Influence of Learning Strategy of Cognitive Conflict on Student Misconception in Computational Physics Course

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Abstract. Misconception is one of the factors causing students are not suitable in to choose a method for problem solving. Computational Physics course is a major subject in the Department of Physics FMIPA UNP Padang. The problem in Computational Physics learning lately is that students have difficulties in constructing knowledge. The indication of this problem was the student learning outcomes do not achieve mastery learning. The root of the problem is the ability of students to think critically weak. Student critical thinking can be improved using cognitive by conflict learning strategies. The research aims to determine the effect of cognitive conflict learning strategy to student misconception on the subject of Computational Physics Course at the Department of Physics, Faculty of Mathematics and Science, Universitas Negeri Padang. The experimental research design conducted after-before design cycles with a sample of 60 students by cluster random sampling. Data were analyzed using repeated Anova measurements. The cognitive conflict learning strategy has a significant effect on student misconception in the subject of Computational Physics Course.

1. Introduction

Physics is a unique subject because it involves many levels of abstractions in different forms, such as, conceptual, mathematical formulation, experimental, descriptive. Knowing a phenomenon's cause, effects, and how to interact with it are some of the attributes related to understanding which also fit the purposes of learning physics [1]. For this reason, students must be known and understand the concept that they studied. Consistently, students often hold conceptions that are incompatible with established knowledge that known as misconceptions. If the number of misconceptions increases, students will have difficulty in understanding the subject's material such as Computational Physics.

The learning outcome of Computational Physics course is, student can formulation of the basic technique of numerical analysis to solve physics problem algorithmically. The creation of a flow chart is independent of a specific computer language and is useful for developing and understanding the basic structure of a program [2]. Embedding computational thinking content into required science coursework [3]. In computational thinking, students construct their experience thought to think about data and ideas, and about using and combining data and ideas to solve problems. Students have skills
in designing computational programs related to problem solving and physics phenomena as well as natural phenomena related to Physics using application program. Students have curiosity, logical thinking, critical, creative, and innovative, disciplined, confident, appreciative of others’ work, communicate, appreciative and participative.

The learning objectives of Computational Physics Courses will achieve if the lecturer encourages students to think computationally. Computational thinking is integrating the power of human thinking with the capabilities of computers. To encourage computational thinking in the classroom, teachers must ask different questions related to problem solving and the use of technology, such as what are the power and limit of human and computer intelligence [4]. Thinking computationally is systematically with well-organized groove thinking with clear flow charts.

The problem in the Computational Physics course is the student difficult to construct their knowledge through scientific procedures. Indication of this problem was a lot of students do not get mastery learning. This problem occurs due to the generative thinking ability of the underdeveloped students. Generative thinking skills students are required to understand conceptual more. A conceptual understanding is needed student to get a quantitative solution of qualitative problems [5]. The conceptual understanding of students can grow through the ability to think critically. Critical thinking allows students to discover the truth in the midst of an abundance of events and information that surrounds them [6]. Students with critical thinking will argue in an organized manner and systematically evaluate the quality of their opinions. Critical thinking of students has been growing by cognitive conflict learning strategies [7]. When the irrelevant information is associated with a response, reliance on automatic processing might facilitate the task if this response is desirable. However, when the irrelevant, automatically processed information is associated with an inappropriate response, the resulting conflict between appropriate and inappropriate responses might be difficult to overcome [8]. In order for students to construct their knowledge conceptually in learning without misconceptions required, a model of learning that can encourage students to participate actively in learning. Based on the above reasons, the use of generative thinking model based on cognitive conflict is one of the solutions to solve the problems in Computational Physics learning. Students through learning by cognitive conflict strategy will be able to reduce their misconceptions in the course of Computational Physics.

Cognitive conflict is the discomfort one feels when his beliefs, values or behaviors contradict one another. When an individual believes very strongly in something that proves to be false, he will experience conflict [9]. Cognitive conflict strategy is a part of psychological theories of conceptual change. This strategy is effective in correcting a misconception as well as in improving performance. The conflict teaching approach as a means of helping learners reconstruct their knowledge [10].

A cognitive conflict strategy emphasises destabilising students’ confidence in their existing conceptions through contradictory experiences such as discrepant events and then enabling students to replace their inaccurate preconceptions with scientifically accepted conceptions [11,12]. Among cognitive strategies, cognitive dissonance is the perception of incompatibility between two cognitions, which can be defined as any element of knowledge, including attitude, emotion, belief, or behavior. The cognitive dissonance strategy holds that contradicting cognitions serve as a driving force that compels the mind to acquire or invent new thoughts or beliefs, or to modify existing beliefs, in order to reduce conflict between cognitions [13]. Moreover, creating and resolving cognitive dissonance can have a powerful impact on students’ motivation for learning. In our case-study, we use cognitive dissonance to increase motivation for learning as well as foster students’ inner self-regulation [14]. Likewise, novice science teachers are unaware of student prior knowledge and its role in instruction to effectively implement constructivist teaching practices [15]. Science teacher educators have sought to raise pre-service science teachers’ concern about students thinking and to assist them in learning.

Cognitive conflict strategies are effective enough to address misconceptions among learners in order to establish a higher science balance [16]. Cognitive conflict stimuli in learning helps the assimilation process become more effective and meaningful in the intellectual formation of learners. Giving cognitive conflicts helps learners reflect on conceptions, explanations of the phenomena they
learn to develop the activation of phenomena obtained. Encouraging students to think critically in understanding the concept thoroughly can reduce their misconceptions. Cognitive conflict strategies are an active process of constructing the relationship between new knowledge and the old one. The essence of the cognitive conflict strategies is thinking is not a passive consumer of information [17]. Students participate in the learning process and generate knowledge by forming mental relationships between concepts. There are four elements in cognitive conflict strategies that are recalled, integration, organization, and elaboration [18]. Cognitive conflict strategies in its implementation is divided into four phases, namely preliminary phase, focus, challenge and application phase in the form of algorithm making.

Preliminary phase that is to give the initial task to the students through reading the reference according to the topic to be studied. Pre-focusing that students are asked questions are open and students answer in accordance with the knowledge they have. Phase focusing that student activity in this phase is to participate in scientific activities understanding of concepts associated with new concepts. Phase challenge that students are facilitated to make a change of views on the problem and guide students to perform numerical analysis of the given problem. Confirmation Phase that students are given consideration to all alternative answers given by students. Phase Confirmation that students are given logical consideration of all alternative answers that have been given by the group of students to lead to the achievement of learning objectives. Phase checking comprehension that students are given pretest. Phase verification that students carry out the practice of making a Matlab script in base on the algorithm. The work of the students is directly examined and given a feedback on the results of his work.

2. Research Method
In order to create cognitive conflict situations on student we selected two tasks with the potential of evoking conflict, Tasks 1 is familiar content, while Tasks 2 is an unfamiliar content. Half the students worked on Task 1 in pairs and on Task 2 in groups of four, and the other half worked on Task 1 in groups of four and on Task 2 in pairs. Each task began with an individual assignment, in which each student was asked to solve a computational physics problem on his or her own, in writing. After solving the problem alone, the members of the group were asked to discuss their solutions and reach an agreement. They were then asked to resolve the contradiction as a group. For clearer analysis, the data were divided into three categories as follows: (a) the percentage of correct responses (full understanding), (b) the percentage of students partial correct responses (misconceptions), and (c) the percentage of students' incorrect response (not understand). An open-ended question was set to ask students to explain their difficulties in each problem. Data was analyzed by Spanova statistics in order to look for the effect of cognitive conflict strategy on student misconceptions in the Computational Physics course.

3. Results and Discussion
The comparison of the increase in student learning outcomes, both the experimental and control groups are shown in Figure 1. The graph in Figure 1 shows that there is an interaction effect of the average score of the students' learning outcomes in the Computational Physics course of experimental class and control class during the three measurement periods. Figure 1 shows that learning by cognitive conflict strategy can increase the average score of student learning outcomes in Computational Physics courses. The significance of learning effect of cognitive conflict strategy can increase the average score of students' learning outcomes in the Computational Physics course.

Test of Within-Subject Contrasts analysis indicates that there is a significant linear relationship between dependent variables (score midterm-semester and end of semester). The result of pair comparison shows that after controlling with the Bonferroni method, the average score of student's learning outcomes in the Computational Physics course of midterm-second semester is lower than the end of the semester, but not significantly (differences is 0.19, p < .05). The average score of student's learning outcomes in Computational Physics end of the semester two is higher than mid-semester two
significantly (differences is score is 3.25, p < .05). Table 1 shown that students achieve mastery in learning generally they experience misconception in choosing a suitable method to solve the problem given. For example, students were calculate the electric field strength of a certain distance from a non-homogeneous charge density as shown in Figure 2. Based on electric field equations, $E = \int_{-L}^{L} \frac{1}{4\pi\varepsilon_0} \frac{e^{-x}}{r^3} \, dx$. Students generally assume $r$ does not depend on $x$.

| No | Topic | Understanding Level | Misconception Level |
|----|-------|---------------------|---------------------|
| 1  | Interpolation with the same difference | No understanding: 20.00 | Misconception: 43.33 | Full understanding: 36.67 | No understanding: 13.33 | Misconception: 56.67 | Full understanding: 30.00 |
| 2  | Calculate the solution equations of Van der Waals equations | No understanding: 20.00 | Misconception: 50.00 | Full understanding: 30.00 | No understanding: 16.67 | Misconception: 53.33 | Full understanding: 30.00 |
| 3  | Calculates the coefficient friction of turbulent flow | No understanding: 23.33 | Misconception: 53.33 | Full understanding: 23.33 | No understanding: 13.33 | Misconception: 60.00 | Full understanding: 26.67 |
| 4  | Calculate differential based on given data | No understanding: 10.00 | Misconception: 30.00 | Full understanding: 60.00 | No understanding: 10.00 | Misconception: 50.00 | Full understanding: 40.00 |
| 5  | The Numerical Solution of the Electrical Fields on the wire | No understanding: 10.00 | Misconception: 40.00 | Full understanding: 50.00 | No understanding: 13.33 | Misconception: 50.00 | Full understanding: 36.67 |
| 6  | Determine the numerical solution of damped vibration equations | No understanding: 10.00 | Misconception: 43.33 | Full understanding: 46.67 | No understanding: 16.67 | Misconception: 40.00 | Full understanding: 43.33 |
| 7  | Using the first order Runge Kutta method to complete the LR circuit | No understanding: 20.00 | Misconception: 40.00 | Full understanding: 40.00 | No understanding: 16.67 | Misconception: 50.00 | Full understanding: 33.33 |
| 8  | Determine the numerical solution to complete the RLC circuit | No understanding: 23.33 | Misconception: 26.67 | Full understanding: 50.00 | No understanding: 23.33 | Misconception: 26.67 | Full understanding: 50.00 |
The data analysis showed that the average of the students' learning outcomes in the group that were studied using the cognitive conflict learning strategy was lower than the average of the students' learning outcomes in the group that were given the lesson did not use cognitive conflict strategy in the Computational Physics course at the beginning of the lecture. Misconceptions can hinder student achievement in learning [19]. Misconceptions in the student self will cause cognitive conflict in a person has not been solved perfectly [11]. Cognitive conflict is not resolved properly will lead to continuous misconception, resulting in low student learning outcomes. Students fail to construct their learning experiences so that they mistakenly solve the problem [15]. This is what is expected to influence the negative learning of cognitive conflict strategy on the average of student learning outcomes at the beginning of this strategy is applied. This shows that this strategy works well. This strategy cannot work well, because students do not make a good introduction, do not read the practicum module and teaching materials before the lecture.

This problem is solved by giving students the pretest before the practicum beginning in the mid-semester and the end of the semester. This strategy has a positive impact, where the students' misconception rate in the middle of the mid-semester two and the end of the semester two may be reduced. If students are accustomed to construct their learning experiences well, their ability to build knowledge and skills will also improve [20;21]. If students who experience cognitive conflicts can be resolved properly misconceptions in the minds of students will reduce. The cognitive conflict is a mismatch in the mind (old knowledge) of the students with information gained during the learning (new information). In order to increase student learning outcomes, the old concepts that exist in the minds of students they must be consciously revised [9,16]. This research can be seen as a replication as from research [21]. Implementation is learning by cognitive conflict strategy well used in learning Computational Physics, if students have the power of reason and reference reading power well.

4. Conclusions and Recommendations
The learning strategy of cognitive conflict can increase the average score of student learning outcomes in Computational Physics at the Physics Department of FMIPA Padang. Therefore, it means that learning by cognitive conflict strategy can reduction of student misconception on Computational Physics course at the Department of Physics, Faculty of Mathematics and Science, Universitas Negeri Padang, but so far not significantly. Based on the analyzed of student’s answer sheet, students that are not mastery at Computational Physics learning is caused by students have misconception in choosing a method to solve the problem. Implementation is a generative learning based on cognitive conflict strategy well used in Computational Physics learning. However, further research with more samples and other moderator variations should be undertaken. Cognitive conflict strategy needs to be proved in other courses because each subject has its own characteristics.

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