attention (Arends, 2012; Pandiangan, 2019); advance organizer theory which states that the initial statement about a material to be studied provides a structure for new information and relates it to previously owned information (Moreno, 2010); giving responsibility roles to students can increase participation, active involvement, cooperation, respect for others, helping friends, and leadership in carrying out tasks (Escarti, Wright, Pascual, & Gutiérrez, 2015).

The results of this study are also supported by several learning theories, including assisted learning theory which states that tutors guide learning in such a way that students can learn thoroughly and transmit skills that can function higher cognitive (Moreno, 2010); zone of proximal development states that students learn concepts best when the concepts are in their closest developmental zone (Slavin & Davis, 2006); scaffolding theory which states that students should be given complex, difficult, and realistic tasks and then given sufficient assistance gradually to solve problems (Slavin & Davis, 2006); Cognitive apprenticeship states that a student's learning process can be carried out step by step until he reaches expertise in his interaction with an expert, whether an adult or a peer with higher knowledge (Moreno, 2010).

The high student activity as described above shows that the PEPSA teaching model is designed with a certain scenario so that it can provide a learning environment that requires students to be more actively involved in the learning process. This PEPSA teaching model fulfills one of the characteristics of learning that views the student-cantered constructivist (Arends, 2014) which states that the student cantered constructivist requires students to play an active role in the tutorial process, interact with fellow students, and participate actively in research and problem-solving activities. Based on the cognitive constructivist view, students can construct knowledge through knowing problems and reflecting on answers to existing problems (Moreno, 2010). Student activities during the learning process are in accordance with the demands of the Indonesian National Qualifications Framework (INQF) and the National Higher Education Standards (NSHE) in Indonesia, which can direct students to play an active role and be able to learn independently in carrying out learning activities.

According to the view of constructivist theory, student-cantered learning can generate student activity in learning (Slavin & Davis 2006; Moreno, 2010). The very high achievement of student activities illustrates that the PEPSA teaching model is very practical and can be implemented well. This is in accordance with the social constructivist theory, which states that students should be able to build their own knowledge through social interactions and develop deeper meanings based on their previous experiences (Greenspan, 2016). The constructivist learning approach can improve conceptual understanding, self-directed learning skills, and critical thinking skills to solve various problems (Akpan & Beard, 2016).

CONCLUSION

Based on the background, problem formulation, and research objectives, the conclusions from the results of this study are as follows.

1. The PEPSA teaching model developed is included in the very validity and reliable category, both content validity and construct validity so that it can meet the learning needs that are used to improve students' critical thinking skills in open and distance education.
2. The PEPSA teaching model is categorized as very practical to use. This is shown from the results of implementing each step in the PEPSA teaching model syntax that is easy to implement, very high student activity, and there are no significant obstacles during the learning process for all groups of students.

LIMITATIONS & FURTHER RESEARCH

This research has not been applied to a wider trial and is only used on the basics of quantum physics. This research has also been applied to students of open and distance education through online tutorials. Therefore, this research needs to be continued in wider trials involving more students and using other materials with characteristics of the same course or different subjects. In addition, it is also necessary to develop PEPSA teaching device that can accommodate face-to-face education starting from primary school, secondary school, high school, and university with various levels of education.

REFERENCES

Akpan, J. P., & Beard, L. A. (2016). Universal journal of educational research. *Using Constructivist Teaching Strategies to Enhance Academic Outcomes of Students with Special Needs, 4*(2), 392-398.

Armenteros, E. M., Ruiz, F. J., & Zamora, M. V. (2012). Differences between online and face to face focus groups, viewed through two approaches. *Journal of Theoretical and Applied Electronic Commerce Research, 7*(2), 73-86.

Arends, R. I. (2014). *Learning to teach.* New York: McGraw-Hill Companies, Inc.

Brookfield, S. (2017). *Becoming a critically reflective teacher*. John Wiley & Sons.

Seechaliao, h., Natakuatoong, O., & Wannasuphoprasit, W. (2012). The validation of an instructional design and development model based on engineering creative problem-solving principles to develop creative thinking skills of undergraduate engineering students. Singapore: IACSIT Press.

Darling-Hammond, L., Barron, B., Pearson, P. D., Schoenfeld, A. H., Stage, E. K., Zimmerman, T. D., Tilson, J. L. (2015). *Powerful learning: What we know about teaching for understanding*: John Wiley & Sons.

Ennis, R. (2011). Critical thinking: Reflection and perspective Part II. *Inquiry: Critical thinking across the Disciplines*, *26*(2), 5-19.

Ersoy, E., & Güner, P. (2015). The place of problem solving and mathematical thinking in the

mathematical teaching. *The Online Journal of New Horizons in Education, 5*(1), 120-130.

Escarti, A., Wright, P. M., Pascual, C., & Gutiérrez, M. (2015). Tool for assessing responsibility-based education (TARE) 2.0: Instrument revisions, inter-rater reliability, and correlations between observed teaching strategies and student behaviours. *Universal Journal of Psychology, 3*(2), 55-63.

Frankel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research and education* (8 ed.). New York: McGraw-Hill.

Greenspan, Y. F. (2016). *A guide to teaching elementary science.* Rotterdam, The Netherlands: Sense Publishers.

Guglielmino, L. M., & Long, H. B. (2011). Perspectives: the international society for self-directed learning and the international self-directed learning symposium. *International Journal of Self-Directed Learning, 8*(1), 1-6.

Jennifer, Strand, N. E., Mestre, J. P., & Ross, B. H. (2015). Conceptual problem solving in high school physics. *Physical Review Special Topics - Physics Education Research, 11*(2), 1-13.

Joyce, B. R., & Weil, M. (2003). *Model of teaching* (5 ed.). New Jersey: Pearson Education Inc.

Kemdikbud No.109. (2013). *Penyelenggaraan pendidikan jarak jauh pada pendidikan tinggi* [Implementation of distance education in higher education]. Jakarta: Ministry of Education and Culture of the Republic of Indonesia.

Kemdikbud No.73. (2013). *Penerapan kerangka kualifikasi nasional Indonesia* [Application of Indonesia's national qualifications framework]. Jakarta: Ministry of Education and Culture of the Republic of Indonesia.

Kim, K., Sharma, P., Land, S. M., & Furlong, K. P. (2013). Effects of active learning on enhancing student critical thinking in an undergraduate general science course. *Innovative Higher Education*, *38*(3), 223-235.

Kimbell, R., & Stables, K. (2007). *Researching design learning: issues and findings from two decades of research and development.* London: Springer.

Klegeris, A., & Hurren, H. (2011). Impact of problem-based learning in a large classroom setting: student perception and problem-solving skills. *Advances in physiology education, 35*(4), 408-415.

Leech, N. L., Barret, K. C., & Morga, G. A. (2005). *SPSS for intermediate statistics: Use and interpretation* (2 ed.). New Jersey: Lawrence Erlbaum Associates, Inc.

Malhotra, N. K., & Birks, D. F. (2010). *Marketing research: An applied approach* (3 ed.). Italy: Trans-Atlantic Publication, Inc.

Marin, L. M., & Halpern, D. F. (2011). Pedagogy for developing critical thinking in adolescents: Explicit instruction produces greatest gains. *Thinking Skills and Creativity*, *6*(1), 1-13.

Moreno, R. (2010). *Educational psychology.* USA: John Wiley & Sons, Inc.

Nilson, L. B. (2016). *Teaching at its best: A research-based resource for college instructors*. John Wiley & Sons.

O'Sullivan, M. K., & Dallas, K. B. (2017). A collaborative approach to implementing 21st century skills in a high school senior research class. *Education Libraries*, *33*(1), 3-9.

Paans, W., Sermeus, W., Nieweg, R., & Van der Schans, C. (2010). Determinants of the accuracy of nursing diagnoses: influence of ready knowledge, knowledge sources, disposition toward critical thinking, and reasoning skills. *Journal of Professional Nursing*, *26*(4), 232-241.

Pandiangan, P., Jatmiko, B., & Sanjaya, I. M. (2015). *Investigasi kesiapan belajar mandiri mahasiswa program Inservice training pada pendidikan terbuka dan jarak jauh* [Investigating the readiness for independent learning of Inservice training program students in open and distance education]. *Physics National Seminar*. Jember: UNEJ Publisher Press.

Pandiangan, P., Sanjaya, M., Gusti, I., & Jatmiko, B. (2017). The Validity and Effectiveness of Physics Independent Learning Model to Improve Physics Problem Solving and Self-Directed Learning Skills of Students in Open and Distance Education Systems. *Journal of Baltic Science Education*, *16*(5).

Pandiangan (2018). *Pengembangan Perangkat Model Physics Independent Learning Bahan Ajar Gelombang dan Bunyi untuk Meningkatkan Keterampilan Belajar Mandiri dan Keterampilan Berpikir Kritis Mahasiswa pada Pendidikan Jarak Jauh* [Development of Physics Independent Learning Model Devices for Wave and Sound Teaching Materials to Improve Self-directed learning and Physics Problem Solving Skills in Open and Distance Education]. LPPM Universitas Terbuka.

Pandiangan (2019). *Pengembangan Perangkat Model Physics Independent Learning dalam Tutorial Online untuk Meningkatkan Keterampilan Belajar Mandiri dan Keterampilan Pemecahan Masalah Fisika pada Mata Kuliah Pengantar Fisika Kuantum* [Development of Physics Independent Learning Tools in Online Tutorials to Improve Self-directed learning and Physics Problem Solving Skills in Introductory Quantum Physics Courses]. LPPM Universitas Terbuka.

Pithers, R. T., & Soden, R. (2000). Critical thinking in education: A review. *Educational research, 42*(3), 237-249.

Plomp, T. (2013). Preparing education for the information society: the need for new knowledge and skills. *International Journal of Social Media and Interactive Learning Environments, 1*(1), 3-18.

Plomp, T., & Nieveen, N. (2007). *An introduction to educational design research.* Paper presented at the Proceedings of the Seminar Conducted at the East China Normal University [Z]. Shanghai: SLO-Netherlands Institute for Curriculum Development.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in Human Behaviour*, *63*, 50-58.

Slavin, R. E., & Davis, N. (2006). Educational psychology: Theory and practice. New Jersey: Pearson Education Inc.

Teal, C., Vess, K. R., & Ambrose, V. K. (2015). Linking positive psychology with self-directed learning: A model of self-directed wellness. *International Journal of Self-directed Learning, 12*(1), 16-28.

Yilmaz, R. (2017). Exploring the role of e-learning readiness on student satisfaction and motivation in flipped classroom. *Computers in Human Behaviour, 70*, 251-260.