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DEVELOPMENT OF CCDSR TEACHING MODEL TO IMPROVE SCIENCE PROCESS SKILLS OF PRE-SERVICE PHYSICS TEACHERS

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Abstract. *CCDSR teaching model is physics teaching with the scientific activities by design to improve science process skills and its learning. This research was conducted to develop and produce a qualified CCDSR teaching model to improve the science process skills of pre-service physics teachers. The analysis of CCDSR teaching models' quality was done by using mean validity score, Cronbach's coefficient alpha, Paired t-test, N-gain, and ANOVA test. The results showed that the CCDSR teaching model was proved to be qualified (valid, practical, and effective) to improve the science process skills of pre-service physics teachers. Based on response results was that the CCDSR teaching model can improve the learning skills of science process skills (designing and implementing science process skills learning) owned by pre-service physics teachers. The implication of this research is that the CCDSR teaching model can be an innovative solution to improve science process skills of pre-service physics teachers.*

Keywords: *CCDSR teaching model, research and development, pre-service physics teachers, science process skills.*

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Introduction

Physics cannot be separated from systematic scientific approach process. Physics is the result of experiments and observations to produce patterns of natural phenomena (Young & Friedman, 2012). Physics involves also inventing a new hypothesis which suggests the cause of the observed natural phenomena. One of the most important aspects of physics is the science process skills (In & Tongperm, 2014). Science process skills are used by scientists to build knowledge, find problems, and make conclusions (Aydin, 2013; Karsli & Ayas, 2014). Along with its development, the process contained in scientific approach is packed more systemic in the form of skills that must be owned by pre-service physics teachers to conduct a scientific approach. This skill is called as science process skills (SPS). Science process skills are procedural, experimental, and systemic skills of science as the basis of science (Colvill & Pattie, 2002; Dogan & Kunt, 2016; Karsli & Şahin, 2009; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018; Zeidan & Jayosi, 2015), so it is important for physics teachers to have a good understanding of science process skills. Thus, students study physics is not enough just to remember and understand the physics concepts that scientists find, but they can behave like a scientist in discovering the concepts of physics. Students use the science process skills as basic skills to master physics (Prayitno, Corebima, Susilo, Zubaidah, & Ramli, 2017; Zakar & Baykara, 2014). Science process skills can be developed in a scientific approach-based learning (Karsli & Ayas, 2014; Zakar & Baykara, 2014).

The results showed that when the early science process skills are low, it will hamper the learning process in the classroom (Arabacioglu & Unver, 2016; Dogan & Kunt, 2016; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018). Some researchers showed that the quality of education, science process skills of physics teachers and learners in Indonesia is still relatively low (Bakri & Raharjo, 2015; Limatahu, 2017; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018). Reinforced by the results preliminary studies (Limatahu, 2016) show that: (1) The quality of pre-service physics teachers' science process skills in Indonesia is generally considered to be low, (2) Teachers and lecturers have limited time to develop learning models and tools that emphasize science process skills, and (3) Pre-service physics teachers still have trouble in using science process skills in learning. The results of these preliminary studies indicated that there is a need for a learning model that can improve sciences process skills of pre-service physics teachers in Indonesia.

The inquiry model of learning can overcome problems about the weakness of science process skills. The advantages of inquiry learning model are (1) Increase student learning motivation, (2) Give students the opportunity to think carefully about ideas, problems, and questions, (3) Provide opportunities for students to participate fully that will increase their curiosity both inside and outside the classroom, (4) Encourage students to have a spirit of initiative, (5) Encourage patience, cooperation, unity, and decision making among students, (6) Improve students' understanding of science process skills, conceptual understanding, and relationships, and (7) Provide educational rights and knowledge that enable them to explore the social environment (Arabacioglu & Unver, 2016; Berg, Bergendahl, & Lundberg, 2003; Crawford, 2000; Crockett, 2002; Dewi, Poedjiastoeti, & Prahani, 2017; Luft, 2001). This inquiry model is able to develop the basic skills that are necessary in working and in everyday life in the 21st century (Gerald, 2011; Opara & Oguzor, 2011). The previous research found that the inquiry model was able to improve the science process skills of teacher candidates, high school students, and junior high school students (Arabacioglu & Unver, 2016; Prahani, Winata, & Yuanita, 2015; Stone, 2014; Sudiarman, Winata, & Susantini, 2015).

Some of these studies showed that the inquiry model can improve the science process skills, but in its implementation, there are still some weaknesses that need to be improved. The results of the literature study indicated the weakness of the inquiry model in improving the science process skills. (1) The results of Fellenz (2004) and Kirschner, Sweller, & Clark (2006) showed that the inquiry model has a challenge that is when students are frustrated, they will not find the idea. (2) The recommendation of Alkan (2016) is that learning requires a scientific process and teacher candidates must be equipped with the skills of the science process to improve their quality. (3) The results of Harlen (2014) suggested that the inquiry model can improve the science process skills and understanding of learners' concepts through scientific activities, but it still needs an action from teachers or lecturers that are capable to develop other skills. The results of this research indicated that at the college level, the inquiry-learning model has not yet touched the science process skill for teacher candidates. (4) Reinforced by the results of Arabacioglu & Unver (2016), which found that there is no integration of skills training in the science process and the skills of teacher candidates to plan the learning by using various learning resources in order to create active learning, and the process of reflection in learning is still poorly implemented. That research is limited and stops at the activities of teaching science process skill for students and teacher candidates only; it is not yet about how to learn designing and implementing science process skills learning to improve science process skills for students.

The results of the above studies indicated that innovation is still needed from the inquiry model, which is specifically developed to improve the science process skills for pre-service physics teachers. The innovation of this research is to develop and produce CCDSR teaching model with the main objective to improve the science process skill of pre-service physics teachers and have a companion effect that teacher candidates can improve the way of teaching science process skills to the students. The CCDSR teaching model is a physics learning with the scientific approach by design approach to improve science process skill and its learning of pre-service physics teachers (Limatahu, 2017) is based on Modelling process flow by Bandura and is supported by learning theories, they are cognitive-social constructivist theory, cognitive learning theory, behavioural learning theory, and learning theory behaviours and motivational learning theories (Arends, 2012; Moreno, 2010; Slavin, 2011). The CCDSR teaching model consists of five phases; they are (1) Condition, (2) Construction, (3) Development, (4) Simulation, and (5) Reflection. Each phase of the CCDSR teaching model by design improve the science process skill indicators including: formulating problems, formulating hypothesis, identifying variables, defining operational variables, designing experiments, collecting data, making an observation recapitulation, conducting analysis, and formulating conclusions (Dogan & Kunt, 2016; Limatahu, 2017; Limatahu, Suyatno, Wasis, & Prahani, 2018).

Problem of Research

The problem of this research was to analyze the development of a qualified CCDSR teaching model. This research was conducted to find an answer to the following questions: (1) What is the validity of CCDSR teaching model to improve the science process skills of pre-service physics teachers? (2) What is the practicality of CCDSR teaching model to improve science process skills of pre-service physics teachers? (3) What is the effectiveness of CCDSR teaching model to improve the science process skills of pre-service physics teachers? According to Limatahu (2017) a companion affects that pre-service physics teachers can improve the way of teaching science process skills to the students. This research was conducted on basic physics course by using CCDSR teaching model which emphasizes the improvement of science process skill and its learning through scientific approach activities (Limatahu, Wasis, Suyatno, & Prahani, 2018).

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Focus of Research

The focus of this research was to develop a qualified CCDSR teaching model. The quality of the CCDSR teaching model was determined based on: Validity (content and construct, and reliability), practicality, and effectiveness of the CCDSR teaching model to improve the science process skills of pre-service physics teachers. The validity of the CCDSR teaching model was determined to be at least to satisfy the valid criteria (content and construct, and reliability). The practicality of CCDSR teaching model is determined at least on the criteria of applicable enough (score 1-2, from maximum score 4). The effectiveness of the CCDSR teaching model is determined by: (1) Significant improvement (statistically) on the score between pre-test and post-test of science process skills, (2) The average of n-gain was determined at least on the low improvement criteria, (3) The consistency of the average score of n-gain students of pre-service physics teachers' science process skills, and (4) The response of pre-service physics teachers was determined to be at least positive enough.

Methodology of Research

General Background

This research was conducted at University of Khairun and STKIP Kie Raha (Ternate, Indonesia). The sample of this research was pre-service physics teachers who take the basic physics course in academic year 2016/2017 and 2017/2018. This research is categorized as Research and Development (R & D). The main product was qualified as CCDSR teaching model to improve the science process skills of pre-service physics teachers. The quality of the CCDSR teaching model was determined based on validity, practicality, and effectiveness of the CCDSR teaching model to improve the science process skills of pre-service physics teachers. The validity of the CCDSR teaching model was determined based on the results of the assessment with the average score of validity and Cronbach's alpha. The practicality of the CCDSR teaching model was determined by referring to the results of the assessment with the average score of practicality. The effectiveness of the CCDSR teaching model was analysed based on the assessments determined before and after using the CCDSR teaching model. The results of pre-test, post-test, and *n*-gain of pre-service physics teachers' science process skills were further analysed by using inferential statistics. The choice of statistical testing methods relies on fulfilling the assumptions of normality and homogeneity of variants for pre-test, post-test, and *n*-gain of the pre-service physics teachers' science process skills. *N*-gain was determined by using the equation: *n*-gain = (maximum score - pre-test score) / (4 - pre-test score) (Hake, 1998) with criteria: (1) if *n*-gain ≥ .70 (high), (2) if .30 <*n*-gain <.70 (moderate), and (3) if *n*-gain ≤ .30 (low).

Sample of Research

The selection of sample was based on the Slovin formula, i.e. Sample = [population / (1 + e^2 x population)] with error tolerance *e* = 5% (Sevilla, Ochave, Punsalam, Regala, Uriarte, 1984). A whole sample is 132 pre-service physics teachers. The sample of limited trial research was 10 pre-service physics teachers at University of Khairun (Ternate, Indonesia), odd semester of academic year 2016/2017 (2 months). The implementation stage research is a process of improving the quality of CCDSR teaching models based on the results of the large-scale trial research. Judging from the number of samples, the implementation stage research has more samples when compared to the large-scale trial research. The sample of large-scale trial research was 12 pre-service physics teachers at University of Khairun, even semester of academic year 2016/2017 (4 months) and the sample of implementation stage research was 110 pre-service physics teachers at University of Khairun and STKIP Kie Raha (Ternate, Indonesia), odd academic year 2017/2018 (4 months) of the population of 198 pre-service physics teachers taking basic physics courses.

Instrument and Procedures

This research is proposed to develop a valid, practical and effective CCDSR teaching model to improve the science process skills of pre-service physics teachers. Noting the implementation steps of education design research which was proposed by Gall, Gall, & Borg (2003), Sukmadinata (2013), and based on the considerations and needs in this study as a solution of educational problems to design and develop learning process intervention and learning environment that have meet valid criteria, practical and effective, so the implementation stages of R & D in this

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research was adapted the development flow of Gall, Gall, & Borg (2003) and Sukmadinata (2013). The reason to select this development path is based on the cyclical process in the development of a product although it is applied to smaller samples and has been proven to be effectively used by educational researchers from various countries around the world. Based on these reasons, the R & D was developed by researchers to develop the CCDSR teaching model that was simplified into three stages. The three stages are: (1) Preliminary study and development, (2) Limited trials and large-scale trial, and (3) Implementation of CCDSR teaching model. The process of such a model development cycle is believed to produce a valid, practical, and effective CCDSR teaching model. The three stages of the study are shown in Figure 1. The procedures of each stage of the study applied different methods that are in a line with the intended objectives and outcomes. In more detail, the research stages can be described as follows.

1. Preliminary studies and model development of CCDSR teaching model
   The undertaken activities in the preliminary study and development of the CCDSR teaching model were: (1) analysing the teachers' competence based on their expertise area and (2) analysing theories that support the CCDSR teaching model and empirical support related to indicators of the science process skills of pre-service physics teachers.

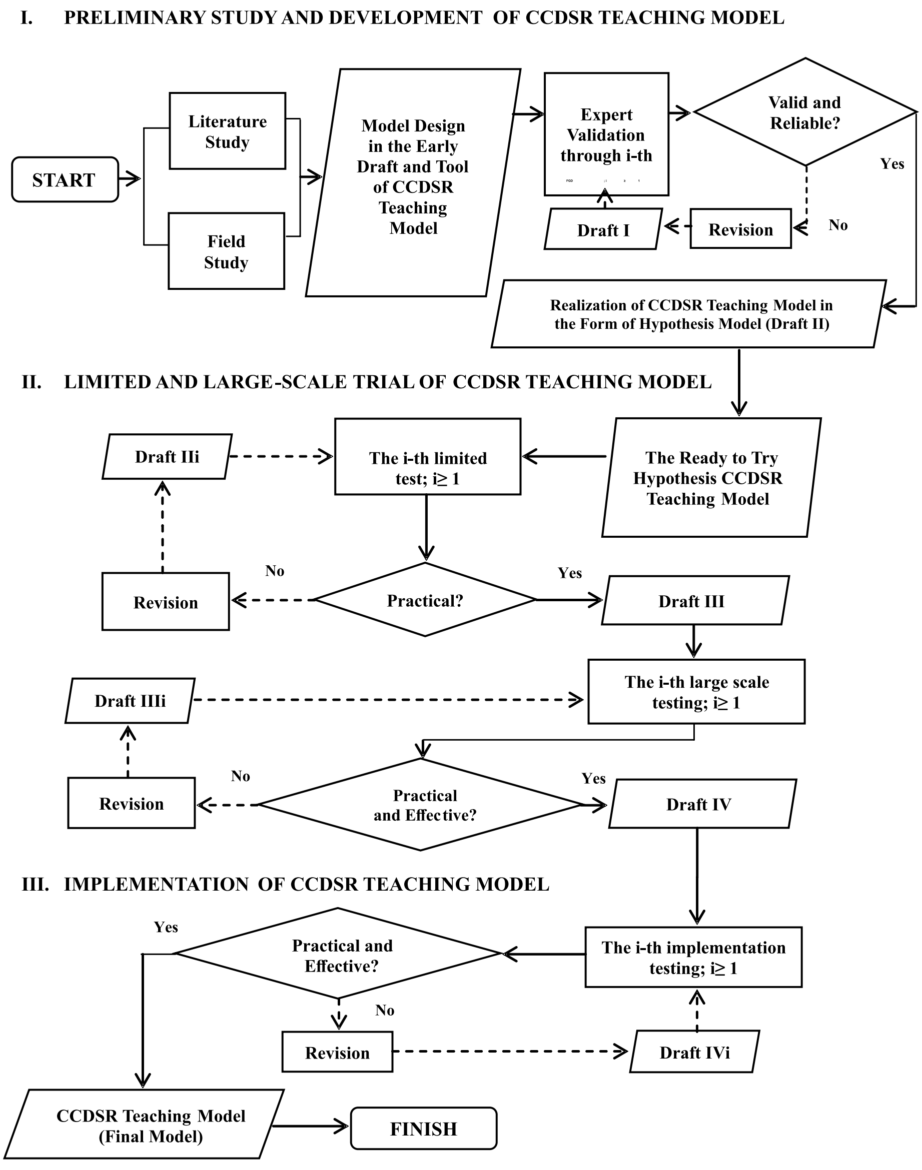

Figure 1. The research development stages of CCDSR teaching model (adapted from Gall, Gall, & Borg, 2003 and Sukmadinata, 2013).

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The preliminary research was conducted to collect data related to: (1) the science process skills of the pre-service physics teachers, (2) the learning and teaching model used in science process skill learning, (3) the supportive factors of learning and the lecturers or students' views about the learning. The result of this preliminary study is the model design in the form of CCDSR teaching model draft. The results obtained in the literature study and preliminary studies are used as materials to develop the learning device products as the operational form of CCDSR teaching model. They are: (a) development of CCDSR learning mode, (b) realization of CCDSR teaching model, (c) preparation of CCDSR teaching model (Lesson Plan, Student Worksheet, Student Learning Materials, Science Process Skills Test Sheet, Teaching Model Implementation Sheet, and Student Response Sheet), and (d) validation of CCDSR teaching model devices through Focus Group Discussions (FGD).

2. Limited trial of CCDSR teaching model
   A limited trial was conducted to test the practicality of the CCDSR teaching model toward 1 class of pre-service physics teachers in cycle of 10 pre-service physics teachers for three meetings. The practicality of the CCDSR teaching model includes the level of model execution by using teaching model implementation sheet instruments. The undertaken activities on a limited trial may be described as follows.
   (a) The researchers prepared for the implementation of the trial by determining university place that would be used for the trial, the CCDSR teaching model lecturers, and preparing the trial implementation facility.
   (b) The model lecturers were trained by using the CCDSR teaching model until they understood the procedures and steps of the CCDSR teaching model.
   (c) The lecturers conducted three lessons meetings by applying the CCDSR teaching model and it is observed by two observers. Observations were made to determine the implementation of the CCDSR teaching model syntax, social systems, reaction principle, student activities, and barriers during the learning process.
   (d) After the implementation trial of the CCDSR teaching model, responses were conducted with lecturers to find out the syntax model, social system, reaction principle, CCDSR teaching model obstacles.
   (e) The researchers revised the CCDSR teaching model and the CCDSR teaching model devices based on the responses with lecturers, pre-service physics teachers, and observers so that the CCDSR teaching model is practicality used in large-scale testing and model testing.

3. Large large-scale trial of CCDSR teaching model
   A large-scale trial of the CCDSR teaching model was conducted in 1 class (12 pre-service physics teachers) for one semester at University of Khairun (Ternate, Indonesia). The practicality of the CCDSR teaching model includes the level of the model implementation and the obstacles that can be known through the observers' observation by using the observation instrument. While the effectiveness of the CCDSR teaching model includes the improvement of pre-service physics teachers' science process skills that were measured by using the science process skills test sheet, and pre-service physics teachers' response measured by using questionnaires that were filled by pre-service physics teachers. The undertaken activities in the large-scale trial can be described as follows.
   (a) The researcher prepared the trial implementation by determining the university place that would be used for the trial, the CCDSR teaching model lecturer, and prepared the trial implementation facility.
   (b) The CCDSR teaching model lecturer was re-trained by using the CCDSR teaching model to understand the procedures and steps of the CCDSR teaching model.
   (c) The CCDSR teaching model lecturer provided pre-test. The test was used in the pre-test and was intended to measure the science process skills of pre-service physics teachers.
   (d) The lecturer conducted one semester by applying the CCDSR teaching model and was observed by two observers. Observations were made to determine the implementation of the CCDSR teaching model syntax, social systems, reaction principle, student activities, and barriers during the learning process.

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(e) The CCDSR teaching model lecturer performed a post-test, in which the test was the same as the pre-test and was intended to measure the science process skills of the pre-service physics teachers.
(f) The CCDSR teaching model lecturer gave questionnaires to the students to be filled to know the pre-service physics teachers' response about the learning which uses the science process skills of pre-service physics teachers.
(g) The researchers collected all the data obtained, processed the data, and compiled a large-scale trial report. It is followed by a research seminar.
(h) Researchers perfected the CCDSR teaching model.
(i) Refers to step (a) - (g) based on the results of large-scale trials and research seminars to obtain a valid, practical, and effective CCDSR teaching model to improve the science process skills of pre-service physics teachers to be ready to be used in implementation of CCDSR teaching model.

4. Implementation of CCDSR teaching model
The improved CCDSR teaching model based on the results of a limited trial and a large-scale trial was re-tested through the implementation of CCDSR teaching model. The CCDSR teaching model test was conducted at 2 universities, at University of Khairun and STKIP Kie Raha (110 pre-service physics teachers). This stage was proposed to test the practicality and effectiveness of the CCDSR teaching model to improve the science process skills of pre-service physics teachers and was conducted during one semester as well as to see the pre-service physics teachers' responses to the CCDSR teaching model that is used during the learning. The undertaken activities in the implementation phase of the CCDSR teaching model are the same as large-scale trial of the CCDSR teaching model. The differentiating stage was that the number of samples was enlarged and the generalization was done at different universities.

The validity of the CCDSR teaching model was measured by using the valid and reliable Validation Sheet of the CCDSR teaching model construct and content validity (Limatahu, 2017). The practicality of the CCDSR teaching model was measured by using the Learning Model Implementation Sheet that has been declared valid and reliable (Limatahu, 2017). The effectiveness of the CCDSR teaching model was measured by using the valid and reliable Science Process Skills Test Sheet (SPSTS) (Limatahu, 2017), there were 9 problems based on science process skill indicators, they were formulating of a problem, formulating of a hypothesis, identifying variables, defining operational variables, designing experiments, collecting data, making a recapitulation of observations, conducting analysis, and formulating conclusions.

The large large-scale trial and implementation of CCDSR teaching model in this research used one group pre-test and post-test design, O1 X O2 (Fraenkel, Wallen, & Hyun, 2012). The learning began by giving pre-test (O1). Each pre-service physics teacher was required to complete SPSTS. After the pre-test, the lecturer will apply the CCDSR teaching model and learning device to each group (X). Implementation of CCDSR teaching model has been done for one semester. The learning of CCDSR teaching model has five syntaxes: (1) Condition, (2) Construction, (3) Development, (4) Simulation, and (5) The complete reflection is presented in Table 1 (Limatahu, 2017; Limatahu, Suyatno, Wasis, & Prahani, 2018).

Table 1. Syntax of CCDSR teaching model.

Lecturer Activity	Pre-service Physics Teachers Activity
Phase 1: Conditioning the pre-service physics teachers (Condition)	
1. Lecturer conveys the purpose of learning and the importance of science process skills (SPS). 2. The lecturer explains the learning process that will be done. 3. Lecturer guides pre-service physics teachers to form groups (4-6 people) and distribute the worksheets.	1. Pre-service physics teachers listen to the explanation of learning objectives and description of activities to be implemented. 2. Pre-service physics teachers listen to the explanation of the learning process that will be implemented. 3. Pre-service physics teachers form groups (4-6) people and then receive the worksheets to carry out experiments in scientific approach activities.

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Phase 2: Constructing the science process skills (Construction)	
1. The lecturer presents the phenomenon and the pre-service physics teachers observe it to get one problem to be solved together. 2. Lecturer guides pre-service physics teachers to identify alternative problem solving by using SPS. 3. Lecturer guides pre-service physics teachers to conduct experimental activities (scientific approach) to train SPS as a process of internalizing their own SPS.	1. Pre-service physics teachers observe to get one problem to be solved together. 2. Pre-service physics teachers identify alternative problem solving by using SPS. 3. Pre-service physics teachers conduct experimental activities (scientific approach) to trace SPS as a process of internalizing their own SPS (formulating of a problem, formulating hypothesis, identifying variables, defining operational variables, designing experiments, collecting data, making a recapitulation of observations, conducting analysis, and formulating conclusions).
Phase 3: Developing Science Process Skills oriented tools (Development)	
Lecturer guides pre-service physics teachers to develop SPS tools (different topic with the Phase II) to improve SPS and SPS learning skills.	Pre-service physics teachers develop SPS tools (different topic with the Phase II) to improve understanding of SPS and SPS learning skills.
Phase 4: Simulation	
Lecturer guides pre-service physics teachers to simulate SPS learning tools.	Pre-service physics teachers simulate the SPS learning tools.
Phase 5: Reflection	
1. The lecturer guided to evaluate the process and results of the SPS process of pre-service physics teachers in scientific approach activities. 2. The lecturer guided pre-service physics teachers to evaluate the SPS learning skills.	1. The pre-service physics teachers evaluate the process and results of the SPS process in scientific approach activities. 2. The pre-service physics teachers evaluate the SPS learning skills.

Teaching tools consist of: Lesson Plan, Student Worksheet, Student Learning Materials, Science Process Skills Test Sheet, Teaching Model Implementation Sheet, and Student Response Sheet (valid and reliable through FGD process) (Limatahu, 2017; Limatahu, Suyatno, Wasis, & Prahani, 2018). Each phase of the CCDSR teaching model by design trains the science process skill indicators including: formulating problems, formulating hypothesis, identifying variables, defining operational variables, designing experiments, collecting data, making an observation recapitulation, conducting analysis, and formulating conclusions (Dogan & Kunt, 2016; Limatahu, 2017; Limatahu, Suyatno, Wasis, & Prahani, 2018). According to Limatahu (2017) and Limatahu, Suyatno, Wasis, & Prahani (2018), there were 9 problems based on science process skill indicators. They were: formulating of a problem, formulating of a hypothesis, identifying variables, defining operational variables, designing experiments, collecting data, making a recapitulation of observations, conducting analysis, and formulating conclusions. The implementation of the CCDSR teaching model ends with post-test (O2) by using SPSTS and Student Response Sheet. Each pre-service physics teacher is required to complete science process skills test in post-test. The pre-service physics teachers' response toward learning that implemented the CCDSR teaching model was done by giving the Student Response Sheet for pre-service physics teachers after the learning process.

Data Analysis

The validity of the CCDSR teaching model was judged by the validity of the content and the validity of the construct. The validity of the product (model) is divided into two, namely the content validity and construct validity (Nieveen, McKenney, & Akker, 2007; Plomp, 2013; Prahani, Nur, Yuanita, & Limatahu, 2016). FGD results were served as a reference to revise the CCDSR teaching model. The validity of the CCDSR teaching model is determined based on the results of the assessment with the average score of validity criteria, namely: 3.25 < Very valid ≤ 4.00; 2.50 < Valid ≤ 3.25; 1.75 < Less valid ≤ 2.50; 1.00 ≤ Invalid ≤ 1.75 (Erika, Prahani, Supardi, & Tukiran, 2018; Limatahu, 2017; Prahani, Nur, Yuanita, & Limatahu, 2016). Further analysis to determine the quality of CCDSR teaching model that has been developed in terms of the reliability of CCDSR teaching model was done by using Cronbach's coefficient alpha.

The practicality of the CCDSR teaching model was analysed by reviewing the implementation of the CCDSR teaching model observed by 2 observers. Assessment options on practical instruments consisted of impractical (score 0), less practical (score 1.00), enough practical (score 2.00), practical (score 3.00) and very practical (score 4.00). The practicality of the CCDSR teaching model was determined by referring to the results of the assessment with the average score of practicality criteria, namely: 3.25 < Very practical ≤ 4.00; 2.50 < Practical ≤ 3.25; 1.75 <

Less practical ≤ 2.50; 1.00 ≤ Impractical ≤ 1.75 (Erika, Prahani, Supardi, & Tukiran, 2018; Limatahu, 2017; Prahani, Nur, Yuanita, & Limatahu, 2016).

The effectiveness of the CCDSR teaching model was analysed based on the assessments determined before and after using the CCDSR teaching model. The results of pre-test, post-test, and *n*-gain of pre-service physics teachers' science process skills were further analysed by using inferential statistics with the help of SPSS software. The choice of statistical testing methods relies on fulfilling the assumptions of normality and homogeneity of variants for pre-test, post-test, and n-gain of the pre-service physics teachers' science process skills. Statistical test with Paired *t*-test / Wilcoxon test (analysis of statistical improvement) and *n*-gain consistency analysis of all groups after using the CCDSR teaching model was done by using ANOVA test / Kruskal-Walls test. *N*-gain was determined by using the equation: *N*-gain = (post-test score - pre-test score) / (4 - pre-test score) (Hake, 1998) with criteria: (1) if *n*-gain ≥ .70 (high), (2) if .30 <*n*-gain <.70 (moderate), and (3) if *n*-gain ≤ .30 (low). In order to see the responses of pre-service physics teachers, pre-service physics teachers' responses data was analyzed by using qualitative descriptive (Prahani, Soegimin, & 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 CCDSR Teaching Model

The developed CCDSR teaching model has been validated by 3 experts in FGD. Experts in the FGD consisted of 1 professor and 2 doctors. The CCDSR teaching model quality assessment results are presented in Table 2. Table 2 shows that the content validity of the CCDSR teaching model includes: (1) CCDSR teaching model Development Needs, (2) Advanced Knowledge, (3) Support of CCDSR teaching model Theories, (4) CCDSR teaching model Planning and Implementation, (5) Management of Learning Environment, and (6) The assessment has an average validation score of 3.60, 4.00, 4.00, 4.00, 3.00, and 4.00 with very valid and valid criteria. As for the reliability, each component of the content validity is also reliable.

Table 2. Results of the CCDSR teaching model quality assessment.

Component	Validity and reliability of CCDSR model			
	Score	Validity	α	Reliability
Content Validity				
1. Development Needs of CCDSR Teaching Model	3.60	Very Valid	.97	Reliable
2. Recent Knowledge	4.00	Very Valid	1.00	Reliable
3. Support Theory of CCDSR Teaching Model	4.00	Very Valid	1.00	Reliable
4. Planning and Implementation	4.00	Very Valid	1.00	Reliable
5. Management of Learning Environment	3.00	Valid	.97	Reliable
6. Assessment	4.00	Very Valid	1.00	Reliable
Construct Validity				Reliable
1. Overview of the CCDSR Teaching Model	3.60	Very Valid	.98	Reliable
2. Theoretical and Empirical Support	4.00	Very Valid	1.00	Reliable
3. Planning and Implementation	4.00	Very Valid	1.00	Reliable
4. Management of Learning Environment	4.00	Very Valid	1.00	Reliable
5. Implementation of Evaluation	3.00	Valid	.98	Reliable
6. Closing	4.00	Very Valid	1.00	Reliable

Note = α (Cronbach's alpha)

Table 2 shows that the construct validity of the CCDSR teaching model includes: (1) CCDSR teaching model overview, (2) Theoretical and Empirical Support CCDSR teaching model, (3) CCDSR teaching model planning and

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implementation, (4) Management of Learning Environment, (5) Implementation of Evaluation, and (6) The closing has an average validation score of 3.60, 4.00, 4.00, 4.00, 3.00, and 4.00 with very valid and valid criteria. As for the reliability of each component of construct validity is reliable.

Table 3. The result of learning and research instruments validity of CCDSR teaching model.

Components	Content Validity				Construct Validity			
	Score	Validity	α	Reliability	Score	Validity	α	Reliability
Lesson Plan	3.60	Very Valid	.96	Reliable	3.90	Very Valid	.96	Reliable
Student Worksheet	3.00	Valid	.99	Reliable	3.20	Valid	.99	Reliable
Student Learning Materials	3.00	Valid	.77	Reliable	3.10	Valid	.77	Reliable
Science Process Skills Test Sheet	3.00	Valid	1.00	Reliable	3.00	Valid	1.00	Reliable
Teaching Model Implementation Sheet	3.00	Valid	1.00	Reliable	3.00	Valid	1.00	Reliable
Student Response Sheet	3.00	Valid	1.00	Reliable	3.00	Valid	1.00	Reliable

Note = α (Cronbach's alpha)

Table 3 shows that the content validity of the learning instruments and research instruments includes: (1) Lesson Plan, (2) Student Worksheet, (3) Student Learning Materials, (4) Science Process Skills Test Sheet, (5) Teaching Model Implementation Sheet, and (6) Student Response Sheet has an average validation score of 3.60, 3.00, 3.00, 3.00, 3.00, and 3.00 with very valid and valid criteria. As for the reliability of each component of the content validity is reliable.

Table 3 shows that the construct validity of the learning instruments and research instruments includes: (1) Lesson Plan, (2) Student Worksheet, (3) Student Learning Materials, (4) Science Process Skills Test Sheet, (5) Teaching Model Implementation Sheet, and (6) Student Response Sheet has an average validation score of 3.90, 3.20, 3.10, 3.00, 3.00, and 3.00 with very valid and valid criteria. As for the reliability of each construct component is reliable. Based on the above description of Table 3, it can be said that the learning instruments of CCDSR teaching model have fulfilled the content and construct validity requirements to improve the science process skills of pre-service physics teachers. The learning instruments of CCDSR teaching model can be implemented in the learning process.

Practicality of CCDSR Teaching Model

Table 4. Implementation of CCDSR teaching model.

Phase	Group-1			Group-2			Group-3			Group-4			Group-5		
	S	*C*	*r*	*S*	*C*	*r*	*S*	*C*	*r*	*S*	*C*	*r*	*S*	*C*	*r*
1	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R
2	3.80	VP	R	3.80	VP	R	3.80	VP	R	3.80	VP	R	3.80	VP	R
3	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R
4	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R
5	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R	3.50	VP	R

Note: S (Score); C (Criteria); VP (Very Practical); r (Reliability); R (Reliable); Phase 1 (Condition); Phase 2 (Construction); Phase 3 (Development); Phase 4 (Simulation); Phase 5: Reflection

The practicality of CCDSR teaching model that has been developed is seen from the implementation of the CCDSR teaching model. Table 4 explains that all learning steps used can be very well executed and are reliable (fulfilling the practical aspect).

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Effectiveness of CCDSR Teaching Model

The effectiveness of the CCDSR teaching model is presented in Table 5, Table 6, Table 7, Table 8 and Table 9, which will be explained as follows.

Table 5. The average scores of pre-test, post-test and n-gain of SPS at all groups.

Group	*N*	Average scores pre-test, post-test and n-gain of science process skills					
		Pre-test		Post-test		*N*-gain	
Group-1	12	.10	Low	2.20	High	.50	Moderate
Group-2	30	1.00	Low	2.80	High	.60	Moderate
Group-3	30	1.00	Low	2.70	High	.50	Moderate
Group-4	25	.90	Low	2.60	High	.50	Moderate
Group-5	25	.90	Low	2.50	High	.50	Moderate

Table 5 describes the average pre-test scores, post-test and n-gain of the pre-service physics teachers' science process skills. In all groups the average pre-test score was .10 - 1.00 (low category). This is because pre-service physics teachers still have many difficulties and are unfamiliar to implement science process skills. The findings are in a line with the results of preliminary studies that science process skills are still relatively low. In contrast to post-test scores after the implementation of CCDSR teaching models, all groups of 2.20, 2.80, 2.70, 2.60 and 2.50 were all in the high category. Table 5 shows that the n-gain of pre-service physics teachers' science process skills in all groups are .50, .60, .50, .50, .50 and in the moderate category. The results of this study prove that the implementation of the CCDSR teaching model proved to be effective in improving the science process skills of pre-service physics teachers. The science process skills indicators of all groups are in Table 6.

Table 6. The science process skills indicators at all groups.

Group		Indicators of science process skills																	
		FP		FH		IV		DOV		DE		CD		MRO		CA		FC	
G1	O1	.80	L	.00	L	.00	L	.00	L	.00	L	.00	L	.00	L	.00	L	.00	L
	O2	2.80	H	3.50	H	2.50	M	2.50	M	2.80	H	2.50	M	2.50	M	2.50	M	2.50	M
	<g>	.60	M	.90	H	.60	M	.60	M	.70	M	.60	M	.60	M	.60	M	.60	M
G2	O1	.90	L	0.10	L	.90	L	.90	L	1.10	L	1.80	L	1.00	L	.90	L	.90	L
	O2	2.90	H	2.30	H	2.10	M	2.80	H	3.80	H	2.90	H	2.90	H	2.80	H	2.80	H
	<g>	.60	M	.70	M	.40	M	.60	M	.90	H	.50	M	.60	M	.60	M	.60	M
G3	O1	.90	L	.90	L	.90	L	.90	L	1.00	L	1.80	L	1.00	L	.90	L	.90	L
	O2	2.70	M	2.80	H	2.70	M	2.80	H	2.80	H	2.90	H	2.80	H	2.70	M	2.70	M
	<g>	.60	M	.60	M	.60	M	.60	M	.60	M	.50	M	.60	M	.60	M	.60	M
G4	O1	.80	L	.80	L	.80	L	.80	L	1.00	L	1.70	L	1.00	L	.80	L	.80	L
	O2	2.60	M	2.60	M	2.60	M	2.60	M	2.60	M	2.80	M	2.60	M	2.60	M	2.60	M
	<g>	.60	M	.60	M	.50	M	.60	M	.60	M	.50	M	.60	M	.60	M	.60	M
G5	O1	.70	L	.80	L	.80	L	.80	L	1.10	L	1.70	L	1.00	L	.70	L	.70	L
	O2	2.40	M	2.50	M	2.40	M	2.50	M	2.60	M	2.80	H	2.60	M	2.40	M	2.40	M
	<g>	.50	M	.50	M	.50	M	.50	M	.50	M	.50	M	.50	M	.50	M	.50	M

Note: G1 (Group 1); G2 (Group 2); G3 (Group 3); G4 (Group 4); G5 (Group 5); FP (Formulate of Problem); FH (Formulate of Hypothesis); IV (Identifying Variables); DOV (Defines Operational Variables); DE (Designing Experiments); CD (Collecting data); MRO (Make a recapitulation of Observations); CA (Conduct Analysis); FC (Formulate Conclusions); L (Low); M (Moderate); H (High)

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Table 6 shows that all the science process skill indicators in the pre-test are in the low category, whereas after the implementation of learning with the CCDSR teaching model, the result informs that all the indicators of the science process skills have increased. N-gain in general indicator of science process skills were in medium and high category (score .40 - .90). The positive result is because the implementation of learning with CCDSR teaching model was designed to improve the science process skills indicators through five phases of the CCDSR teaching model: (1) Condition, (2) Construction, (3) Development, (4) Simulation, and (5) Reflection that is presented in Table 1.

The results of the normality and homogeneity test of variance showed that the pre-test, post-test, and n-gain scores of pre-service physics teachers' science process skills were homogeneous and normally distributed for the whole group. Therefore, the impact of CCDSR teaching model implementation in improving the science process skills of pre-service physics teachers for the whole group by using Paired t-test and consistency test was done by using ANOVA test. Paired t-test and ANOVA test results are presented in Table 7 and Table 8.

Table 7. The results of paired *t*-test of science process skills at all groups.

Group	*N*	Paired t-test, α = 5%				Effect Size	
		Mean	*t*	*df*	*p*		
Group-1	12	-2.60	-10.00	11	.0001	.83	Moderate effect
Group-2	30	-1.80	-30.02	34	.0001	.84	Moderate effect
Group-3	30	-1.80	-25.50	34	.0001	.78	Moderate effect
Group-4	25	-1.70	-14.91	24	.0001	.65	Moderate effect
Group-5	25	-1.60	-16.06	24	.0001	.63	Moderate effect

Note: N (Sample)

Table 7 shows the average of science process skills for groups 1, 2, 3, 4, and 5 are -2.60, -1.80, -1.80, -1.70, -1.60 and the *t* score gives *t* value = -10.00, -30.02, -25.50, -14.91 and -16.06. Each score is considered significant, because $p < .05$. Therefore, the mean and t result of the calculation is negative, so it showed there is an increase in science process skills of pre-service physics teachers after the application of CCDSR teaching model for all groups. The result of effect size for groups 1, 2, 3, 4, and 5 (.83, .84, .78, .65, and .63) were in moderate effect category.

Table 8. The results of ANOVA test of science process skills at all groups.

ANOVA test, α = 5%	Sum of squares	*df*	Mean square	*F*	*p*
Between groups	.19	4	.04	1.50	.20
Within groups	4.10	127	.03		
Total	4.30	131			

Table 8 shows that F arithmetic gives $F = 1.50 < F_{table}$ (4,127) with significance level $p = .20 > .05$. This clearly indicates that there was no difference in the increase of science process skills of the pre-service physics teachers after the application of learning with CCDSR teaching model at all groups.

Table 9. The responses of pre-service physics teachers at all groups.

Responses of pre-service physics teachers														
Group I			Group II			Group III			Group IV			Group V		
N	*R*	*C*	*N*	*R*	*C*	*N*	*R*	*C*	*N*	*R*	*C*	*N*	*R*	*C*
12	96.00%	VP	30	95.00%	VP	30	95.00%	VP	25	93.00%	VP	25	94.00%	VP

Note: N (Sample); R (Response); C (Category); VP (Very Positive)

The increase of science process skills of pre-service physics teachers after the application of learning with CCDSR learning have been supported by pre-service physics teachers' response. The results of the pre-service physics teachers' responses are presented in Table 9. The analysis of pre-service physics teachers' response toward learning that implemented the CCDSR model was done by giving the Student Response Sheet for pre-service physics teachers after the learning process. Table 9 shows that in general pre-service physics teachers responded very positively to the CCDSR teaching model and learning instruments. Responses of pre-service physics teachers showed that pre-service physics teachers felt that their science process skills were increasing. In addition, students also feel that they have improved skills in planning and implementing science process skills. The results of this response that the CCDSR teaching model can improve the skills of planning and implementing science process skills are owned by pre-service physics teachers.

Discussion

The results in Table 2 explain that the CCDSR teaching model has been declared valid (valid in content and constructs, and reliability) by experts. The novelty of the CCDSR teaching model was built to correct the weaknesses based on existing researchers' recommendations from the inquiry model (Alkan 2016; Arabacioglu & Unver, 2016; Fellenz, 2004; Harlen, 2014; Kirschner, Sweller, & Clark, 2006). Compared to the inquiry model in improving the science process skills and SPS learning planning for pre-service physics teachers, the novelty of the CCDSR teaching model lies in phases 3, 4, and 5 that do not exist in the inquiry model. Phase 3: Developing SPS learning tools, students develop learning tools to tap into SPS learning skills about SPS (focus on learning to practice SPS). Phase 4: Simulations, students simulate SPS learning tools. Phase 5: Reflection, students evaluate the process and outcomes of the SPS and its learning skills. The CCDSR teaching model is supported by cognitive learning theory, cognitive-social constructivist theory, behavioural learning theory, and motivational learning theory (Arends, 2012; Moreno, 2010; Slavin, 2011). Experts say the CCDSR teaching model has been developed based on theoretical and empirical studies that can improve the science process skills of pre-service physics teachers. So that the CCDSR teaching model has fulfilled the validity aspect that became one of the qualified product requirements (Limatahu, 2017), CCDSR teaching model that has been valid can be used to see the next aspect that is the practicality and effectiveness of the developed model (Limatahu, Suyatno, Wasis, & Prahani, 2018; Madeali & Prahani, 2018; Plomp, 2013). The valid CCDSR teaching model is then tested for the implementation of the CCDSR teaching model conducted in Physics Education of University of Khairun and STKIP Kie Raha. Qualitative data from the pilot test of the implementation of the CCDSR teaching model is used as a reference for the revision of the CCDSR teaching model.

The practicality of CCDSR teaching model that has been developed is seen from the implementation of the CCDSR teaching model. Table 4 explains that all learning steps used can be very well executed and are reliable (fulfilling the practical aspect). This suggests that the CCDSR teaching model meets the practical aspects of improving the science process skills of pre-service physics teachers. The CCDSR teaching model consists of five phases; they are (1) Condition, (2) Construction, (3) Development, (4) Simulation, and (5) Reflection. A good learning and teaching model should have 5 (five) major components in the model, namely: (1) syntax, (2) social systems, (3) reaction principles, (4) support systems, and (5) instructional impact and impact accompanist (Joyce, Weil, & Calhoun, 2009). These five components have been met during the implementation of the CCDSR teaching model. It is supported by the practically of CCDSR teaching model that has been developed and is seen from the implementation of the CCDSR teaching model. Table 4 explains that all learning steps used can be very well executed and are reliable (fulfilling the practical aspect of five major components in the model by Joyce, Weil, & Calhoun, 2009). Another positive result is the evidence of empirical validity that the CCDSR teaching model has been well implemented and can be used in trials to improve science process skills and its learning for pre-service physics teachers. The results are relevant to Barthelemy, Dusen, & Henderson (2015), Shubert & Meredith (2015) that learning is basically an educator effort to help learners learn to gain knowledge. This is in accordance with the implementation results of the CCDSR teaching model as shown in Table 4 indicates that the learning activities in each model that have been planned in the lesson plan can be implemented by the lecturer very practically. The learning process in the developed learning and teaching model contains the components of the CCDSR teaching model. The findings of practicality of CCDSR teaching model are supported by Vygotsky social constructivist theory; this theory has three major implications: (1) social learning, (2) Zone of Proximal Development (ZPD), and (3) scaffolding (Arends, 2012; Moreno, 2010; Slavin, 2011). The CCDSR teaching model has been practical; it can be used to see the next aspect that is the effectiveness of CCDSR teaching model to improve the science process skill of pre-service physics teachers.

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The effectiveness of the CCDSR teaching model is presented in Table 5, Table 6, Table 7, Table 8 and Table 9, which will be discussed as follows. Table 5 describes the average pre-test scores, post-test and n-gain of the pre-service physics teachers' science process skills. In all groups the average pre-test score was .10 - 1.00 (low category). This is because pre-service physics teachers still have many difficulties and are unfamiliar to implement science process skills. Some researchers showed that the quality of education, science process skills of physics teachers and learners in Indonesia is still relatively low (Bakri & Raharjo, 2015; Limatahu, 2017; Suprapto, Suliyanah, Prahani, Jauhariyah, & Admoko, 2018; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018). Table 5 shows that the n-gain of pre-service physics teachers' science process skills in all groups are .50, .60, .60, .60, and .50 in the moderate category. The results of this study prove that the implementation of the CCDSR teaching model proved to be effective in improving the science process skills of pre-service physics teachers. This is because the CCDSR teaching model that has been developed meets the validity (content and construct), the practicality, and the effectiveness to improve the science process skills of pre-service physics teachers (Limatahu, 2017; Limatahu, Suyatno, Wasis, & Prahani, 2018). This is supported by the results (Erika & Prahani, 2017; Jatmiko, Prahani, Munasir, Supardi, Wicaksono, Erlina, Pandiangan, Althaf, & Zainuddin, 2018; Plomp, 2013; Prahani, Limatahu, Soegimin, Yuanita, & Nur, 2016; Prahani, Suprapto, Suliyanah, Lestari, Jauhariyah, Admoko, & Wahyuni, 2018; Purwaningsih, Suyatno, Wasis, & Prahani, 2018; Sunarti, Wasis, Madlazim, Suyidno, & Prahani 2018; Susantini, Isnawati, & Lisdiana, 2016; Susantini, Lisdiana, Isnawati, Al Haq, & Trimulyono, 2017; Suyidno, Nur, Yuanita, & Prahani, 2017) that the model meets the validity (content and construct), practicality, and effectiveness will be able to improve and achieve the learning objectives. Table 6 shows that all the science process skill indicators in the pre-test are in the low category, whereas after the implementation of learning with the CCDSR teaching model, the result informs that all the indicators of the science process skills have increased. N-gain in general indicator of science process skills were in medium and high category (score .40 - .90). The positive result is because the implementation of learning with CCDSR teaching model was designed to improve the science process skill indicator including the formulation of a problem, formulation of hypothesis, identifying variables, defining operational variables, designing experiments, collecting data, making a recapitulation of observations, conducting analysis, and formulating conclusions through five phases of the CCDSR teaching model: (1) Condition, (2) Construction, (3) Development, (4) Simulation, and (5) Reflection that is presented in Table 1. This is reinforced by research findings (Arabacioglu & Unver, 2016; Limatahu, 2017; Sudiarman, Winata, & Susantini, 2015; Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2018) that science process skills can be enhanced through inquiry process which is reflected by formulating of a problem, formulating hypothesis, identifying variables, defining operational variables, designing experiments, collecting data, making a recapitulation of observations, conducting analysis, and formulating conclusions. The results of this study are reinforced by the perspective of John Dewey (1916), schools should be the laboratory for solving real-life problems (Arends, 2012). Reinforced with a top-down process; students start with complex problems to solve and then solve or find (with the lecturers' help) the necessary basic skills (Slavin, 2012). This condition is to facilitate students in processing the concepts to be learned in learning because the beginning of learning concepts will be more remembered by students. Table 7 explains that there is a significant difference between pre-test and post-test (there is improvement) of the pre-service physics teachers' science process skills. Table 8 shows that there is no significant difference (consistency) of the pre-service physics teachers' science process skills improvement as the impact of applying CCDSR teaching model to all groups. This is because the CCDSR teaching model has been developed by design to improve the science process skills of the pre-service physics teachers that are more fully presented in Table 1 (Limatahu, 2017; Limatahu, Suyatno, Wasis, & Prahani, 2018). The results are reinforced by theoretical and empiric study that the CCDSR teaching model is a physics learning with the scientific approach by design approach to improve science process skills and its learning is based on Modelling process flow by Bandura and is supported by learning theories, they are cognitive-social constructivist theory, cognitive learning theory, behavioural learning theory, and learning theory behaviours and motivational learning theories (Arends, 2012; Moreno, 2010; Slavin, 2011). Therefore, the CCDSR teaching model is effective to improve the science process skills of pre-service physics teachers.

The increase of science process skills of pre-service physics teachers after the application of learning with CCDSR learning has been supported by pre-service physics teachers' response. Table 9 shows that in general pre-service physics teachers responded positively to the CCDSR teaching model and learning instruments. Responses showed that pre-service physics teachers felt that their science process skills were increasing. In addition, students also feel that they have improved skills in planning and implementing science process skills. The results of this response that the CCDSR teaching model can improve the skills of planning and implementing science process skills are owned by pre-service physics teachers. The findings are supported by modelling theory (Bandura, 1977) including Attention in Phase 1 (Condition); pre-service physics teachers must pay attention in the learning process. Retention in Phase 2

(Construction), so that the pre-service physics teachers' knowledge of procedural can be remembered, does repetition. Production in Phase 3 (Development), pre-service physics teachers need new problems to be solved for internalization process of their knowledge Motivation in Phase 4 (Simulation), pre-service physics teachers require further training so that potential physics teachers are motivated. The results showed that the CCDSR teaching model was proved to be qualified (valid, practical, and effective) to improve the science process skills of pre-service physics teachers.

Conclusions

CCDSR teaching model is physics teaching with the scientific activities by design to improve science process skills and its learning is based on Modelling process flow by Bandura and is supported by learning theories, they are cognitive-social constructivist theory, cognitive learning theory, behavioural learning theory, and learning theory behaviours and motivational learning theories. The CCDSR teaching model consists of five phases; they are (1) Condition, (2) Construction, (3) Development, (4) Simulation, and (5) Reflection. The results of this study prove that CCDSR teaching model quality is reviewed from: (1) The validity of CCDSR teaching model that fulfils the validity criteria (content and construct, and reliability); (2) The practicality of CCDSR teaching model belongs to very practical category (score 3.60); 3) The effectiveness of the CCDSR teaching model: (a) There is an improvement in pre-service physics teachers' science process skills at $\alpha = 5\%$, (b) Average score of n-gain of pre-service physics teachers' science process skills was .6 (medium category), (c) there is no difference (there is consistent) significant improvement in pre-service physics teachers' science process skills in all groups, and (d) Pre-service physics teachers responded positively (93.00% - 96.00% very positive). Another finding is the nurture effects of the CCDSR model can improve the skills of planning and implementing the science process skills of pre-service physics teachers. Implication of this research is that the CCDSR teaching model can be an innovative solution to improve science process skills of pre-service physics teachers. Readers or school teachers can get actual science process skills test instruments by contacting corresponding authors. Further research can explore the effectiveness of the CCDSR teaching model to enhance pre-service physics teachers' skills in teaching science process skills to students at the elementary, junior and high school levels.

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