Promoting critical thinking skills of chemistry learning students using preparing doing concluding (PDC) learning models

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Abstract. The 21st century learning paradigm emphasizes the ability of students to think at a higher level. Critical thinking skills are one part of these higher order thinking abilities. One of the learning models that can be used to answer these challenges is the PDC model. The PDC model involves students directly in the process of finding facts or information material being taught. This study aims to promoting students’ critical thinking skills using the PDC learning model. The subjects in this study were 68 students of eleventh grade at senior high school at Mataram city, Indonesia. This research is quasi-experimental with research instruments consisting of 5 open ended questions of critical thinking skills. Five indicators considered critical are studied: interpretation, analysis, evaluation, inference and explanation. The results showed that learning with the PDC model able to improve students' critical thinking skills, especially in the interpretation indicator with N-gain 0.71 in the high category, evaluation with N-gain 0.68 in the medium category, and analysis with N-gain 0.64 in the medium category.

1. Introduction
Technological advances in the 21st century have entered various aspects of life, including education. The learning of the 21st century emphasizes four things, namely critical thinking and problem solving, creativity and innovation, communication, and collaboration [1]. The curriculum in the 21st century focuses on building knowledge and encouraging students to get meaningful information to develop new skills [2].

Critical thinking is one part of 21st century learning skills. Critical thinking skills are the ability to think logically, reflectively, and productively to assess situations to make the right decision [3]. Critical thinking skills are an important aspect of education that must be developed in facing the challenges of the 21st century [4]. Developing students' critical thinking skills in learning is an effort to improve student learning outcomes [5,6]. Achievement of these skills can be achieved by the application of innovative learning models to encourage creativity and thinking skills of students.

One of the innovative and new learning models is the Preparing Dong Concluding (PDC) learning model. The PDC learning model involves students directly in the process of finding facts and information on the material being taught. Knowledge obtained by students through the steps of learning with the PDC model will be easier to remember [7]. This can be the basis for developing students' critical thinking skills.
The PDC learning model is divided into 3 phases, namely; preparing, doing and concluding. Preparing is an activity that allows students to obtain good initial knowledge through reading and discussion activities. Doing is an activity to enhance student learning activities through experimental activities and discussions. Concluding is an activity that can train students to express their opinions through presentation activities [8]. Students' critical thinking skills can be trained through learning activities in each phase of the PDC model. In addition to practicing critical thinking skills, learning with the PDC model can also strengthen students' mastery of concepts. Other research states that learning to use the PDC model can improve students' critical thinking skills [9].

The results of initial observations at the state high schools in Mataram are shown in Table 1. Data from observations were obtained through a questionnaire given to students in the academic year 2018/2019. The questionnaire contains the learning experience and students' knowledge about critical thinking skills in school.

**Table 1. Initial observation results at the state high schools in Mataram Indonesia**

| No. | Aspects contained in the Questionnaire | Answer choices | Percentage (%) |
|-----|----------------------------------------|----------------|----------------|
| 1   | Know about critical thinking skills    | Yes            | 26.67          |
|     |                                        | No             | 73.33          |
| 2   | Apply indicators of critical thinking skills in learning | Yes | 4.44 |
|     |                                        | No             | 95.56          |
| 3   | Practicing problem solving skills in learning activities | Yes | 35.56 |
|     |                                        | No             | 64.44          |

Based on the data in Table 1, it can be seen that teachers have not yet developed students' thinking skills in accordance with the development of 21st century learning. One of the challenges of learning in the 21st century is that it requires students to have high-level thinking skills. Based on these background researchers are interested in applying the PDC learning model to improve students' critical thinking skills. The purpose of this research is to find out the improvement of students' critical thinking skills taught using the PDC model.

2. Methods

This research uses experimental research methods. This type of research is quasi-experimental. The sample in this study was eleventh grade Senior High School students at Mataram city as many as 68 students. Sampling is done by random sampling. The data obtained in this study are quantitative data consisting of students' critical thinking skills data. Data about students' critical thinking skills is collected through tests of critical thinking skills. The instrument used contains a description of 5 open-ended questions. Data were analyzed using simple pre-test and post-test one group design with the help of the SPSS program. Data analysis to determine the learning device application is done using the N-gain test.

Learning activities follow the steps of the PDC learning model. The stages of learning the PDC model is divided into three phases, namely: Preparing, Doing and Concluding [10]. Learning with the PDC model is guided through the application of seven learning steps, namely: the Preparing phase includes: (1) recitation activities, (2) group discussions about the material that has been read, and (3) writing resumes from observations and reading related material. The Doing phase includes: (4) Group discussions gathering information, conducting experiments, analyzing, and solving problems, (5) Group discussions to match the results of experiments with theory, and (6) Making reports on the results of experiments. The Concluding Phase is (7) Presenting the results of an experiment and making conclusions.
3. Result and Discussion

Table 2 shows the pre-test and post-test results, it can be determined that the acquisition of N-gain or increase in critical thinking skills. The average pre-test score was 31.25 and the post-test score was 73.81. With Hake's normalized gain equation, the gain value is 0.62 which is categorized as moderate. These results can interpret that learning to use the PDC model can improve students' critical thinking skills.

Table 2. Descriptive test results from pre-test and post test

|                  | Mean | N   | Std. Deviation | Std. Error Mean |
|------------------|------|-----|----------------|-----------------|
| Pre-Test         | 31.25| 68  | 6.97           | 1.19            |
| Post-Test        | 73.81| 68  | 10.49          | 1.80            |

Figure 1. N-gain on each critical thinking skill indicator.

Furthermore, Figure 1 shows the critical thinking skills of high category, especially on the indicator of interpretation. This finding is due to students having strong initial knowledge through recitation activities in the preparing phase. The recitation method plays an important role in developing students' skills and creativity in gaining knowledge independently [11]. Students are easier to remember information that is found alone compared to information obtained from teachers through the lecture method [12, 13].

Students are very active and enthusiastic in discussing and drawing conclusions from the results of experiments that have been conducted especially at the third and fourth meetings in the class. Students quickly understand the questions in LKPD and relate them to concepts they have learned previously through recitation activities as their initial knowledge. Previous research states that students who have strong initial knowledge will more easily master new concepts [14].

The doing phase trains students in developing critical thinking skills through experimental activities, observation and discussion. Group discussion activities help students to gain new knowledge that will reinforce the concepts obtained during learning [15]. In addition, the conclusions obtained from the discussion are better understood by students, because they follow the thought process before coming to a conclusion [16]. This activity develops students' critical thinking skills, especially on the evaluation indicators. Increased critical thinking skills in the evaluation indicators can be seen in Figure 1.

The increase in critical thinking skills in the evaluation indicators is also due to the learning activities in the concluding phase, namely the stage of presenting the results of an experiment. This activity trains students to be able to provide responses and conclusions based on the results of experiments, observations and group discussions that have been conducted [17]. Based on observations during the
learning process in class, students were enthusiastic when presenting and giving responses. At this stage the teacher also helps each group to conclude the results of the experiment and relate them to the concepts they have learned. Through this activity, the teacher can see the success of students achieving learning goals [18].

Figure 1 also shows an increase in critical thinking skills in the analysis indicators with high N-gain scores. The learning process in the doing phase, students conduct experiments, observe the process and write the results of experiments to develop students' critical thinking skills. Learning by conducting observations and direct experiments in the laboratory can train the accuracy of students in analyzing data and adjusting to existing theories [19, 20]. This phase students are trained in analyzing and solving problems that correlate with increasing critical thinking skills. Learning in laboratory activities has been reported by many researchers [21, 22, 23].

4. Conclusion
Students' critical thinking skills are improved by using the PDC model. This is seen from the high N-gain scores on each indicator of critical thinking skills. Increased critical thinking skills, especially on the interpretation indicator with N-gain 0.71, evaluation with N-gain 0.68 and analysis with N-gain 0.66. The increase in the interpretation indicator is caused by the use of recitation and discussion methods in learning. The increase in critical thinking skills in the evaluation indicators is caused by the use of discussion and presentation methods. The increase in critical thinking skills in the analysis indicators is due to the experimental activities, observations and group discussions.

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