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The Effect of Cognitive Conflict Strategy on Improving Understanding of Students' Physics Concepts Reviewing from Cognitive Style

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Abstract: This study aims to determine the extent of the influence of cognitive conflict strategies on students' conceptual understanding in terms of cognitive style. This research is a quasi-experimental with one group pretest-posttest design. The sample used in the research consisted of 28 students who were studying at one of the universities in the city of Mataram. There are two main instruments used in this study, (1) the concept understanding test and (2) the Group Embedded Figure Test (GEFT). Concept understanding tests are given before and after treatment, while GEFT is only before treatment. The test result data was then analyzed using the N-Gain calculation. The results of data analysis showed that the average creativity of physics teacher candidates increased in the moderate category (N-Gain = 0.52). Students who have FD (filed dependence) cognitive style get a higher average N-gain score (N-Gain = 0.57) when compared to students who have FI (filed independence) learning style (N-Gain = 0.48). Based on the results of the effect size calculation, it shows that the effect of differences in cognitive style on increasing students' conceptual understanding is in the medium category.

Keywords: Cognitive conflict, concept understanding, cognitive style

INTRODUCTION

Science and technology are two important things that cannot be separated. Without science, technology will not be born and vice versa, without technology, science will be difficult to develop. If we look at history, starting from the first generation industrial revolution (industrial revolution 1.0) to the fourth generation industrial revolution (industrial revolution 4.0), there are always discoveries in the fields of science (physics) and technology. The first generation industrial revolution, for example, was initiated by the invention of the steam engine by James Watt. The industrial revolution 2.0 began with the discovery of electric power which was initiated by Faraday and Maxwell's inventions. Likewise, the industrial revolution 3.0 was initiated by the invention of the transistor which ushered in the electronic era and has given birth to computers and the internet. The fourth industrial revolution is driven by artificial intelligence (AI) and Physical-Cyber Systems (Suardana, 2018; Fajariah & Suryo, 2020). Therefore, it is not an exaggeration to state that mastery of science (physics) and technology is the initial capital that a nation must have if it wants to build a more advanced civilization.

Physics is a part of science that studies natural phenomena and their causes. In physics, natural phenomena that are complex are outlined in the form of concepts, principles, laws, postulates, and theories (Hikmawati & Sutrio, 2019). Understanding physics means understanding the regularities of nature and its causes. By understanding the cause of a phenomenon, we can condition a phenomenon by engineering the cause of the phenomenon. For example, when we expect the acceleration (a) of an object to be greater, it can be done by increasing the resultant force ($\sum F$) and reducing the object's mass (m). Of course, this can only be explained if someone really understands the concepts of force (F), acceleration (a), and mass (m). Therefore, an important role that must be done by an educator is to help students understand physics concepts properly and correctly.

But in fact, educators often find skilled students to answer math problems using mathematical equations that they have memorized even though they do not yet understand the physical meaning of each of these equations. In other words, students are doing what they don't understand. This can be seen from the results of observations made at one of the universities in the city of Mataram. When students are instructed to determine the magnification of a loupe with the eye accommodated and the eye not accommodating if the near point of the eye (Sn) and the focus of the lens (f) are known. As many as 74.07% of students can answer correctly. However, when they were asked to explain the difference in the concept of accommodated eyes and non-accommodating eyes, only 25.93% of students were able to answer correctly. This phenomenon shows that so far in studying physics, educators and students have focused more on memorizing equations and solving problems mathematically without first understanding the physical meaning of each given equation.

Concept understanding is an important aspect that must be mastered by students in learning because it is the basis for building a higher level of knowledge (Santrock & John, 2014). The word understanding here implies that students are not only able to remember but they can also explain, give examples, interpret, classify, and compare one concept with another (Anderson, et.al., 2010). Understanding can be defined as a process of understanding certain meanings or meanings and the ability to use them in other situations (Depdiknas, 2006).

According to constructivist learning theory, students do not come to class with an "empty head", but they already have prior knowledge or preconceptions derived from their own experiences (Blizak, et.al., 2009; Suparno, & Paul, 2005). Initial knowledge that already exists in the cognitive structure of students is called a schema. A person is said to understand something if there has been an integration of a new concept with an existing schema in their cognitive structure until there is a balance (equilibration). This integration process can be through the process of accommodation and assimilation (Jamaris, 2015).

Assimilation is the process of integrating new information or concepts with existing schemas in a person (Sanjaya, 2010). This assimilation process occurs if the new concept learned is in accordance with or in line with the initial concept of the learner. The new concept is accepted as a complement to the previously existing initial concept. In contrast to assimilation, accommodation is an adaptation process in which existing knowledge is changed or modified to fit new information (Dahar, 2011). In this accommodation process, there will be cognitive conflict due to a discrepancy or consistency between existing schemas in a person's cognitive structure and new information or concepts from the environment. This process of change is usually known as conceptual change.

Cognitive conflict is a discrepancy that occurs between a person's initial cognitive structure and his environment (Kang, 2004). This cognitive conflict strategy is needed so that the process of assimilation and accommodation occurs so as to create a balance (equilibration) of the concept. Learning with cognitive conflict strategies means trying to present information or events that can lead to assimilation and accommodation processes in students (Foster, 2011). So that students always build their knowledge until the concepts they understand do not conflict with the concepts of scientists. This cognitive conflict learning can also present concrete objects in learning a concept, namely through experimentation. Students are faced with real situations, namely through experiments, and are directly involved in the process of achieving the concept (Sirait, 2010).

Empirical research related to the use of a cognitive conflict approach in improving students' understanding of concepts has been done before. Baser's research results, Setyosari, et.al., & Zuhdi, et.al., showed that the application of a cognitive conflict approach in learning physics can improve students' understanding of concepts and learning outcomes (Baser, 2006; Setyowari, 2011; Zuhdi & Makhrus, 2020). Therefore, in this study, the researcher plans to examine the effect of the cognitive conflict approach in increasing the understanding of concepts at the student level. The basic difference between this study and previous research is that in this study the researcher tried to see the effect of cognitive conflict strategies on increasing understanding of concepts in terms of differences in students' cognitive styles. This aims to determine how the tendency of cognitive conflict can affect the conceptual change of students who have Field Dependent (FD) and Field Independent (FI) cognitive styles.

METHODS

This study is a quantitative study with a one group pretest-posttest design (Frankel, et.al., 2012). The design of this research can be seen in the following table.This study is a quantitative study with a one group pretest-posttest design

(Sugiyono, 2012). The design of this research can be seen in the following table.

Table 1. *One Group Pretest-Posttest Design*

Pretest	Treatment	Posttest
O_1	Cognitive conflict strategy	O_2

The research was conducted at one of the universities in the city of Mataram. The sample consisted of 28 students who were taking Basic Physics courses. Sampling using a simple random sampling technique. A simple random sampling technique is a technique of taking samples from members of the population which is done randomly without regard to the existing strata in the population (Sugiyono, 2012).

The instrument used in this study was the Group Embedded Figure Test (GEFT) and conceptual understanding in the form of multiple-choice questions. GEFT is a form of standardized test developed by Witkin, et.al., [20]. This test is used to identify students' cognitive styles into two forms of cognitive style, namely field independent (FI) and field-dependent (FD). GEFT is given once, namely at the beginning of the lesson. The concept understanding test was carried out twice, namely before and after treatment. Two main concepts are the focus of the study in this research, namely; the concept of friction and Newton's law.

The collected data was then analyzed using normalized gain (N-gain) calculations to determine the effectiveness of using the cognitive conflict approach in improving students' understanding of concepts. The average normalized gain is the ratio of the actual average gain (gain) with the maximum average increase that may be achieved by students. The equation for calculating the average normalized gain <g> is as follows (Hake, 1999).

$$< g > = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

The calculation results are then interpreted with Hake's (1999) criteria, namely; <g> < 0.3 (Low); 0.3 <g> 0.7 (Medium); and <g> > 0.7 (height). In addition, to determine the effect of implementing cognitive conflict strategies on increasing conceptual understanding of students with FD cognitive style relative to prospective teachers with FI cognitive style, an effect size calculation was carried out. The size of the effect (effect size) in this study is sought by calculating the size of the difference in the standardized mean (d) with the following equation made by Cohen, et.al., (Busyairi, & Sinaga, 2015).

$$d = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{(n_1-1)+(n_2-1)}}}$$

The calculation results were then consulted with the criteria made by Cohen (1998), namely; 0 < d < 0.2 (small effect); 0.2 d 0.8 (medium effect); and d 0.8 (large effect).

RESULTS AND DISCUSSIONS

The average pretest, posttest, and N-gain calculation results for students' understanding of the concept can be seen in the following table.

Table 2. Average scores of pretest, posttest and results of the calculation of N-Gain

Learning outcomes	Average scores of pretest	Average scores of *Posttest*	N-Gain	Category
Concept Understanding	36,43	71,07	0,52	Medium

The pretest and posttest scores in the table above show that in general students' understanding of concepts has increased. Based on the N-Gain score, the large increase in student concept understanding is in the medium category. The results of this data analysis show that the application of cognitive conflict strategies can be used as an alternative to improve students' understanding of concepts. The results of this study are in line with the results of previous studies which found that the application of cognitive conflict strategies in physics learning was effective in increasing students' conceptual understanding (Sirait, 2010; Baser, 2016; Setyowari, et.al., 2011; Zuhdi & Makhrus, 2020).

Next, we will review the improvement of conceptual understanding based on differences in students' cognitive styles. This aims to determine whether there is a difference in the improvement of concept understanding between students who have Field Dependent (FD) and Field Independent (FI) cognitive styles. The following is the data from the pretest and posttest results for each group of students' cognitive styles.

Table 3. Increased understanding of student concepts in terms of cognitive style

Cognitive style	Average scores of pretest	Average scores of *Posttest*	N-Gain	Category
Field Dependence (FD)	20,71	66,43	0,57	Medium
Field Independence (FI)	52,14	75,71	0,48	Medium

The data in the table above shows that the average pretest and post-test scores of students with FI cognitive style are always greater than students with FD cognitive style. That is, the understanding of the concept of students who have the FI cognitive style before and after treatment tends to be better when compared to students who have the FD cognitive style. These findings are in line with the results of Ulya's research which found that students who have the FI cognitive style tend to have better cognitive learning outcomes compared to students who have the FD cognitive style (Ulya, 2015). Furthermore, Lu, et., al., stated that someone who has the FI cognitive style tends to be more critical, analytical, and has better solving abilities when compared to people who have the FD cognitive style (Lu & Lin, 2018). Therefore, based on the results of data analysis in this study and the results of previous studies, it can be concluded that differences in cognitive style affect the level of understanding of students' concepts.

Furthermore, if we look at the N-Gain scores for the two groups of students (FI and FD), it can be seen that the two groups of students both experienced an increase in understanding of concepts in the moderate category. However, although the two groups of students both experienced an increase in the moderate category, there was a difference in the average N-Gain scores of students with FI and FD cognitive styles. The average N-gain score of students who have an FD cognitive style (N-Gain = 0.57) tends to be greater than the average N-Gain score of students who have an FI cognitive style (N-Gain = 0.48).

To find out the effect of implementing cognitive conflict strategies on improving students' conceptual understanding of students with FD cognitive style relative to prospective teachers with FI cognitive style, an effect size calculation was carried out.

Table 4. Effect Size Calculation Results

Group	N	N-Gain	Std	Cohen's d	Interpretation
Field Dependence	20	0.57	0,018	0,45	Medium
Field Independence	20	0.48	0,060		

Based on the results of the calculation of the effect size, it shows that there is an effect of differences in cognitive style on increasing students' understanding of concepts. The magnitude of this effect is in the moderate category (0.2 d 0.8). The increase in understanding of the concepts of students who have FD cognitive style is greater than FI even though the final score of students who have FI cognitive style is greater than those of FD. This difference is thought to be caused by student activities during learning with a cognitive conflict strategy which is more dominant in the accommodation (adjustment) process when compared to the assimilation (integration) process. Accommodation is an adaptation process in which existing knowledge is adjusted, changed, or modified to fit new information that is considered correct.

Cognitive conflict is a contradictory state between students' initial conceptions and new information or concepts in the surrounding environment. In the cognitive conflict strategy, the lecturer tries to present a situation that can make students feel that there is information that is contradictory/contrary to their initial concept. Cognitive conflict is a learning process that brings students to situations that are contrary to the concept and after that students are invited directly to solve these problems through experimental observations or demonstrations to prove it (Sirait, 2010).

Broadly speaking, the main steps in the cognitive conflict strategy consist of 4 phases, namely the identification of misconceptions, the creation of conflict conditions, the provision of assistance for equilibration, and the reconstruction of student understanding (Hewson & Hewson, 1984). For example, when discussing the frictional force, at first the lecturer asks the students a question by asking them to determine the ratio of the magnitude of the frictional force to the thrust that acts on an object that is pushed but remains at rest. More than 90% of students answered that the object remained at rest because the frictional force acting on the object was still greater than the thrust ($F_{friction} > F_{push}$). Next, students are invited to draw a diagram of the force acting on the object and are told to give any value/magnitude of the thrust and friction force with the notes $F_{friction} > F_{push}$, for example, as shown in the following figure.

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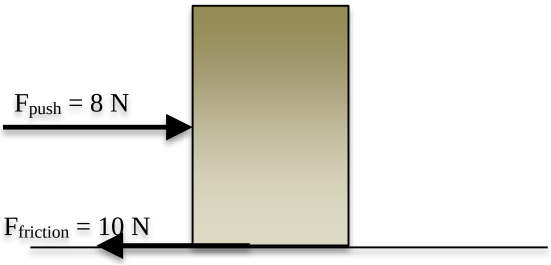

Figure 1. Diagram of the force on the object

When students were given follow-up questions be asked to determine what would happen if Ffriction > Fpush (∑F≠0) as shown in Figure 1 and asked them to recall the discussion on Newton's First Law. More than 50% of students answered that the object should move to the left because the force to the left is greater than the force to the right. But of course, that is not possible because friction can't cause objects to move. This phenomenon triggers cognitive conflicts in students.

If we look at the learning process using cognitive conflict strategies, it seems that students who have an FD learning style tend to be more suitable than students who have an FI cognitive style. Someone who has an FD cognitive style tends to be easier to adjust new information with old information that already exists in their cognitive structure. Their mindset tends to be more easily guided and directed [25]. In contrast to FD, someone who has an FI cognitive style is someone who has an impersonal orientation, prefers to study individually, is not easily influenced by criticism, suggestions, and directions that are not considered logical by them so their mindset tends to be difficult to change if they have experienced misconceptions (Chen & Macredie, 2002; Shou, 2001; & Alomyan, (2004). This is what causes a big difference in the increase in understanding of the concepts of students who have FI and FD cognitive styles. FD students are easier to experience conceptual changes from misconceptions to understanding concepts compared to FI students. However, what needs to be underlined is that this discussion discusses the differences in the magnitude of conceptual changes that occur in each group of students. This discussion is not discussing which group of students has a better understanding of the concept because in the previous paragraph it has been explained that students who have the FI cognitive style have a better conceptual understanding than the FD.

CONCLUSION

Based on the results of data analysis as described above, it can be concluded that in general cognitive conflict strategies can improve students' understanding of concepts, especially in the medium category of frictional force and Newton's law. Students who have FD cognitive style tend to experience a greater increase in concept understanding when compared to FI.

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