DESIGN OF PHYSICAL TEACHING MATERIALS BASED ON COGNITIVE CONFLICT LEARNING IN DIRECT CURRENT ELECTRICITY INTEGRATING VIRTUAL LABORATORY

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ABSTRACT

Learning Physics in the 2013 Curriculum requires students to understand concepts. However, the facts found in the field show that students' understanding of concepts is still low and there are misconceptions, especially on direct current electricity. One solution to overcome this problem is to make physics teaching materials based on cognitive conflict integrating virtual laboratories on direct current electricity materials to improve students' conceptual understanding. The aim this study was to produce a valid cognitive conflict teaching material design. This type of research was design/development research. using the Plomp model development which has two phases, namely preliminary research, at this phase an initial problem analysis was carried out by conducting concept tests on students and conducting interviews with teachers. The second phase of the Plomp model is the prototype phase, it was the development stage by designing the required teaching materials. For the design of teaching materials that have been made, a self-evaluation test was carried out, after which the expert validation or expert review was carried out using the V Aiken's formula for each indicator. Based on the analysis of the data obtained, it can be explained, at the preliminary research phase, it was found that more than 30% of students experienced misconceptions and 50% of students did not understand. Meanwhile, teachers still use conventional learning (teacher centered) and insufficient laboratory tools to do practicum. The prototype phase creates teaching material design based on cognitive conflict. The results of the self-evaluation test showed that teaching materials at the validation level were very good with an average value of 86.7 and the expert validation test for materials at the validation level was very valid with an average value of 0.87. The conclusion from the acquisition of the validity assessment of physics teaching material design based on cognitive conflict in direct current electricity integrating virtual laboratory is declared valid.

Keywords : Cognitive Conflict, Virtual Laboratory, Direct Current Electricity, CCBL Model, Misconceptions

I. INTRODUCTION

This modern era or better known as the industrial revolution 4.0 is an era in which the development of technology and science can change the basis of human life. Advances in technology require humans to have the more skills needed so that it creates very fierce competition, the way to overcome this is to increase Human Resources (HR). Quality human resources must be mastered by 4C skills. 4C skills are a type of soft skill in daily implementation, namely Communication, Collaboration, Critical Thinking, Creativity and innovation. Education plays a very important role in improving 4C skills.

One of the important roles in getting quality human resources is education, the government's effort to improve education in Indonesia is curriculum development. Curriculum development that has been carried out from the Education Unit Level Curriculum (EULC) to the 2013 curriculum that prioritizes student-centered learning and teachers as facilitators.

Physics learning in the 2013 curriculum aims to make students master concepts, and have skills that can develop knowledge, move students to find out for themselves the various problems that must be resolved by

educators using the scientific approach method. Physics learning must be supported by learning tools that can help students develop understanding of concepts. Learning tools are one of the elements that must be in the learning process, one of the learning tools is teaching materials. Learning physics is not only remembering formulas or material, the most important thing is understanding concepts, so that they can be applied in everyday life, which can be realized through teaching materials.

Learning activities carried out in schools require teaching materials to assist the learning process. Teaching materials are part of learning resources with various forms of material used to assist teachers in implementing learning[1]. Physics learning activities, teaching materials are important things for teachers and students, the teaching material should challenge, stimulate, and link the material being taught with real situations, so that it can help students understand the subject matter. The function of teaching materials is to save time in the learning process, students can learn by themselves from teaching materials, learning becomes effective and interactive, as a tool for evaluating learning outcomes. However, the reality on the schools is that the education process that the government wants has not been implemented properly, this is known based on a preliminary research conducted at SMAN 2 Padang. The preliminary research was given to class XII MIA 1 consisting of 36 students. The preliminary research was conducted in the form of a concept test consisting of 10 questions including 5 concept questions and 5 calculation questions on unidirectional electrical material. The results of the analysis can be seen as Tabel 1.:

Table 1.Analysis of Students' Understanding of Physics Concepts in Direct Current Electricity Matter.

Type of Question	Misconception	Sure Understand	No Understand
Calculation (with numbers)	25 %	40 %	35 %
Concept (without numbers)	34 %	16 %	50 %

Based on Table 1, students' understanding of physics concepts, especially in electrical material, is classified as low. This can be seen in the questions of counting that conduct by 36 students; 25% experienced misconceptions, 40% could answer calculation questions, 35% students could not answer calculation questions. This can also be seen in the concept questions of 36 students. 34% of students experienced misconceptions on concept questions, 16%   can answer concept questions, 50% students cannot answer concept questions. In general, students can answer questions if there are numbers, but concept questions (without numbers) cannot be answered by students. This shows that students only memorize the equations of physics without understanding the concepts in these equations. This is reinforced by interviews with teachers, it show that the learning carried out is still using conventional learning, and has not fully used the learning model that is in accordance with the 2013 curriculum, the teaching materials used have not been able to overcome misconceptions, and the experiments carried out have not been carried out properly due to limited tools in laboratorium. It is similar to the result of the study which state that learning in schools is still carried out traditionally or teacher-centered learning and students' understanding of concepts is also low and misconceptions often occur[2].

One of the efforts to overcome this problem is by designing teaching materials based on cognitive conflict. The design of cognitive conflict-based teaching materials is useful for knowing students' initial knowledge before learning begins and for improving conceptual understanding and remediating misconceptions[3]. In addition, this teaching material can increase conceptual understanding which can reduce student misconceptions in conducting experiments. According to Mufit & Fauzan; cognitive conflict-based learning (CCBL) model has four syntax, namely: (1) activation of preconceptions and misconceptions, (2) presentation of cognitive conflict, (3) discovery of concepts and equations, (4) reflection[4]. Each of the stages of cognitive conflict learning has the impact of conceptual changes, from wrong to right[5].

The results of the preliminary study concluded that students experienced misconceptions in direct current electricity material. According to Suparno there are 700 misconceptions that occur in physics, including 159 about electricity[6]. According to Rohma, students experience many misconceptions in direct current circuits[7]. Some examples of misconceptions, students think that voltage only occurs in a closed circuit, many students misunderstand the lightness of the capacitor in a series electric circuit, some students reveal that it is enough to connect the lamp with a battery and one cable, the light will turn on.

In direct current electrical material experiments can be done in two ways, doing experiments real or virtual experiments. Practicum is virtually designed in such a way as the original, aiming to make students understand physics concepts better[8][9]. The virtual laboratory is a means of adding experience and motivating students to carry out an experiment and be able to develop experimental skill activities[10]. The benefits that can be obtained from virtual laboratories are: (1) Reducing time constraints, by using virtual, it does not waste much time compiling components or looking for data, (2) reducing geographical barriers, if there is a natural disaster or conditions that make it impossible to come to the laboratory, can use a virtual laboratory, (3) do not use many components, (4) improve the quality of the experiment, because it allows it to be repeated to clarify doubts about measurements in real labor, (5) increase the effectiveness of learning, because by using a virtual laboratory students can spend time because doing the practicum repeatedly[11]. During the current covid-19 pandemic, school activities cannot be carried out, so practicum is carried out virtually, using a virtual laboratory, so students can do their own experiments in their own homes. Based on the background of the problem that has been described, a cognitive conflict-based teaching material design study integrating a virtual laboratory on direct current electrical material was carried out to improve the conceptual understanding of class XII high school students as a solution to the problem.

II. METHOD

Cognitive conflict-based teaching materials are designed using design/development research using the Plomp model. There are three development steps that must be taken according to Plomp, namely (1) preliminary research (conducting a needs analysis and literature review), (2) develpoment or prototyping phase (the stage of designing solutions from previous research in the form of prototype design and formative evaluation and prototype revision), and (3) the sssassment phase (solutions that must be developed will be tested and evaluated in practice). This research is limited in two steps of the Plomp model, namely the preliminary research and prototyping phase[12].

In the preliminary research, interviews were conducted with 3 teachers. Some of the questions asked are: (1) How is the application of the physics learning model in schools, (2) How is the application of the teaching materials used by schools, (3) How do students understand the physics concepts in schools. The analysis of students 'conceptual understanding was carried out by giving concept tests to determine the level of students' understanding of the physics that had been previously studied.

At the development stage, cognitive conflict-based teaching materials are designed according to the results of the needs analysis. In this stage, cognitive conflict-based teaching materials are designed to integrate a virtual laboratory on direct current electrical material. After that, a formative evaluation is carried out, namely self-evaluation by the researcher himself and the validity test through an expert review. In self-evaluation, researchers assessed the completeness of the teaching material prototype and corrected any obvious errors. The validity test was carried out by experts consisting of three physics lecturers at the Faculty of Mathematics and Sciences, Universitas Negeri Padang

Instruments at the development stage are self-evaluation sheets and validation sheets for teaching materials prototypes. The validation sheet from experts is prepared based on several indicators determined from the teaching materials, then translated into several points to facilitate and analyze the advantages and disadvantages of the design of teaching materials that have been made by the researcher, this indicator consists of four criteria, namely content validity, language validity, construct validity , and face validity[13].

The concept test data analysis technique used a coding system with three categories of students' understanding levels, namely conceptual understanding (P), misconceptions (M) and not understanding the concept (TP). The three categories were obtained from the results of the objective answers along with the answers to the students' reasons. The results of the interviews were analyzed descriptively. Self evaluation was analyzed by using percentage technique.

The self-evaluation sheet and expert validation were in the form of a questionnaire using a Likert scale. According to Riduwan, the Likert scale is used to measure the attitudes, opinions and perceptions of a person or group of social events or symptoms [14]. Likert scale analysis has several stages. The first part gives a score for each answer item, the score consists of four categories, four: strongly agree, three: agree, two: disagree, and one: strongly disagree. Self evaluation was analyzed by using percentage technique.:

$$P = \frac{f}{N} \times 100$$

The results of the self evaluation analysis that has been carried out can be seen in the Table 2.

Table 2. Interpretation of Self-Evaluation Analysis

No	Total Score	Criteria
1	0 – 20	Not Good
2	21 – 40	Less
3	41 – 60	Enough
4	61 – 80	Good
5	81- 100	Very Good

Modified [14]

The technique of analyzing expert validation sheet data using the Aiken's V formula. The coefficient of the four aspects of validity is calculated based on the results of the expert review [15]. The Aiken-V formula is as follows:

$$V = \frac{\Sigma s}{[n(c - 1)]}$$

$$S = r - l_0$$

The interpretation of Aiken's V formula results is from zero to one. The Aiken's V index for validity teaching material can be seen in the Table 3:

Table 3.Aiken's V index Assessment

Validity Index	Assessment
V<0,4	Less Valid
0,4<V<0,8	Valid
V>0,8	Very Valid

III. RESULTS AND DISCUSSION

A. Results
At the preliminary research, the results of interviews with physics teachers at SMAN 2 Padang can be obtained, namely: (1) the learning model still uses conventional learning methods and is still teacher-centered, (2) the teaching materials used have not applied the leaning models, (3) the practicum is not thoroughly discussed, it is constrained by time, and the lack of availability of laboratory equipment. There is no use of virtual laboratory experiments.

The results of the concept test on 36 students of class XII MIA 1 at SMAN 2 Padang found that the students' understanding of the concept was still low. The results of the student concept test analysis included: (1) more than 30% of students experienced misconceptions, even though the material related to questions had been previously studied, (2) more than 50% of students did not answer the conceptual questions that were given, (3) students experienced misconceptions in almost every the questions given, (4) students only apply the existing formula without understanding the concept of the formula, this is evidenced by the results of the student's correct answer in answering the count but incorrectly answering concept questions.

This happens because the learning model that is usually used when learning in schools is still conventional, so this means students do not understand the concept and are only interested in memorizing formulas. Student curiosity is greatly reduced and results in misconceptions in students and low levels of understanding of concepts, especially in physics lessons. According to Mufit, teacher-centered learning outcomes result in students not understanding concepts and are only interested in memorizing formulas or physics equestion[2]. When doing lab work is constrained by the availability of tools and time availability, the right solution is to use a virtual laboratory.

The results of the development/protoyping phase resulted in cognitive conflict teaching material products integrating virtual laboratories on direct current electrical materials to improve students' conceptual

understanding. The design of this teaching material has the characteristics, namely; using a cognitive conflict-based learning (CCBL) model and using a vitual laboratory as a practical tool in the third syntax. The following is the design of cognitive conflict-based teaching materials to improve students' conceptual understanding.

Fig. 1. Display Cover and Supporting Information on Direct Current Electricity Teahing Material
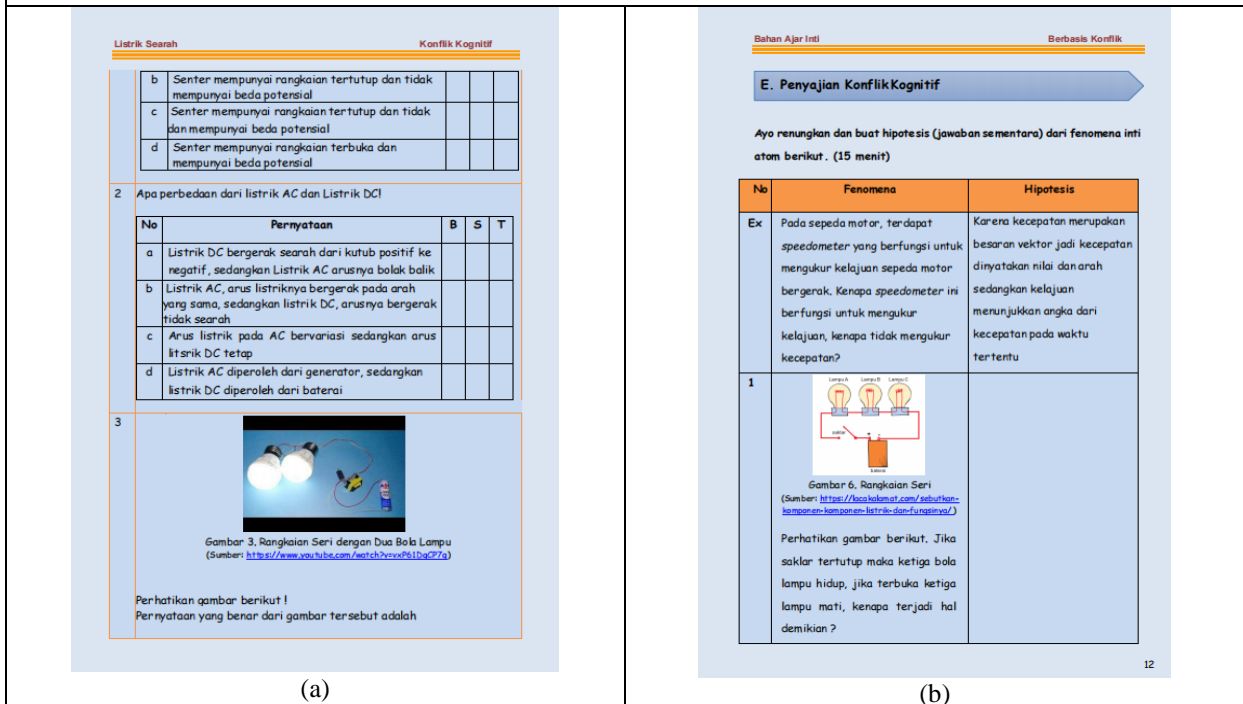

(a)

(b)

Fig. 2. Display of (a) Activation of Preconception and Misconception and (b) Presentation of Cognitive Conflict from the CCBL Model Syntax on Direct Current Electrivity Teaching Material
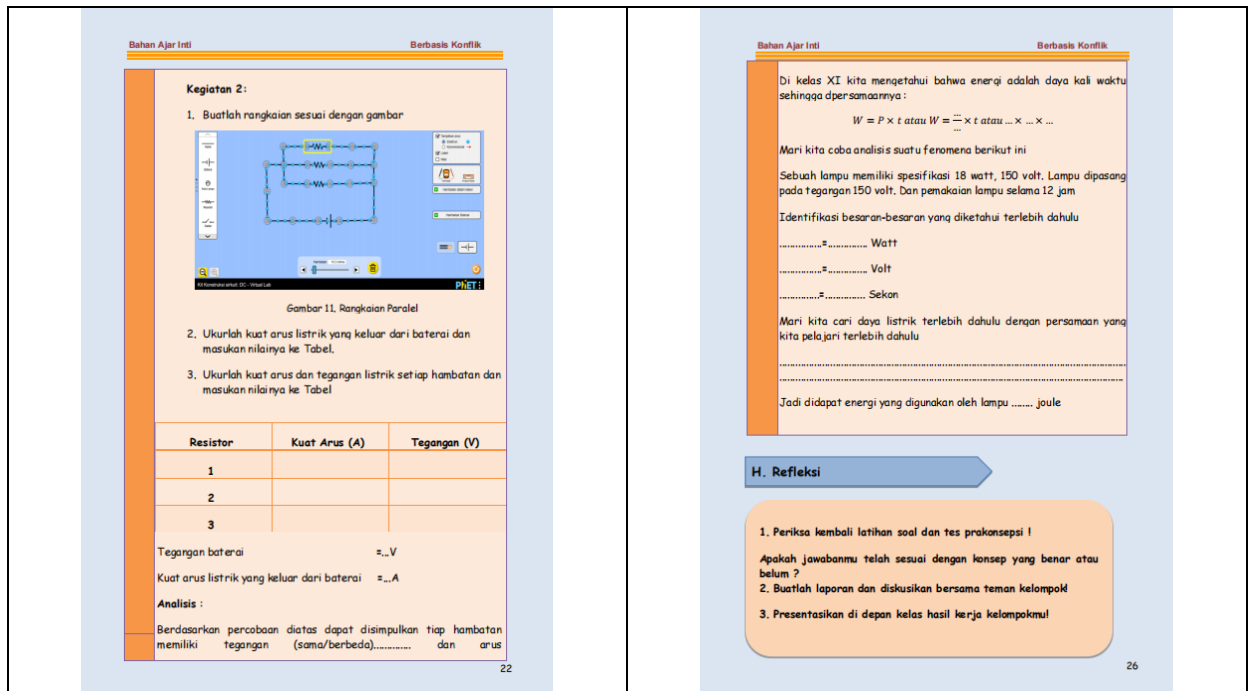
Fig. 3. Display of Discovery of Concepts and Equations Syntax with Virtual laboratories Experiment. At the Reflection Syntax, In the reflection syntax, Students are Invited to Review the Results of the 2 Previous Syntax.

Furthermore, a self-evaluation of the teaching material prototype was carried out. The components assessed in the self-evaluation consist of 5 indicators, namely (1) the structure of teaching materials according to the 2008 Ministry of National Education, (2) teaching materials according to the CCBL model syntax, (3) teaching materials have integrated virtual laboratories, (4) the language is appropriate, (5) the display of teaching materials is appropriate. The results of self-evaluation of each indicator can be seen in Figure 4.
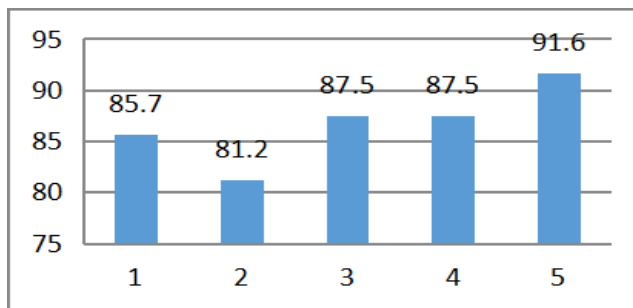

Fig. 4. Self-Evaluation Results

Based on Figure 4, it is found that the value of each indicator ranges from 81.2 to 91.6. All indicators in the self-evaluation assessment are in the very good category, the very good category ranges from 81 to 100, the average value is 86.7, with this value, self-evaluation is in the very good category.

After a self-evaluation is carried out an expert review is carried out, several components that will be assessed are the content validity, the construct validity, the language validity, and the face validity.

The next stage is to test the validity of teaching materials through expert reviews. The four aspects of the validity that were assessed were content validity, construct validity, language validity, and face validity.

First, content validity consists of eleven indicators, namely: (1) the material presented in the teaching material is in accordance with the 2013 curriculum, (2) the material presented in the teaching material is in accordance with Core competencies (KI) and basic competencies (KD) 3.1 and 4.1 , (3) the formulation of indicators presented in teaching materials in accordance with KD 3.1 and KD 4.1, (4) the physics symbols used are accurate, (5) the material presented does not cause multiple interpretations, (6) the images are presented accurately according to the material, (7) illustrations are presented accurately in accordance with the material, (8) there are no misconceptions due to example errors, (9) images quoted from other people's work include references / sources, (10) Teaching materials contain the syntax of cognitive conflict-based learning models (CCBL) namely activation of preconceptions and conceptions, presentation of cognitive conflicts, discovery of

concepts and equations, and reflection, (11) in the syntax of the three CCBL models, virtual laboratories have been properly integrated. The results of the content validity indicator can be seen in Figure 5:
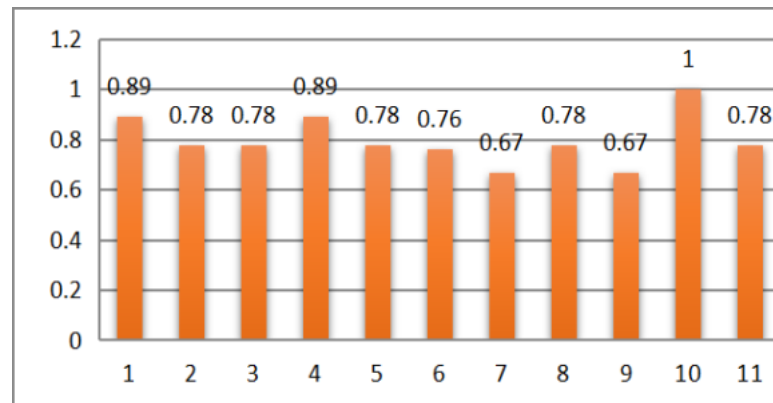

Fig. 5. Result of Content Validity

Based on Figure 5, the value for each indicator of the content eligibility component ranges from 0.67 to 1. All indicators that have been assessed are in the very valid category. The average value of the content validity aspect of the teaching material prototype is 0.79 which is in the valid category.

An assessment of the construct validity aspect was carried out on eight indicators. (1) Teaching materials are arranged systematically in accordance with the provisions of the 2008 Ministry of National Education, namely titles, learning instructions, competencies to be achieved, supporting information, assignments and assessments, (2) presentation of the activation of preconceptions and misconceptions stages, can reveal students' prior knowledge, (3) The presentation of the cognitive conflict presentation stage can trigger students to think deeply, (4) the presentation of the concept and equation discovery stage has integrated virtual laboratory experiments, (5) The presentation of the reflection stage on teaching materials can reveal the progress of student understanding, (6) the numbering of images presented sequentially, (7) the naming of the images is presented appropriately, (8) the presentation of teaching materials made allows interaction between teachers and students. The results of the assessment of the construct validity indicators can be seen in Figure 6:
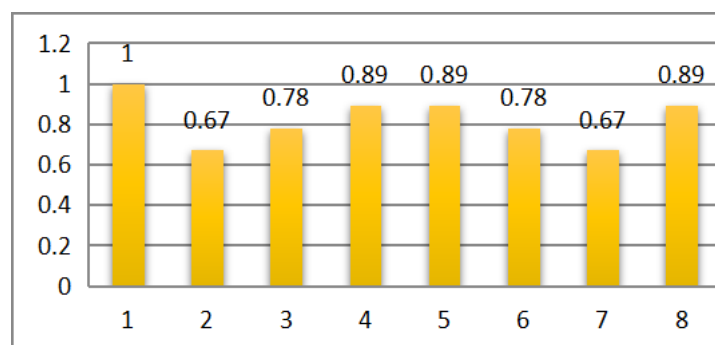

Fig. 6. Results of Construct Validity

Based on Figure 6, it can be seen that the value of each indicator component of the construct validity ranges from 0.67 to 1. There are two categories found from the eight indicators, namely valid and very valid. The average indicator of the construct validity aspect of the teaching material prototype is 0.82, which is in the very valid category.

Assessment of the validity of language has eight indicators, namely: (1) the language used is according to the level of the student, (2) the language used in teaching materials has a beauty value so that students enjoy reading it (aesthetically), (4) the language used is communicative and informative so that the message conveyed is easy to understand (educative), (5) the language used does not mean double, (6) the terms used are in accordance with scientific technical terms, (7) the language used is in accordance with good and correct Indonesian grammar rules , (8) the spelling used refers to the Indonesian language guidelines. The results of the indicator assessment on the aspect of language validity can be seen in Figure 7.
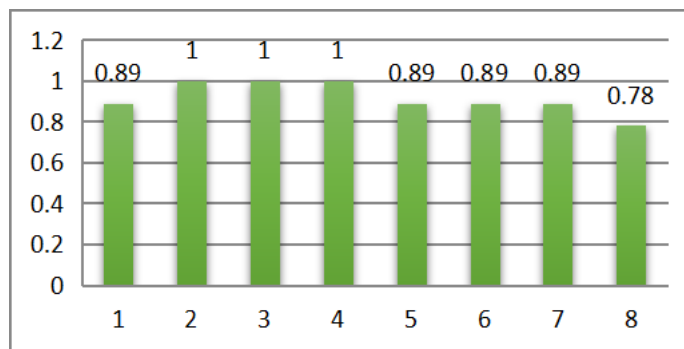
Fig. 7. Result of Language Validity

Based on Figure 7, it can be seen that the value of each indicator of language validity ranges from 0.78 to 1. Based on this assessment, the aspect of language validity is included in the very valid category with an average value of 0.92.

Assessment of the face validity of cognitive conflict-based teaching materials was carried out on six indicators. The indicators assessed are: (1) the arrangement of the cover of the teaching material looks attractive, (2) the font used is correct, (3) the font size can be read clearly, (4) the font size used is correct, (5) the color arrangement The cover and design are correct, (6) the cover illustration describes the contents of the teaching material. The results of the face validity study of the teaching material prototype can be seen in Figure 8.
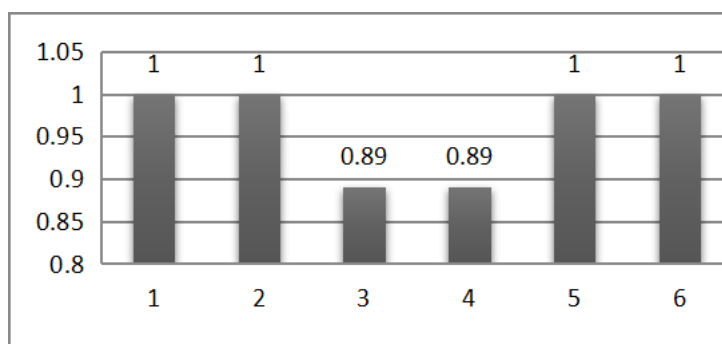

Fig. 8. Results of Face Validity

Based on Figure 8, it can be seen that the value of each face validity indicator ranges from 0.89 to 1. The assessment of facial validity aspects is in the very valid category with an average value of 8.2.

The assessment has been carried out on four aspects of validity, namely content validity, construct validity, language validity, and face validity. The results of the four aspects of the validity of cognitive conflict-based teaching materials integrating virtual laboratories can be seen in Figure 9.
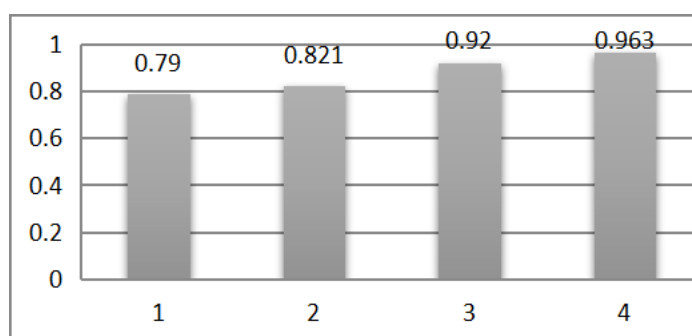

Fig.9. The Validity Value of Each Aspect of Teaching Materials

Based on Figure 9, the average value of each aspect ranges from 0.79 to 0.96. The average value of the whole is 0.87, it can be concluded that the overall components of the teaching materials are in a very valid category. So that cognitive conflict-based teaching materials integrate virtual laboratories on direct current electrical materials to improve conceptual understanding of class XII SMA students have a very valid level of validity.

B. Discussions

The results of students' concept tests were still low in the preliminary research, it was seen from the number of students who could not answer concept questions correctly. This is related to the results of interviews with teachers at school. The results of the interviews indicated that the learning carried out in schools did not meet the 2013 curriculum, because teachers were still implementing conventional (teacher-centered) learning. Learning is still dominated by the lecture method and does not involve students to actively discover concepts. Learning has not used a specific model that enables student learning (student-centered). There are no teaching materials that integrate certain learning models so that learning is effective. The limitations of time and tools when conducting experiments are also an obstacle for students to find concepts. Some of the phenomena resulting from the interview are thought to be the cause of low conceptual understanding and misconceptions. This opinion is reinforced by the results of Mufit's research, that the implementation of learning in schools still uses a conventional or teacher-centered approach, so that students' conceptual understanding is also low and there are misconceptions [1]. These problems indicate that physics learning in schools has not reached the expected target according to the 2013 curriculum.

The development of teaching materials is carried out as a solution to these problems. At the prototype stage, cognitive conflict-based teaching materials were designed to integrate virtual laboratory experiments to overcome misconceptions. Teaching materials are arranged according to the syntax of conflict-based cognitive learning (CCBL) model, because the model is effective in improving conceptual understanding and remediating misconceptions [3] [4]. The results of self-evaluation of the teaching material prototype are very good criteria, indicating that the teaching material components are complete according to the structure of the 2008 Ministry of Education and Culture and in accordance with the CCBL model syntax.

The results of the prototype validity test also showed that the teaching materials were at very valid criteria. Teaching materials are valid in the aspects of content validity, construct validity, language validity and face validity. Teaching materials are valid in the aspect of content validity because they are in accordance with the 2013 curriculum, core competence (KI), basic competence (KD) 3.1 and basic competence (KD) 4.1, the physics symbols used are correct, the material presented does not cause multiple interpretations, materials teach has loaded the CCBL model syntax. This result is reinforced by Khairunnisa's research, that the teaching materials developed must be in accordance with the curriculum used and in accordance with educational goals, so that students will find it easier to follow and understand the teaching materials made [16].

Teaching materials have also been valid on construct validity aspects which are very valid criteria. This is because the systematics of teaching materials are in accordance with the provisions of the Ministry of Education and Culture 2008, the presentation of cognitive conflict has triggered students to think deeply, at the stage of finding concepts and equations, it has led students to find concepts and equations. According to Hanum, the construct validity in teaching materials is very important, because the construct developed in teaching materials can attract students 'interest in learning so that it can increase students' curiosity in studying physics [17].

Teaching materials have also been valid in the language validity aspect with very valid criteria. This is because the writing of each sentence in the teaching material has used polite, beautiful, easy to understand language, does not have many meanings, and is in accordance with good and correct Indonesian rules. This result is reinforced by Khairunnisa's research, that the teaching materials made must use good and correct Indonesian, so that in understanding the teaching materials there are no errors [16].

Teaching materials are valid in the aspect of face validity with very valid criteria. This is because the teaching material is proportional in the use of fonts (type and size), the arrangement of the cover of the teaching material is attractive, the arrangement of the cover color is correct, the cover illustration describes the contents of the teaching material, the image is correct. These results are in accordance with Fadhilah's research which states that the use of appropriate fonts, layouts, illustrations makes the teaching materials used more attractive to read [18].

Based on the results of validation by experts, the design of cognitive conflict-based teaching materials integrating virtual laboratories on direct current electricity material to improve conceptual understanding of class XII high school students is declared valid, and ready for practicality and effectiveness tests.

IV. CONCLUSION

Based on the results of research and discussion, it can be concluded that the design of teaching materials on direct current electricity material has been created with the characteristics described as follows. Teaching materials are composed of four syntax of cognitive conflict-based learning (CCBL) model, namely: (1) activation of preconceptions and misconceptions, (2) presentation of cognitive conflict, (3) discovery of concepts and equations, and (4) reflection. In the third syntax, integrated virtual laboratory experimental steps on direct current electricity. Teaching materials are designed to improve students' conceptual understanding of direct current electricity. Cognitive conflict-based teaching materials on direct current electricity material are valid in

four aspects, namely content validity, construct validity, language validity and face validity with very valid categories.

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