

Developing Physics Textbook Based on Cognitive Conflict for Deeper Conceptual Understanding and Better Characters

S Linuwih^{1*}, N W Lurinda¹, and Fianti¹

¹Physics Education, Mathematic and Science Department, Universitas Negeri Semarang, Indonesia

*Corresponding author: suhartolinuwih@gmail.com

Abstract. These study aims are to develop a textbook based on cognitive conflict approachment, to know the properness of textbook, the legibility of textbook, and also the effect of using the textbook for increasing the conceptual understanding and improving the character of the students. This study was conducted by research and development method employing non-equivalent control group design to test the product. The subjects were ten-grade students of SMA N 1 Gubug in the second semester of 2015/2016. The properness test used properness-questionnaire, while the legibility test used the most closet. The data of conceptual understanding was taken from the pretest-posttest result and the data of characters was taken from direct observation. By analysing the data, we concluded that the textbook based on cognitive conflict approachment was very proper to use with high legibility. By applied this textbook, students would be helped to get a deeper conceptual understanding and better characters.

1. Introduction

Physics is a part of science which is about of knowledge, facts, concepts, theories, and principles, which then referred as the product of science. *Permendiknas No 22, year 2006* explains that physics not only converting to develop the technology, but also educating the students to learn and to act based on critical, analytical, logical, rational, and systematical thinking. Therefore, physics should teach the conceptual understanding and implement the character education.

The observation in SMA N 1 Gubug showed that the physics learning process tended to be conventional. The teacher gave an explanation and then the student did an exercise. The discussion tended to focus on the formula and the calculation. Addition, the sources of study for the student were limited.

Learning process requires strategy and media for achieving the learning's goals that were expected before. One of strategy which can be applied is cognitive conflict approachment. Cognitive conflict is a perceptual state in which one notice the discrepancy between one's cognitive structure and environment (external information) or between the components of one's cognitive structure (*i.e.* one's conceptions, beliefs, sub-structures, etc., which are part of the cognitive structure) [7]. Cognitive conflict approachment in learning process helps the student to build the knowledge by giving cognitive stimulation to make an internal conflict and then creates a process of assimilation and the accommodation in their mind. By this process, most students can build a conceptual understanding which is better than before.

Cognitive conflict must challenge student's existing concept, while it happened, the student will try to make sure the true one and build the new concept by themselves [8]. Making uncertainty can be stimulated through the providing of problems that rise conflict in the student's cognition.



The other hand, cognitive conflict approachment provides an easiness to understand the physics concept, train to think critically and creatively, also improve the students learning activity. It's a chance to improve student character by this approachment. Based on the observation and the literature study, this study develops a physics textbook based on the cognitive conflict which discusses dynamic electricity for ten grade in the second semester. The textbook based on cognitive conflict is expected to increase the conceptual understanding. Besides that, the writing of this textbook guides the student to study in demonstration and discussion-methods. It is an attempt to improve the student's characters, such as discipline, communicative, curiosity, and independently.

The purpose of this study is to develop a textbook based on cognitive conflict approachment, to know the properness of textbook, the legibility of textbook, and also the effect of using the textbook for increasing the conceptual understanding and improving the character of the students.

2. Methods

This study used to research and development method. The procedure covers; (1) finding the problems and potentials, (2) collecting information, (3) designing the product, (4) validation the product, (5) revision the product, (6) testing the product in small-scale, (7) revision the product, (8) testing the product in a large-scale. Validation of product aims to assess the properness of the textbook. The validation-instrument was a questionnaire which was filled out by three teachers as the practitioners. Then, the small-scale test aims to assess the legibility of the textbook. The instrument for the legibility test was a cloze-test. The data of properness and legibility was analysed by the following percentage-score formula,

$$P = \frac{f}{n} \times 100, \quad (1)$$

where P : The percentage of properness, f : obtain total scores, and n : the maximum total scores.

The large-scales test of the textbook aims to know the effect of using a textbook in increasing the conceptual understanding and in improving the character of the student. This test used non-equivalent control group design. The subject is ten-grade students of SMA N 1 Gubug in the second semester of 2016/2017. The sample was chosen by purposive sampling method, X-A as the experimental class and X-B as the control class. The data of conceptual understanding was taken from pretest-posttest by using essay question that has passed the test of validity, reliability, the level of difficulty, and differences-question ability. The data of student character was taken from direct observation. Both of data were analysed by using gain-test as the following formula,

$$\langle g \rangle = \frac{\langle s_p \rangle - \langle s_p \rangle}{1 - \langle s_p \rangle}. \quad (2)$$

Where,

$\langle g \rangle$: gain factor,

$\langle s_p \rangle$: mean scores of posttest,

$\langle s_p \rangle$: mean scores of the pretest.

3. Result and Discussion

3.1. The Description of Textbook

The developed product was physics textbook based on cognitive conflict. This textbook was discussed dynamic electricity for grade ten that was adjusted with the curriculum of 2016. The draft of textbook consists of: cover page, competency standard and basic competency, textbook using instruction, chart of concept, and learning activities. Each learning activity serves several sections to support the activity. Among them are "Problem", contains the goals of learning and the indicators. To stimulate the students for thinking, this textbook gives a section as "hypothesis"; it contains a problem which must be answered or be discussed by the students. They must write the answer on section named "Prediction" which is already available. This section aims to train the students to be discipline

in finding solutions for the problem. When the student used this textbook, they will be guided to find the conclusion through a section named “Go Explore”. The student was asked to do an experiment also to discuss the observation-result. On each ending of the lesson, the student was expected to have a better explanation about the problem at the beginning of the activity. This textbook also provides any example-questions and exercises.

3.2. The Properness of Textbook

There are four components that need to be validated, that are the contents, language, presentations, and graphics properness. Each component consists of several aspects, and each aspect consists of several indicators. The complete assessment-result is presented in Table 1.

TABLE 1. The result of the properness-analysis of the textbook (scored-range is 0-100).

Aspect	Average-score of each aspect	The criteria of properness
Contents	93.75	Very proper
Presentations	91.96	Very proper
Languages	87.81	Very proper
Graphics	89.72	Very proper
Total averages	90.81	Very proper

The calculation above shows that the average score was closer to ideal (100). It is corresponding to the research by Zemenu[12], that the textbook with the average index value for all categories was closer to the ideal standard was good in promoting the students' engagement in active learning. The developing of this textbook was referring on competency standard and basic competency that was predetermined. The textbook provides any problem in section “Problem” that was followed by an instruction to do experiments and discussions, also any exercise to help students in increasing their ability for mastering the topic. The similar opinion was revealed by Daluba[2] that student who learns by demonstration would think about more activity oriented to the problem. The activity made the student to provide a relevant answer by their understanding. Besides that, their research finds that academic achievement score of a student by demonstration method was better than that conventional method.

The textbook was developed to help the learning process, so it prioritised the student active-involvement, the improving of characters, and the best interaction to make the student enjoy. The Izzati *et al.* find that the innovation of learning-presentation can improve the student activity such as to ask a question, to answer, also to discuss, so that students will enjoy the learning process. This textbook also contains illustrations either pictures or photos to attract the readers as well as supporting the information. It aims to stimulate the interest and the curiosity of the student to study with this textbook. According to Yazdanmehr and Shoghi [11], the using of contextualised visuals can turn the student's interest and motivation on, activate their creative mental powers in discussion and even predict what the related content does focus on.

3.3. The Legibility of Textbook

The result of the small-scale test showed that the average score of the legibility is 78.2. So we can say that the textbook has high legibility, so that it is easy to understand. The sentence which was written in the textbook was simple and adapted for the student as a reader. Besides that, the writing concern about the structure (*i.e.* subject, verb, object, and adverb or adjective) so that the reader can understand the topic easily. The legibility is depended on font-type and font-size. Dimtry *et al.*[3] revealed that the mean value of legible line length is about 100-120 mm, while the mean value of the most legible font

size is close to 12 points but without specification of the typeface. The textbook which was developed in this study had 128 mm of line length and 11 points of font size. It was close to the ideal criteria.

3.4. The Using Textbook in Increasing Conceptual Understanding and in Improving Character

The level of conceptual understanding was measured by writing test with essay questions. The questions consist of seven items which are covering all of the competencies. The average score of the pretest-posttest is illustrated in Figure 1 and Figure 2.

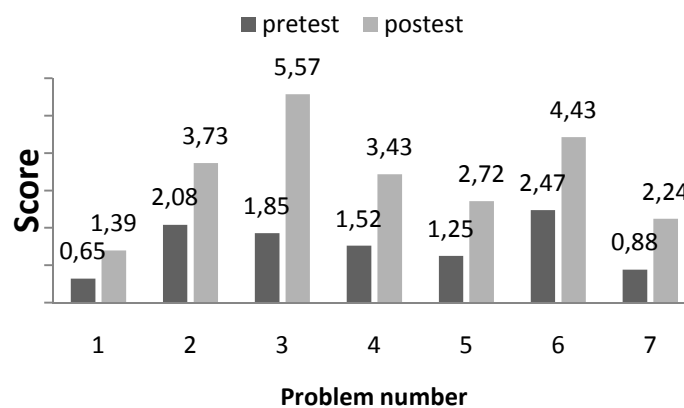


FIGURE1. The average-score of conceptual understanding in experimental class.

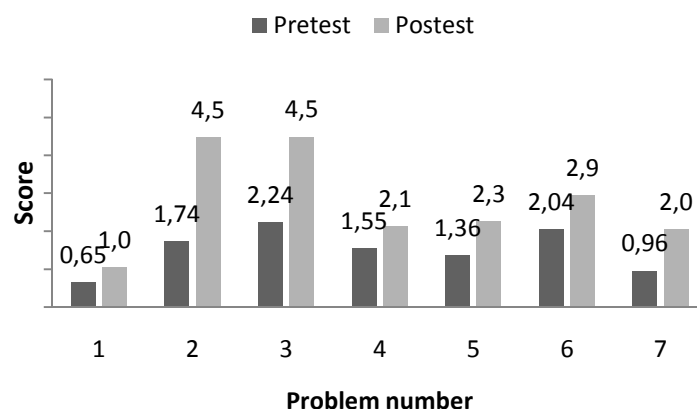


FIGURE 2. The average-score of conceptual understanding in controlled class.

Both Figure1 and Figure 2 show the increasing of conceptual understanding. Actually, the increased score in experimental class is higher than controlled class, so we conclude that the using of textbook based on the cognitive conflict in experimental class can increase the conceptual understanding better than other in controlled class. Gain-test was done to make sure about that conclusion. The result of the gain-test is shown in Table 2.

TABLE 2. Results of gain-test the class-sample.

Class	Average of pretest	Average of posttest	Gain factors	Criteria
Controlled	30	55	0.36	Medium
Experimental	31	65	0.50	Medium

Both of these gain factors are not different far because the process of conceptual changes requires a long time, while this research only takes four meetings in a month. According to Visniadou as cited by Taber [9], that the conceptual changes are a slow process, where any observed apparent sudden changes are hard-won and simply offer the surface evidence of extended, preconscious processes influenced by many months of classroom experience.

To prove if there is a significant difference between conceptual understanding scores in experimental class and controlled class, we have done a hypothesis test by using t-test. The result showed that there is a significant difference of conceptual understanding between the two samples. It is appropriate to research by Amin [1], that the cognitive conflict will make an interaction between the phenomenon and the different existing concept. It will give a chance for the students to build the better conceptual changes.

The assessment about student character was done by direct observation. There are four characters which were observed *i.e.* discipline, curiosity, communicative, and independent. The average-scores of those characters were analysed by gain-test which is the result as the following Table 3.

TABLE 3. The result of gain-test of the characters.

Character	Controlled-class				Experimental-class			
	Initial	Final	Gain	Category of gain	Initial	Final	Gain	Category of gain
Discipline	69.44	95.14	0.84	High	72.22	98.61	0.95	High
Curiosity	45.83	54.86	0.17	Low	25.00	59.72	0.46	Medium
Communicative	47.22	60.42	0.25	Low	46.53	81.94	0.66	Medium
Independent	23.61	25.00	0.02	Low	25.00	76.39	0.69	Medium
Average	46.53	58.85	0.32	Medium	42.19	79.17	0.69	Medium

This result shows that the character of experimental-class has a higher increased than the controlled-class. Although overall the increasing both in experimental-class and controlled-class was in the same category, but actually it was different enough from each character. So we can conclude that the using of textbook based on cognitive conflict can improve the student character. Although there are some students who did not show the increasing of characters significantly, it is a natural thing because some students were familiar with existing learning method, learning by using the cognitive conflict textbook may have been uncomfortable [5].

By using this textbook, the student will find a cognitive conflict situation so that they can explore their self to study about that situation then improve their character. Similar to a study by Iancu[5], that a situation which rises a conflict in students cognition field will make them be more active also to build their knowledge enthusiastically. The experimental class was given any stimulation through problems which are close to their daily life. That raises student interest and enthusiastic to ask, to discuss, and to find the solution to the given problem. This is supported by another report that the curiosity related to the student ability to ask and to respond in academic, practical, and discussion activities [6].

4. Conclusion

This research developed a physics textbook based on cognitive conflict which was very proper to use. This textbook was easy to understand with high legibility. The using of a textbook for physics learning could increase the conceptual understanding of the student also improve their characters *i.e.*, discipline, curiosity, communicative, and independent.

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