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DESIGN AND VALIDITY OF PHYSICS TEACHING MATERIALS BASED ON COGNITIVE CONFLICT INTEGRATED VIRTUAL LABORATORY IN ATOMIC NUCLEUS

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ABSTRACT

The curriculum of 2013 requires the students to improve the understanding of concepts, but it stills not realized. Students' understanding of the concept of the atomic nucleus is still low & misconceptions occur. The solution is to develop physics teaching materials based on cognitive conflicts on the atomic nucleus matter. The purpose of this study is to create a valid cognitive conflict-based teaching material design. The type of research is development research using the Plomp's model. However, this research is limited to the preliminary research and prototyping phase. The first step is a preliminary research by analyzing needs and context by conducting journal analysis and interviews with physics teachers in schools. The second step is a prototype phase, which developed teaching materials design, a validation process by researchers (self-evaluation), and an expert's review. The result of preliminary research showed that student that in the atomic nucleus material, there were still many misconceptions. It had no teaching materials that integrated learning models, and a lack of guidelines for conducting virtual laboratory. The result of prototyping phase showed of teaching materials-based-cognitive conflict developed and revised. The prototipe had passed the self-evaluation and an experts' review. The validity test show that the teaching material was valid with a value of 0.87. The teaching materials-based-cognitive conflict could be try test to student so that can used by a teacher to improve the conceptual understanding of the students.

Keywords : *cognitive conflict, virtual laboratory, misconception, teaching materials, Atomic Nucleus*

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I. INTRODUCTION

The era of globalization in the 21st century is characterized by easy access to technology. So that the information is found and disseminated quickly. Moreover, the competition will get tougher in the future. Qualified employees are required to face this competition. To realize high-quality human resources, the skills of the students are prioritized in the education of the 21st century. One of the most important skills for students is the ability to gather information. To collect information, students must be able to identify, search, find, evaluate, and use the information they receive. So that students can critically and effectively process and analyze the information received.

Students' abilities to develop skills and process information are paramount skills in the 21st century. These 21st-century skills are useful for improving quality and quality so that students can face obstacles and challenges in the future. In addition to the students who need to be able to gather information, there is also a need for teachers who have good learning skills so that the students' skills can develop properly. Good learning needs to be student-centered, which makes the teacher a facilitator in gathering information.

The government effort has been made to bring quality education to Indonesia. These efforts are designed to help society face competition in the 21st century. The current curriculum is the 2013 curriculum. The purpose of learning physics in the 2013 curriculum is the students are required to master the concepts, principles, and some skills so that they will be able to develop knowledge in these students. If the students can scientifically

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master the concept of physics and its principles in everyday life, this is a supporting factor for these students to be able to face future challenges.

A good understanding of the concepts will develop students' skills. In studying physics, conceptual understanding is a very common problem. Reducing misconceptions caused by various factors, including increasing student curiosity about a phenomenon in physics and better mastering concepts with appropriate learning methods [1]. However, most students (81%) have difficulty solving a physics problem despite knowing the concept of the problem involved [2]. This is because many teachers only present the learning in the abstract, without being accompanied by real or virtual experiments. So that most students do not understand in concept, but only in memory. The lack of availability of laboratory facilities, equipment, and materials is one of the factors for the poor quality of physics learning.

To realize high-quality physics learning, experiments must be carried out in learned physics material, so that the concept is constructed by students. This must be supported by appropriate facilities and the infrastructure in the learning process. If the teacher can do this, students will easily understand the physics material, especially the abstract material. Therefore, one of the solutions given is a virtual laboratory. This virtual laboratory is designed to increase student activity and encourage students to study abstract material for learning physics.

The virtual laboratory can support learning by 1) making it easier for students to access learning because experiments are carried out with laptop or smartphone, 2) making it easier for students to find concepts and motivate them, 3) enlivening the learning atmosphere, because students were have previously knowledge, 4) developing students' thinking and problem-solving skills, and 5) allowing students to access these resources during formal and non-formal learning [3]. The virtual laboratory can help overcome problems related to abstract experiments and make students more motivated and active during the learning process.

However, the reality in the field contradicts the desired ideal situation. This emerges from the first study through interviews and analysis of previous research on student conceptual understanding.

The results of preliminary research at three high schools in the city of Padang showed that the degree of understanding of the students' concepts in physics was still low [4]. Moreover, the conceptual understanding of nuclear physics was low, since the material is abstract and the learning media is inadequate [5]. In modern atomic physics or nuclear physics, most misconceptions occur among students [6]. The results of other studies also suggest that abstract material is very difficult to understand because it cannot be seen and observed directly and requires deep thinking to solve problems [7]. From the two data analyses performed, it appears that the problem of miconceptions is still very common among students, especially when studying abstract physics.

In addition to analyzing journals from preliminary research, interviews were conducted with teachers from several schools, namely SMAN 1 Padang, SMA Adabiah, and SMAN 12 Padang. The survey results show that the learning of physics is on average still a teacher center and neither real nor virtual experiments were carried out with atomic nuclear material. As a result, the students in the school experience a lot of misconceptions in the atomic nuclear material. Besides, the teaching materials used to come only from publishers without the integration of learning models.

The above problem can be overcome with solution, namely the designing of teaching materials based on cognitive conflicts. The cognitive conflict learning model is very helpful to improve conceptual understanding and to minimize misunderstandings among students [8]. This learning model requires students to incorporate deep thinking because when using this model, students' initial concepts will fluctuate and provide students with new scientifically proven concepts [9]. Also, students are given several tests before they begin learning to identify any misconceptions among students [10].

In detail, a solution to overcome that problems is to design cognitive conflict-based learning materials using virtual laboratories on atomic nuclear material to improve students' conceptual understanding. The purpose of this study is to create valid cognitive conflict-based teaching materials, integrate virtual laboratories, which is designed to improve students' conceptual understanding of the atomic nucleus material.

II. METHOD

This research is design research that provides a model for developing and validating a product to make it fit for use. Before testing, a product must go through the validation phase so that the product can be tested on-site. The validation phase in the study consists of two phases, namely validation by researchers (self-assessment) and validation by experts (expert assessment).

This cognitive conflict-based teaching material was designed by using the design/development research model of the Plomp model [11]. The product that will be developed in this research is cognitive conflict-based teaching materials that use virtual laboratories to improve students' conceptual understanding for grade XII students. The subject of this research is the media for learning in the shape of teaching materials that are based on cognitive conflicts. This teaching material consists of Basic Competence (KD) 3.10. Analysis of the properties of the atomic nucleus, radioactivity, use, effects, and protection in everyday life.

There are three steps in this development model: 1) preliminary research (the first step is to carry out a needs analysis and literature research), 2) development or prototype (the phase of a prototype design and formative evaluation and a revision of the prototype) and 3) the assessment phase (Testing the prototype and evaluating it in practice [12]. In this study, however, the researcher limited himself to the development or prototyping phase.

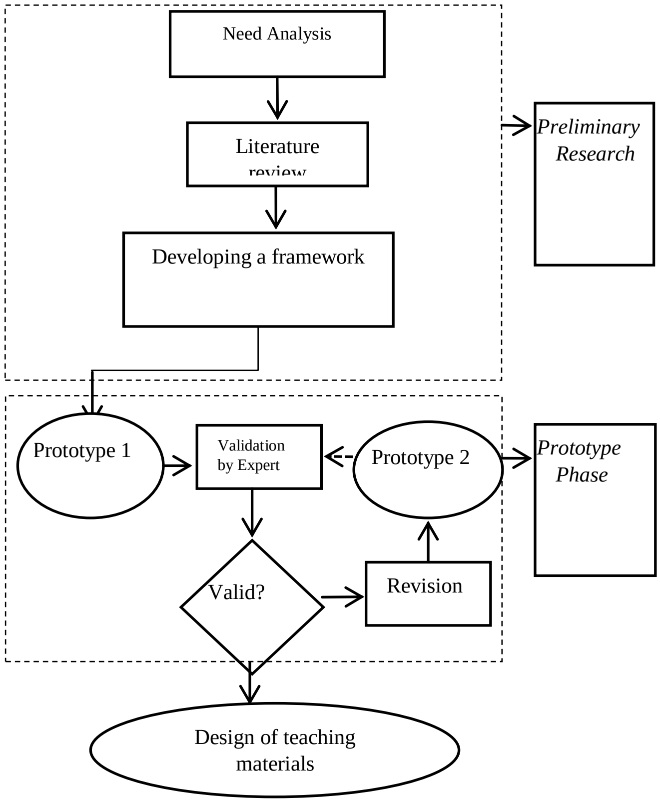


Fig 1. Research phases

In the first phase of preliminary research, the researchers conducted interviews with teachers and journal analysis of preliminary research. And from that first phase, it was found that the conditions on-site did not match the expected ideal conditions.

This cognitive conflict-based teaching material was first designed, then validated directly by the researcher (self-assessment), and finally validated by experts. A self-assessment is performed to review the components that the researcher believes are missing and need revision. After passing the self-assessment, it can be validated by experts. The experts asked for evaluation were 3 physics lecturers from the Faculty of Mathematics and Science, Universitas Negeri Padang.

The validation of the teaching materials produced results from the indicators of the instruments filled in by experts. Descriptive analysis was performed for statistical tests and displayed in graphical form. The weighting is done using a scale determined by Aiken [13]. This study used 4 categories with 3 evaluators/experts. The categories used were as follows: a) Score 4 = fully agree, b) Score 3 = agree, c) Score 2 = disagree, d) Score 1 = totally disagree. The validity of any question answered by the evaluator. Mathematically written as follows.

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

The validity assessment is determined based on the interpretation criteria of the assessments received. The interpretation of the V Aiken formula lies between 0 and 1, which results from expert evaluations [14]. The evaluation index is shown in the following table.

Table 1. Product Validity Criteria [13]

No	Validity Index	Criteria
1.	V<0,4	Less Valid
2.	0,4<V<0,8	Valid
3.	V>0,8	Very Valid

III. RESULTS AND DISCUSSION

The results of the research from the first phase (preliminary research) were a needs and context analysis, interviews with teachers at three high schools, as well as a journal analysis. The interview's results with teachers at schools were that the learning model was used at the beginning of the learning process did not meet the requirements of the 2013 curriculum. Classroom learning was still teacher-centered or used the lecture teaching method and occasionally used group discussions. Teaching materials still used the publisher's output teaching materials which did not integrate certain learning models. Experiments were rarely carried out due to limited facilities and infrastructures. This was done in real and virtual experiments. The student's degree of understanding of the concepts of atomic nuclear material is still relatively low.

Besides, an initial study of journal analysis was carried out about classroom materials, misunderstandings, and virtual laboratories. According to Marlon, up to 25% of the total number of students tested had misconceptions about atomic nuclear material [14]. The general problem that occurs in abstract matter, particularly in atomic nuclei and radioactivity, is the lack of experimental activity [4]. To solve this problem, an alternative is provided, namely a virtual laboratory for abstract material that cannot conduct real experiments.

The second phase is conducting a literature search which found that 47% of students said the physics equations they found did not help them understand the concept scientifically, and 81% of students even found that the problem is a bit difficult to be solved in physics to solve even though c they understood concepts related to the problem topic [10]. This is because one of them is that the learning process did not incorporate a particular model [16]. As well as the student's lack of attention to the phenomena that occur in the environment, while the environment is an important point in learning physics [15].

The results of the preliminary research phase is showed that the students' understanding of physical material was very poor and that there were generally misconceptions among the students and that there were no experimental activities that supported the atomic nuclear material and radioactivity. This was due to several factors, namely the lack of application of learning models and materials which is abstract. Also, there is still very little use of virtual laboratories as teachers and students are still confused about using them. The solution to this problem is to create teaching materials that use virtual atomic nuclear material laboratories to improve student understanding.

The next phase is the development phase or prototyping phase. The design of the material of teaching is based on cognitive conflict follows the structure established by the Ministry of National Education and is based on four syntax or phase of cognitive conflict-based learning model (CCBL). The following is a draft of cognitive conflict-based teaching materials.

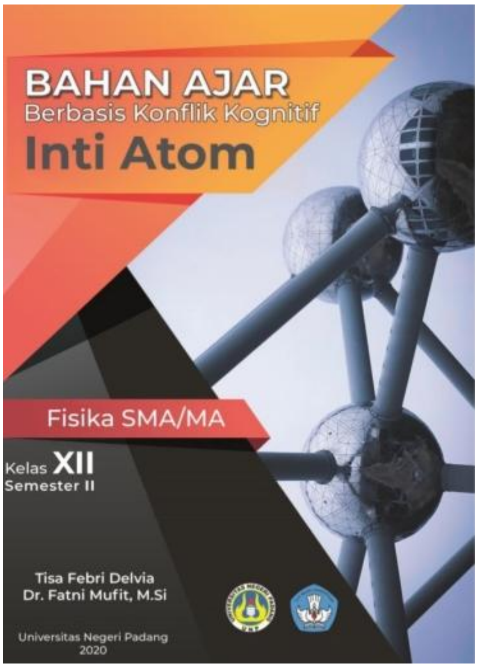
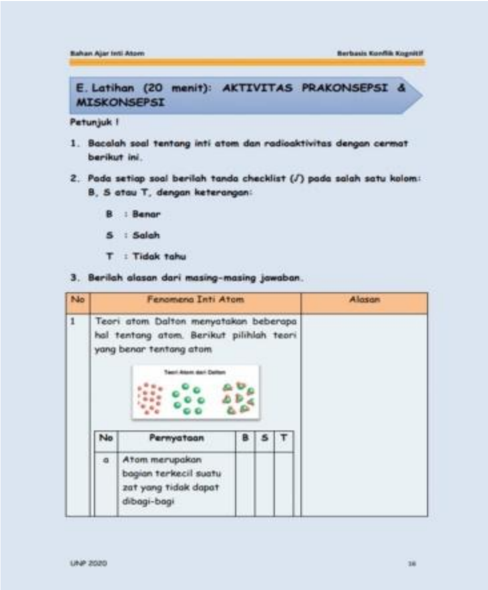


Fig 2. Cover, as initial display of teaching material



Bahan Ajar Inti Atom Berbasis Konflik Kognitif

E. Latihan (20 menit): AKTIVITAS PRAKONSEPSI & MISKONSEPSI

Petunjuk !

1. Bacalah soal tentang inti atom dan radioaktivitas dengan cermat berikut ini.
2. Pada setiap soal berilah tanda checklist (√) pada salah satu kolom: B, S atau T, dengan keterangan:
   - B : Benar
   - S : Salah
   - T : Tidak tahu
3. Berilah alasan dari masing-masing jawaban.

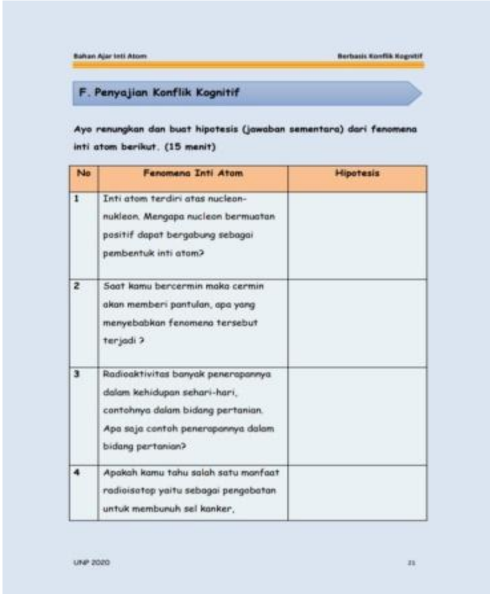
No	Fenomena Inti Atom	Alasan
1	Teori atom Dalton menyatakan beberapa hal tentang atom. Berikut pilihlah teori yang benar tentang atom	

Teori Atom dari Dalton

No	Pernyataan	B	S	T
a	Atom merupakan bagian terkecil suatu zat yang tidak dapat dibagi-bagi			

UNP 2020 16

Fig 3. First phase of activation of preconception and misconception for knowing student's initial concept



Bahan Ajar Inti Atom Berbasis Konflik Kognitif

F. Penyajian Konflik Kognitif

Ayo renungkan dan buat hipotesis (jawaban sementara) dari fenomena inti atom berikut. (15 menit)

No	Fenomena Inti Atom	Hipotesis
1	Inti atom terdiri atas nucleon-nukleon. Mengapa nucleon bermuatan positif dapat bergabung sebagai pembentuk inti atom?	
2	Saat kamu bercermin maka cermin akan memberi pantulan, apa yang menyebabkan fenomena tersebut terjadi ?	
3	Radioaktivitas banyak penerapannya dalam kehidupan sehari-hari, contohnya dalam bidang pertanian. Apa saja contoh penerapannya dalam bidang pertanian?	
4	Apakah kamu tahu salah satu manfaat radioisotop yaitu sebagai pengobatan untuk membunuh sel kanker,	

UNP 2020 21

Fig 4. Second phase, presentation of cognitive conflict, to shake student misconceptions

Bahan Ajar Inti Atom Berbasis Konflik Kognitif

Gambar 6. Tampilan Menu Buat Atom

Analisis :

a) Apa yang membuat inti stabil atau tidak stabil ?.........
b) Apa yang dimaksud bilangan massa pada atom ?........

Kesimpulan : (buat kesimpulan dari pertanyaan berikut ini!)

Apakah atom harus memiliki jumlah proton, neutron dan elektron yang sama?

....

....

Faktor utama yang mempengaruhi kestabilan dan ketidakstabilan inti ?

....

....

Kegiatan 2 (Mengetahui Simbol Atom berdasarkan struktur inti)

1) Pilihlah model orbit (menentukan apakah ingin membuat atom berbentuk orbit atau awan)

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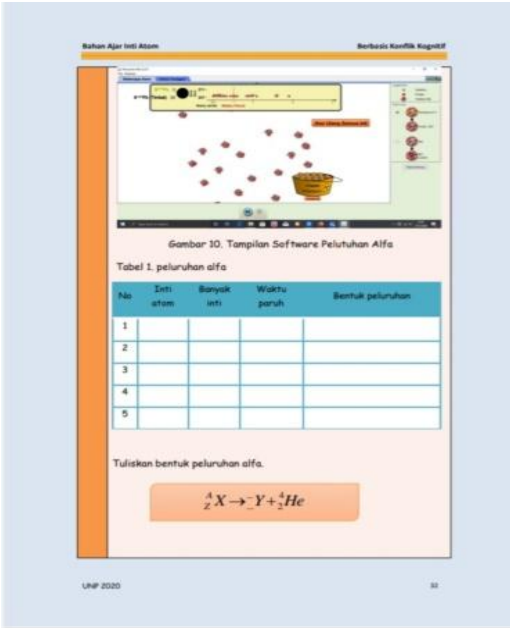
(a)



Bahan Ajar Inti Atom Berbasis Konflik Kognitif

Gambar 10. Tampilan Software Pelutuhan Alfa

Tabel 1. peluruhan alfa

No	Inti atom	Banyak inti	Waktu paruh	Bentuk peluruhan
1				
2				
3				
4				
5				

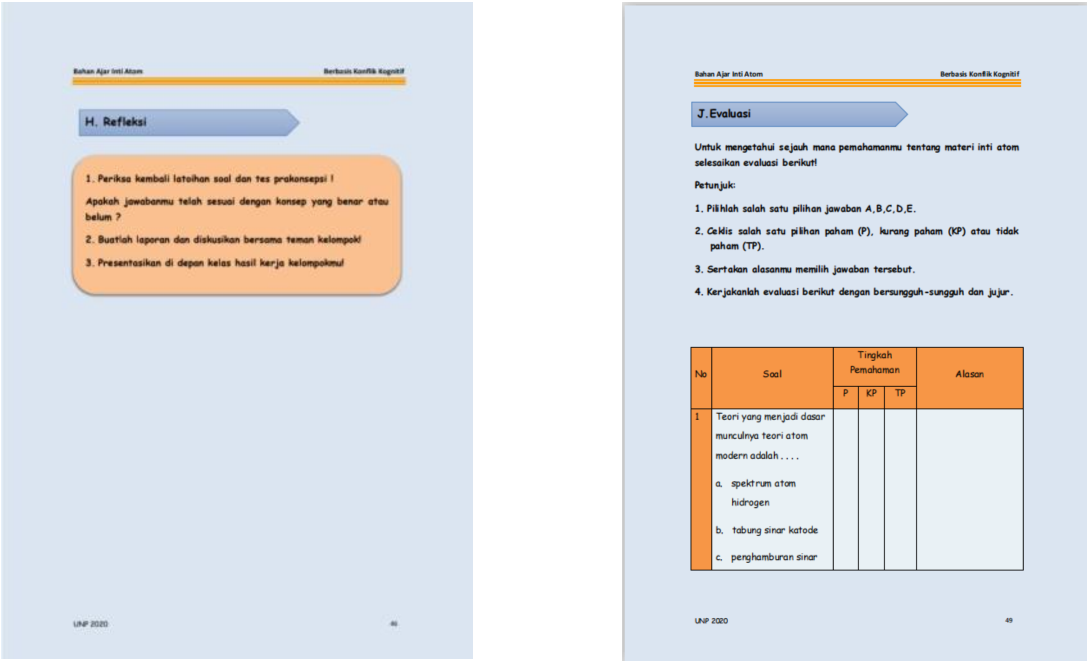
Tuliskan bentuk peluruhan alfa.

$$^{A}_{Z}X \rightarrow ^{-}_{-}Y + ^{4}_{2}He$$

UNP 2020 32

(b)

Fig 5. Third phase; discovery of concept (a) and discovery of equations (b)



Bahan Ajar Inti Atom Berbasis Konflik Kognitif

H. Refleksi

1. Periksa kembali latoihan soal dan tes prakonsepsi !

Apakah jawabanmu telah sesuai dengan konsep yang benar atau belum ?

2. Buatlah laporan dan diskusikan bersama teman kelompok!

3. Presentasikan di depan kelas hasil kerja kelompokmu!

UNP 2020

Bahan Ajar Inti Atom Berbasis Konflik Kognitif

J. Evaluasi

Untuk mengetahui sejauh mana pemahamanmu tentang materi inti atom selesaikan evaluasi berikut!

Petunjuk:

1. Pilihlah salah satu pilihan jawaban A,B,C,D,E.
2. Ceklis salah satu pilihan paham (P), kurang paham (KP) atau tidak paham (TP).
3. Sertakan alasanmu memilih jawaban tersebut.
4. Kerjakanlah evaluasi berikut dengan bersungguh-sungguh dan jujur.

No	Soal	Tingkah Pemahaman			Alasan
		P	KP	TP	
1	Teori yang menjadi dasar munculnya teori atom modern adalah . . . . a. spektrum atom hidrogen b. tabung sinar katode c. penghamburan sinar				

UNP 2020 49

Fig 6. Forth phase; reflection, as feedback on new concepts obtained by students

A self-evaluation of the product developed by the researcher was carried out prior to validation by professional experts. After passing the self-assessment test, the teaching materials go through the validity test phase by experts (expert assessment).

Based on the assessment tool used, an analysis for the four components of the assessment of cognitive conflict-based teaching materials can be carried out. First, the component for assessing the content validity consists of 8 indicators: 1) The included material in the teaching materials corresponds to the 2013 curriculum, 2) The included material included in the teaching materials corresponds to Core Competence (KI), and Based Competence (KD). 3) The formulation of the indicators presented in the teaching materials corresponds to KD. 4) The physics symbols and equations used are correct. 5) The presented material does not lead to multiple interpretations for the students. 6) The images shown are correct. 7) The examples presented in the teaching materials are correct and 8) Images are cited from the work, others are listed as references/sources. The results of the content validity indicator score are shown in Figure 7.

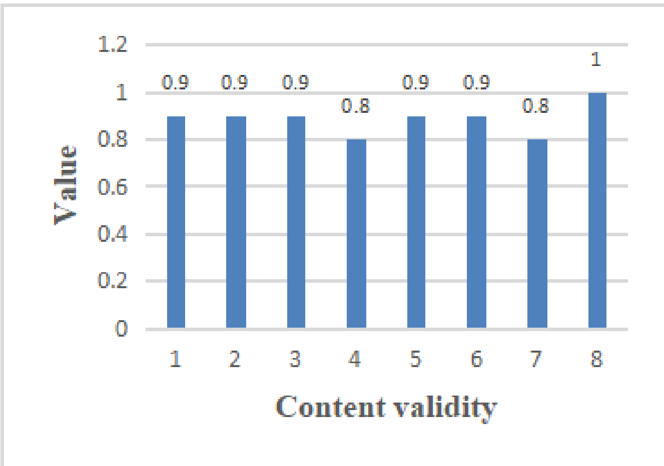


Fig 7. Content Validity Results

Based on Figure 7, the value for each indicator of the content authorization component is between 0.8 and 1. Of all the indicators that receive a rating for the content authorization component, it is in the very valid category. The very valid category ranges from V> 0.8. The average score for the content permissions component is 0.88. With the acquisition of this value, the content validity of teaching materials falls into the very valid category.

In addition, the construct validity is carried out on eight indicators. These indicators are: 1) Cognitive conflict-based physics teaching materials meet the full systematic teaching materials under the Ministry of Education 2008, namely titles, learning c the instructions, the competencies that will be achieved, supporting information, the tasks, work steps and assessments [1]. 2) The presentation of the activation of preconceptions and misconceptions is correct. 3) The presentation of the cognitive conflicts in the teaching materials is correct. 4) The presentation of the discovery of concept and equations in the teaching materials is correct. 5) The presentation of the reflections on the teaching materials is correct. 6) The teaching materials are equipped with virtual laboratories to improve the conceptual understanding of the students. 7) The numbering of the teaching materials is already in order. 8) The presentation of the teaching materials enables interaction between teachers and students. The results of the data plot values for each indicator are shown in Figure 8.

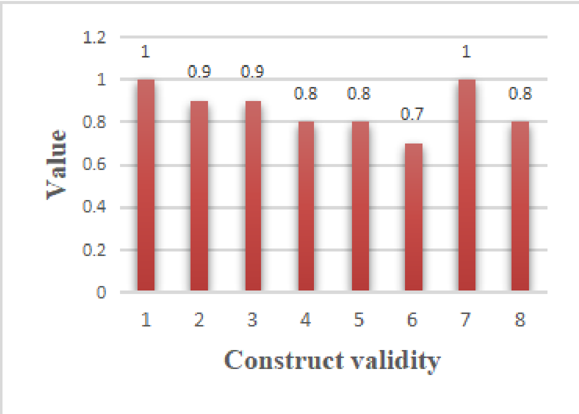


Fig 8. Construct Validity Results

Based on Figure 8, it can be seen that the value of each indicator of the construct validity ranges from 0.7 to 1. Of the eight indicators that gave a rating, two categories were found, namely valid and very valid. The valid category ranges from a value of 0.4 <V <0.8 and the very strong category lies in the value range V> 0.8. The average score obtained in the construct validity component is 0.86. With the component values obtained, the construct validity in the teaching materials fall into the very valid category.

In addition, eight indicators were assessed in the component for assessing the languages validity. The indicators assessed are: 1) The language used corresponds to the level of thought of the student. 2) The language used in the teaching materials has a courtesy (ethical) value. 3) The language used in the teaching materials has a beauty value so that students will enjoy reading it (aesthetic), 4) The language used is communicative and informative so that the information conveyed is easy to understand (educational), 5) The language used means not double, 6) The terms used correspond to the agreed scientific technical terms, 7) The language used corresponds to the grammar Correct Indonesian and 8) The spelling used relates to EJT. The results of the data plot values for each indicator of the voice authorization component are shown in Figure 9.

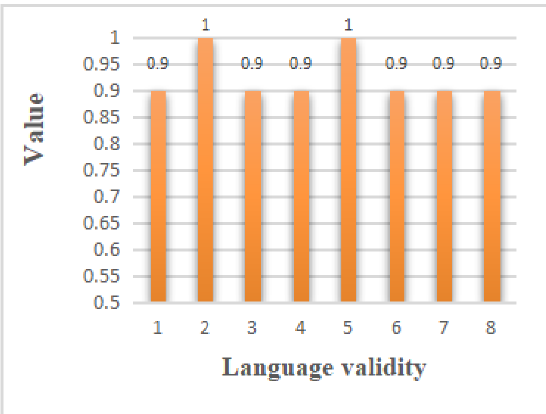


Fig 9. Language Validity Results

It can be seen from Figure 9 that the value of each indicator in the voice authorization component is between 0.9 and 1. Of all the indicators classified as being in the validity category, it is very valid with an average value of 0.92.

Fourth, evaluation of the appearance validity using six indicators. The six indicators are: 1) the arrangement of the cover sheet of the teaching material is displayed harmoniously, 2) the font used is correct, 3) the font size used is correct, 4) the font size in the title of the teaching material is correctly proportional to the size of the content of the teaching material) The arrangement and design of the envelope color are correct and 6) The figure on the envelope shows the content of the teaching material. The results of graphing the value data for each appearance validity indicator are shown in Figure 10.

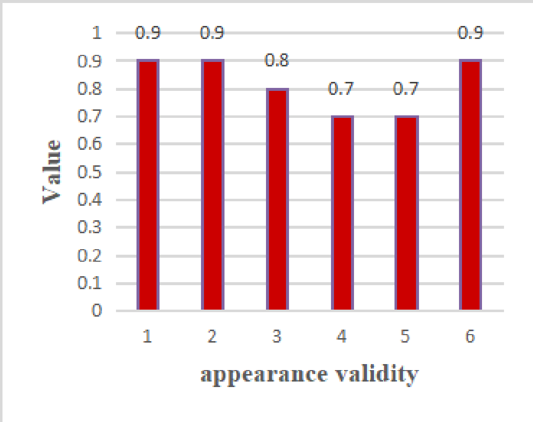


Fig 10. Appearance Validity Results

It can be seen from Figure 10 that the value of each indicator of the appearance validity components is in the range of 0.7-0.9. Of the six indicators for evaluating the appearance component, there are four indicators in the very valid category and two indicators in the valid category. The average value obtained from each indicator of the appearance validity component is 0.82, which is in the very valid validity category.

The average value of each teaching material assessment component based on cognitive conflict using a virtual laboratory in atomic core materials to improve the conceptual understanding of class XII students can be obtained from the scores of the four teaching material assessment components. The four components that were assessed were: 1) the content validity, 2) the construct validity, 3) the language validity, and 4) the appearance validity. The plot results c of the validity value of the material of teaching for each assessment component are shown in Figure 11.

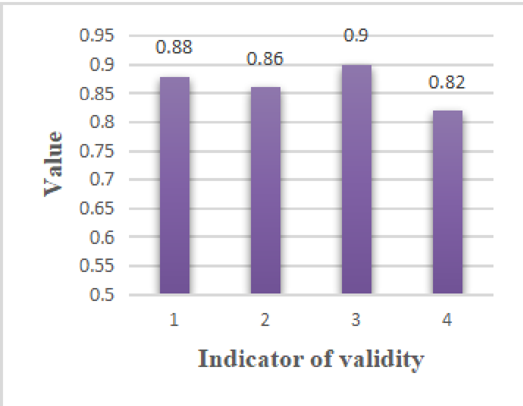


Fig 11. Value of Each Component Validity of Teaching Materials

Based on the above figure, the average value of each component in the validation of teaching materials varies, which is between 0.8 and 0.9. With an overall mean of 0.87. From this value, it can be concluded that the entire material of teaching components is in the very valid category. Cognitive conflict-based teaching materials that use a virtual laboratory in atomic core materials to improve students' conceptual understanding, therefore, have a very valid level of validity.

Discussion of the research results obtained from the phases carried out. In this design research, the researcher is limited to the testing phase of the validity of some teaching materials. The design of teaching materials based on cognitive conflicts was created with the characteristics of the title, learning instructions, competencies to be achieved, material, work steps, summary, and assessment.

In the initial phase, namely the preliminary investigation, it was found that the implementation of the 2013 curriculum was not fully implemented. This was known from the results of interviews with teachers. In addition to the ineffective implementation of the 2013 curriculum, there are other problems, namely the use of learning models that are seldom implemented and are still conventional. This is in line with relevant research in previous studies which found that the lack of student activity was due to conventional learning methods [1].

After learning physics, it is always necessary to participate in experimental activities to support the theory under study. However, the implementation has not yet been fully implemented. This is due to inadequate facilities, especially in relation to atomic nuclei. While the expected situation is reversed, in addition to studying theory, students can also get scientific evidence of experimental activities. This is in line with Mufit's research [2] that student activities in the form of experiments encourage students to find learning concepts that are correct and correspond to scientific facts, compared to not doing experiments. To overcome this, the researchers created a cognitively conflict-based teaching material design using a virtual laboratory for atomic nuclear material.

In the second phase, the prototype phase, there are two research phases. First, the results of the self-assessment, at this point the researcher has checked all the components included in the teaching materials and added components that are considered not to be included in the teaching materials. So that the teaching materials can be validated by experts.

In addition, the validation is carried out by experts. This evaluation is carried out with 4 indicators. The aspect of the content validity of teaching materials is declared valid because it has met the learning standards according to the 2013 curriculum. This is also in line with previous research which stated that classroom materials must be designed with the aim of encouraging students to understand physical concepts and removing previous misconceptions [15].

The second aspect, the construct validity, is also validated as it complies with the 2008 Ministry of National Education guidelines on the structure of teaching materials and follows the syntax of learning cognitive conflict. This teaching material focuses on 4 cognitive conflict-based learning syntaxes to remove student misconceptions [9]. In the third syntax of the CCBL model, namely the discovery of concepts and equations, the experiment has been integrated using a virtual laboratory about the atomic nucleus.

The third aspect, language validity, is also declared valid. The writing structure of the teaching material is adapted to the correct usage rules of Indonesian so that readers can easily understand and understand it.

The fourth aspect, namely the appearance validity, which assesses the composition, appearance, and coherence of teaching materials, is also declared valid. A teaching material must be able to arouse the reader's interest in the use of the teaching material. This has been fulfilled through this cognitive conflict-based teaching material so that it can be validated.

Based on the results of the validation by some researchers and experts, the design of cognitive conflict-based teaching materials using virtual atomic nuclear material laboratories to maintain the improvement of the understanding concept of students can be declared feasible to be used and tested in class XII physics learning. It is in line with previous research that cognitive conflict learning can remove misconceptions by increasing student activity through experimentation in the learning process [18]. Therefore, researchers recommend using this teaching material in the physics learning process.

IV. CONCLUSION

Based on the results of the and a discussion carried out, this can be concluded this study. Has created teaching materials based on cognitive conflict with the following characteristics. The teaching materials consist of titles, study instructions, competencies to be achieved, materials, student worksheets, summaries, and assessments. The learning model in this teaching material consists of 4 syntaxes: 1) the activation of preconception and misconceptions, 2) presentation of cognitive conflicts, 3) discovery of the concepts and the equations and 4) reflection. In the third syntax, the experiment has been integrated using a virtual laboratory about the atomic nucleus. This teaching material is designed to improve students' understanding of physics learning, particularly atomic nuclear material. The validation results of teaching materials based on the cognitive conflict on atomic nuclear material have a very valid validation level. Teaching materials have been valid in four aspects of validity assessment, namely, namely the content validity, the construct validity, the languages validity, and the appearance validity.

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