

CONCEPTUAL MODEL OF LEARNING MATERIALS ORIENTED TO THE DIMENSIONS OF KNOWLEDGE AND COGNITIVE PROCESSES IN BALANCE AND ROTATIONAL DYNAMICS FOR HIGH SCHOOL PHYSICS LEARNING

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ABSTRACT

Revolution 4.0 has changed the demands of the world of education a lot. The national education system expects students to develop the potential for thinking in order to keep up with the times. K-13 is used as a solution to answer it so that learning combines the dimensions of knowledge and cognitive processes. Overcome, real conditions found that the learning materials in balance and rotational dynamics used in schools didn't meet the scope of the dimensions of knowledge and cognitive processes as expected. One solution to this problem is to develop learning materials oriented to the dimensions of knowledge and cognitive processes in balance and rotational dynamics. The purpose of this research was to develop and determine the validity of the dimensions of knowledge and cognitive processes on learning materials in balance and rotational dynamics for high school physics learning. The type of research was RnD by taking the ADDIE model which is reduced to the development stage. The subjects were 3 physics lecturers UNP and 3 physics teachers from SMAN 2, 4, and 12 Kerinci with the object being learning materials consisting of lesson plans, textbook, and evaluation instruments. The results of data analysis obtained of validity values on lesson plans, textbook, and evaluation instruments according to lecturers and teachers respectively with a score 84.67% and 94.58%. Overall learning materials get an average score 89.63% in very valid category and can be continued with field tests to determine its practicality and effectiveness in high school physics learning.

Keywords : Learning Materials; The Dimensions of Knowledge; Cognitive Processes; Balance and Rotational Dynamics



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I. INTRODUCTION

Revolution 4.0 has changed the governance of human life ranging from social, economic, and even educational fields [1][2][3]. This is evidenced by the human power that is replaced with robotic power on the grounds that it is more effective, efficient, and cheap costs. To address this, the world of education is also experiencing changes in demands, especially in skills. These skills are known as 4C skills (critical thinking, creativity, communication, and collaboration). The display is expected to be a provision for students to be skilled in facing revolution 4.0. In Law 20 of 2003 on the National Education System students are expected to develop all the potential that has been possessed. The potential in statement is the ability that God has given to humans, namely the ability to think and reason. So that through the end of the ability can be trained developed as well as possible.

The 2013 curriculum was then used as one of the solutions used in answering the demands of the education world in revolution 4.0 to develop student's thinking and reasoning potential as a refinement of the previous curriculum. In the 2013 curriculum it is expected that learning can lead to the diversity of knowledge that will be obtained by students through the dimensions of knowledge and cognitive processes as state in Bloom's taxonomy revision. Thus, to achieve these goals learning should be designed using a combination of 4 dimensions of knowledge and 6 cognitive level processes. This is intended because the diversity of relevant knowledge in life is very important for students because experience shows that people who have a lot of knowledge will gain a good life and benefit others as well as the community environments.

In Bloom's taxonomy, the revision of the dimensions of knowledge can be divided into 4 knowledge including factual, conceptual, procedural, and metacognitive. Factual knowledge is knowledge that serves as a problem solver that contains basic elements that include symbols that relate to references to obtain certain information. Conceptual knowledge is knowledge that contains explicit and implicit models or theories and schematics on models of cognitive psychology. Procedural knowledge is the knowledge of how to do things in the form of steps and procedures regarding expertise, algorithms, techniques, and methods collectively. While metacognitive knowledge is knowledge in the form of student awareness and responsibility for his own knowledge and thinking [4]. In the study of physics, factual knowledge is the facts related to conceptual and procedural knowledge. Conceptual knowledge includes theories, concepts, laws, and principles acquired through the scientific method. Procedural knowledge includes steps to carry out scientific activities and so on. While metacognitive knowledge is formed based on the mastery of factual, conceptual, and procedural knowledge which is also called thinking about thinking [5].

In Bloom's taxonomy revision of cognitive processes is divided into 6 tans i.e. the ability to remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5) and create (C6) [6]. The six cognitive processes can be described as follows: 1) the ability to remember is the retrieval of relevant knowledge from memory; 2) the ability to understand is the development of meaning through the learning process, can be images, verbal and non-verbal communication and images; 3) the ability to apply is an activity to use or apply procedures in unusual situation; 4) the ability to analyze is the ability to divide matter into its elements and determine how the elements are connected between parts, structures, and wholes; 5) the ability to evaluate is the ability to take decisions based on existing standards and criteria; and 6) the ability to create is the ability to put elements together in order to it can create a functional and coherent whole and rearrange those elements into new structures or patterns [2].

The word model comes from the Greek "*methodos*" with away or way that can be taken. While in the Great Dictionary of Indonesian (KBBI) model is a pattern that can be an example or reference of something that will be produced or made. While conceptual in KBBI includes the word adjective which is interpreted as related to (as self-contained as) concepts. The word concept is a noun that means design or opaque, ideas or understanding abstracted from concrete events. So conceptual is something that will give an idea or meaning of the word concept both theoretically and abstractly. From the above understanding it is found that the conceptual model is term of language has the meaning as the way used to produce something desirable that will describe a concept both abstractly and theoretically. A conceptual model is a descriptive analytical development model, which mentions components or parts of a development product and analyzes and shows relationships between developed components. In this model, there is a relationship between components without having to pay attention to the sequence or stages in development activities, so that this model is considered more constructive and flexible [7].

Learning is an activity that involves several components that affect each other. Where components in learning to include teachers, students, curriculum, as well as facilities and infrastructure that support education. One of the most crucial components is the teacher because it has a role to determine success in achieving the goals of education. Teachers are required to pay attention to various components in learning activities, where before learning activities teachers must first design learning materials that will be used in learning activities. According to Trianto (2010) called learning materials are all tools and materials used by teachers in learning activities [8]. Learning materials designed by teachers include the lesson plans (RPP), textbook, and evaluation instruments that are useful for assessing the ability of desired learning competencies, so that with the arrangement of good learning materials it is expected that in the learning process can increase the diversity of knowledge obtained by students.

RPP is short-term planning that is used as an estimate or projection of what activities will be carried out in learning activities [7]. Where RPP is a learning activity plan that is prepared for one or more meetings. Thus, RPP needs to be developed in order to coordinate all components in learning, such as basic competencies (KD) that serve to develop student potential, standard materials to give meaning to KD, learning outcome indicators to provide instructions for the success of student competency formation, as well as assessments that serve as a gauge of competency success and determine what actions should be taken when the competence of the standard has not been met. The next learning outcome indicator is also called the competency achievement indicator is used to get the formulation of learning goals. Learning objectives are structured using operational verbs that must pay attention to the principle of ABCD +K. The principle of ABCD + K is A (Audience) which is a learning participant, B (Behavior) is an adjustment of student habits and cognitive processes that he does in learning, C (Condition) is a learning condition created by teachers to students in the learning process, D (Degree) is the target to be achieved after the learning process, and K (Knowledge) which is knowledge related to the competence to be achieved. These five components must be in the formulation of learning goals in KD so that learning activities can be of quality [9].

Textbook is a learning device that contains material and is designed in a structured way to result in the creation of an atmosphere and environment that can make students to learn [10]. While according to Fahrurrozi and Mohzana, textbook is subjects that can be used as standard sources and references in learning activities [7]. So, it can be concluded that textbook is learning materials that contain material and are designed as sources and references that are used as a medium to help students in the learning process.

Evaluation instruments or also referred to as assessment instruments are all things that are used in the learning process in order to facilitate teachers in carrying out tasks so that they are reached for learning objectives effectively and efficiently [11]. So that the learning evaluation instrument is arranged in order to facilitate teachers in assessing the process and results of the learning process based on the learning goals to be achieved, where evaluation instruments are structured using 6 levels of cognitive processes according to Bloom's taxonomy revision.

Physics is a compulsory lesson in the 2013 Curriculum revision 2017 which is taught in high school for students who are interested in mathematics and natural sciences. Physics is a subject that requires understanding concepts that are related to each other so as to form a separate relationship. Physics itself is a part of the natural sciences that studies matter and energy and the changes that come with it. The difficulty in learning physics experienced by students in school is because in physics learning there are many formulas that are difficult to understand and apply. The difficulty is felt by students when they have to choose which formula is appropriate and can be applied in solving problems and physics problems [12]. If only students still assume that physics is a difficult subject, then indirectly their learning interest will also be reduced and in the end the learning results obtained are also not optimal. Not optimal learning outcomes obtained by students is a problem that arises in learning activities to school. This can be seen from the average student learning outcomes that have not been in accordance with what is expected. Preliminary studies conducted at state high school in Kerinci Regency showed the results displayed in Table 1.

Table 1. PH Value of Balance and Rotational Dynamics in academic year 2020/2021

Data	SMAN 2 Kerinci		SMAN 4 Kerinci	SMA 12 Kerinci
	XI MIA 3	XI MIA 4	XI IPA 1	XI IPA
Number of Students	33	34	28	19
KKM	75	75	78	75
Highest Value	78	79	80	75
Lowest Value	65	60	63	50
Average Value	68,79	68,47	70,57	60,53
% Completion	9,09%	8,82%	7,14%	10,52%

(Source: Physics Teacher SMAN 2, 4, and 12 Kerinci)

Data in Table 1 show that the learning outcomes achieved have not been in accordance with what is expected. This is one indication of the quality of planning and implementation of learning is still low. Low learning outcomes do not arise just like that but rather have causal factors that must be investigated further. For this reason, observations and interviews have been conducted on teachers who teach physics in class XI at state high school in Kerinci Regency. The result of observations, interviews, and questionnaire can be spelled out as follows:

The observations showed that the learning materials in balance and rotational dynamics available in school namely textbook, has not presented the scope of knowledge dimensions optimally and proportionally. Where the highest intensity is still on factual and conceptual knowledge while procedural and metacognitive knowledge tends to be invisible. This causes variations in the dimensions of knowledge available yet to facilitate students to be able to increase the variety of knowledge so as not to be able to develop their thinking skills. This statement can also be seen in the Figure 1.

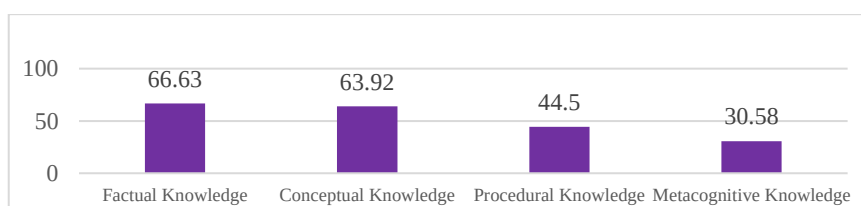


Fig. 1. Percentage graph of availability of knowledge dimensions in textbook

Furthermore, learning materials designed by teachers namely textbook in balance and rotational dynamics involving the exercise of 6 levels of cognitive processes applied are still dominated by the ability to remember, understand, apply, and analyze only while the ability to evaluate and create also tends not to be seen. Then in teaching materials, evaluation instruments in balance and rotational dynamics has not trained the level of cognitive processes proportionally. Where the practice of skills includes remember, understand, and apply only. While the ability to analyze, evaluate, and create is also not yet visible. Even existing evaluation instruments have not been fully created and developed based on a combination of dimensions of knowledge and cognitive processes. This data can be seen in the Figure 2.

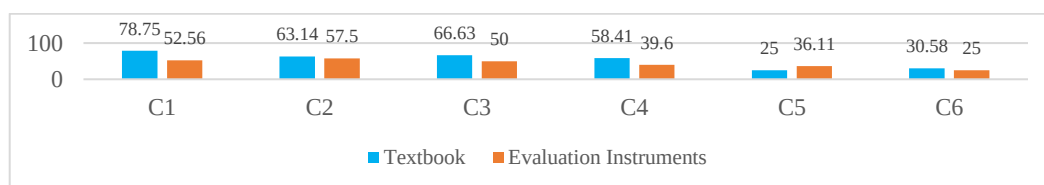


Fig. 2. Percentage graph of availability of cognitive process levels in textbook and evaluation instruments

In scientific approach used is still not maximal, it appears that the lesson plans used is still mostly inclined to use the lecture method, while demonstration and other methods are also not too visible. This data can be seen in the Figure 3.

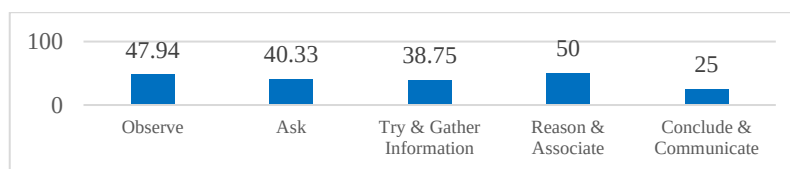


Fig. 3. Percentage graph availability of scientific approaches in lesson plans

The result of interviews showed that teachers still need the development of learning materials oriented to the dimensions of knowledge and cognitive processes in balance and rotational dynamics. This is intended because the development of this learning materials can increase the diversity of student's knowledge to support thinking skills and ultimately can also improve student learning outcomes. From the analysis of need, research is carried out with the aim of developing and knowing the validity of conceptual models of the dimensions of knowledge and cognitive processes in learning materials including lesson plans, textbook, and evaluation instruments in balance and rotational dynamics that can be used for high school physics learning.

II. METHOD

The research method used is a type of research and development (RnD) which is one of the research methods that can be used in researching, designing, producing, and testing the validity of products that have been developed [13]. The development model used takes the ADDIE model (Analysis, design, development, implementation, and evaluation). The ADDIE model was chosen because it is more complete and rationally compared to the 4D model. Where the ADDIE model consist of five stages, including: (1) Analysis is a stage related to the activity of analyzing the work situation and environment aimed at finding what products need to developed; (2) Design is the stage undertaken to design the product needed or to be produced; (3) Development is the stage related to the activities of making products and testing products that have been produced; (4) Implementation is the stage related to product use activities; and (5) Evaluation is a stage that is in accordance with the activity of assessing the extent of the product that has been developed in accordance with the desired product specifications. In this research used only reached the third stage, namely development.

The research was conducted in the Kerinci Regency area with samples of SMAN 2, SMAN 4, and SMAN 12 Kerinci. The subjects in this research were 3 lecturers of the Department of Physics FMIPA UNP (expert team) and 3 physics subject teachers (practitioner team) from the selected sample. While the objects in the research are learning materials (lesson plans, textbook, and evaluation instruments) oriented to the dimensions of knowledge and cognitive processes in balance and rotational dynamics for high school physics learning. The instrument used is a validation instrument to assess the validity of every aspect of all learning materials based on existing theories. Data from the assessment of validation instruments from the learning materials developed will be analyzed using the following formula:

$$Final Value = \frac{\text{the number of validation scores obtained}}{\text{maximum number of validation scores}} \times 100\% \quad (1)$$

with the criteria for the final value obtained after data processing shown in Table 2.

Table 2. Modified Likert Scale Validity Criteria

Percentage	Criteria
0-20	Not Valid
21-40	Less Valid
41-60	Enough Valid
61-80	Valid
81-100	Very Valid

(Source: Ref [13][14])

The learning materials developed is said to be valid if it is based on the score interpretation criteria obtained is in a valid or very valid category. With guarantee the validity of the data obtained in the process of getting the data done, where the data that has been obtained will be triangulation a data derived from different data sources. The different sources in question are data from each indicator on an instrument based on different sources. In this case the data source can come from every aspect on the validation instrument assessed by the subject in the research, so that the data obtained is more guaranteed validity.

III. RESULT AND DISCUSSION

Based on the research conducted, the results and discussions obtained at each stage are as follows: At analysis stage, a preliminary research is conducted to determine whether research is important to do. Based on preliminary research conducted by means of observation and interview, at this stage it was obtained that research into the development of learning materials oriented to the dimensions of knowledge and cognitive processes still needed to be carried out. This is because in schools there are still no learning materials that provide optimal and proportional scope of knowledge dimensions and cognitive processes.

Furthermore, teachers still do not understand very well about the scope of the dimensions of knowledge and the level of cognitive processes that can be applied in physics learning. While learning materials made by teachers mostly still use internet references and preexisting learning materials, so that the learning materials available in schools have not covered the scope of dimensions of knowledge and cognitive processes optimally and proportionally, where this has previously been researched by Asmara [6]. With textbook made by the teacher is still limited to being a reference teacher to teach. While the textbook used by students are still dominated by student's worksheet and textbooks from publishers. Student's worksheet tends to contain only summaries of materials and problems and textbooks contain rigid sentence structures that are difficult for students to understand. While the learning materials designed by the teacher based on observations about the dimensions of knowledge and cognitive processes can be seen in the Figure 1., Figure 2., and Figure 3.

At design stage all information about problems in physics learning obtained and solutions are applied creatively to design conceptual model of learning materials developed. At this stage also selected physics materials developed into conceptual model of learning materials, in this case selected the balance and rotational dynamics. Balance and rotational dynamics were chosen because it has a low percentage of the lead in daily assessment (PH) and is still not as desirable as Table 1. In addition, this material has characteristics that are quite difficult to understand because it has a lot of formulas and is an application of other physics materials. So that in physics learning, this material is very suitable for development on learning materials oriented to the dimensions of knowledge and cognitive processes.

The final result at this stage is a blue print (detailed framework) in the form of validation sheet design, and the design of conceptual model of learning materials oriented to the dimensions of knowledge and cognitive processes in balance and rotational dynamics for high school physics learning developed including 5 components namely: 1) Competency Achievement Indicators (IPK); 2) Learning Objectives (TP); 3) Essential Learning Materials (MEP); 4) Lesson Plans (RPP) design; 5) Textbook (BA) design; and 6) Evaluation Instrument (IE) design. The resulting IPK takes a 4x6 matrix model using KKO based on Bloom's taxonomy revision. TP are formed with the ABCD+K component, while MEP is produced based on analysis on KD in the curriculum syllabus 2013 revision 2017 published by the Ministry of Education.

1. Lesson Plans Validation Result

Lesson plans validation is done using lesson plans validation instruments that assess component aspects and scientific (5M) approaches. Lesson plans validation results can be seen in Figure 4.

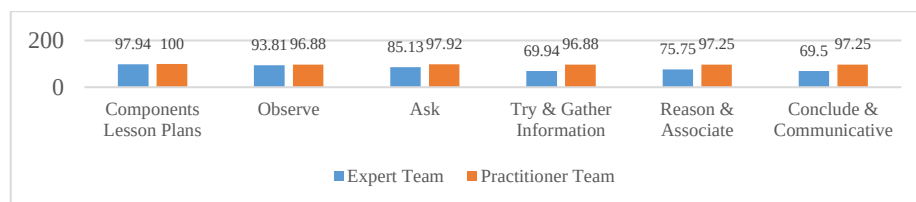


Fig. 4. Percentage of lesson plans validation result

Based on Figure 4. It is known that lesson plans validation results get a score of 82.38% from the expert team and 97.75% from the practitioner team. So that overall aspects of lesson plans that are considered to get a category are very valid and can be used for high school physics learning.

2. Textbook Validation Result

a. Validation Results Based on Aspects of Complexity of Knowledge Dimensions in Textbook

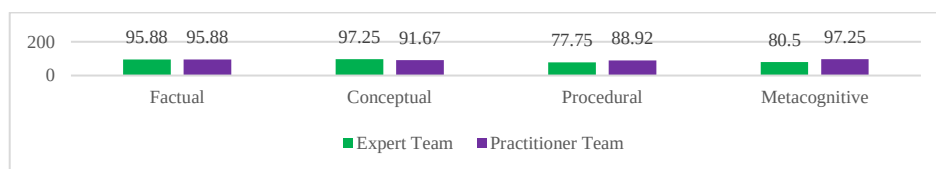


Fig. 5. Graph Of Validation Results Based on Aspects of Complexity of Knowledge Dimensions in Textbook

Based on Figure 5. It is known that the results of validation of textbook based on aspects of complexity of the knowledge dimension get a score of 87.88% from the expert team and 93.50% from the practitioner team. So that overall the complexity aspect of the dimension of knowledge in textbook that are assessed to get a category is very valid and can be used for high school physics learning.

b. Validation Results Based on Aspects of Scope Of Cognitive Process Levels In Textbook

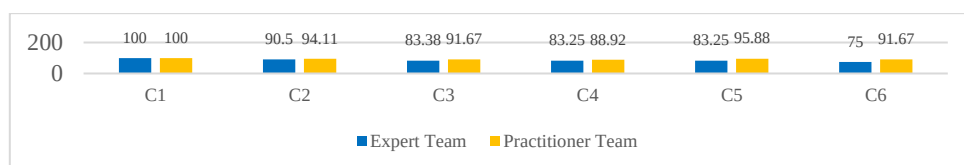


Fig. 6. Graph of validation results based on aspects of scope of cognitive process levels in textbook

Based on Figure 6. it is known that the results of validation of textbook based on the scope aspect of cognitive process levels get a score of 85.92% from the expert team and 93.75% from the practitioner team. So that overall aspects of the scope of cognitive process levels in textbook that are assessed to get a category are very valid and can be used for high school physics learning.

c. Validation Results Based On Aspects Of Textbook Requirements

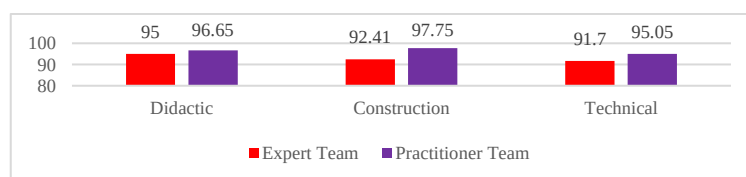


Fig. 7. Graph of validation results based on aspects of textbook requirements

Based on Figure 7. It is known that the results of validation of textbook based on aspects of its requirements get a score of 93.03% from the expert team and 96.50% from the practitioner team. So that overall aspects of textbook requirements that are assessed to get a category are very valid and can be used for high school physics learning.

d. Validation Textbook Result

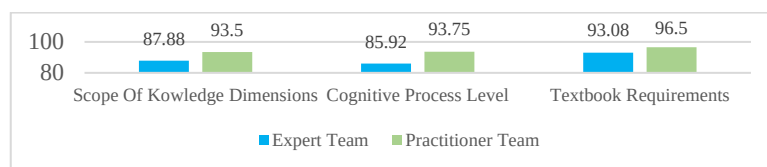


Fig. 8. Graph of validation textbook result

Based on Figure 8, it is known that the results of validation of textbook get a score of 89.00% from the expert team and 94.58% from the practitioner team. So that overall textbook that are considered to get a category are very valid and can be used for high school physics learning.

3. Evaluation Instruments Validation Result

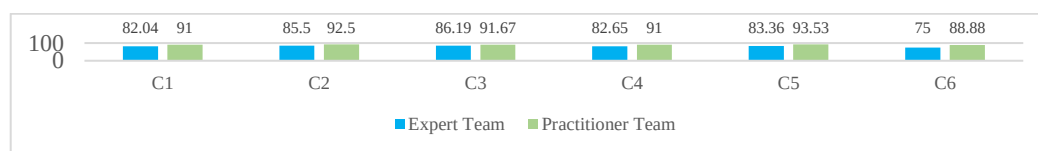


Fig. 9. Graph of evaluation instruments validation result

Based on Figure 9, it is known that the validation results of evaluation instruments get a score of 82.38% from the expert team and 91.46% from the practitioner team. So that over all the evaluation instruments that are assessed to get a category are very valid and can be used for high school physics learning.

4. Conceptual Model Learning Materials Validation Result

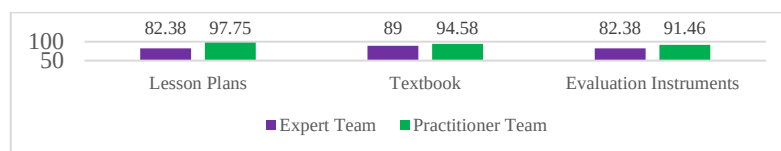


Fig. 10. Graph of conceptual model learning materials validation result

Based on Figure 10. it is known that the results of validation of conceptual model of learning materials get a score of 84.67% from expert teams and 94.58% from practitioner teams. Overall, the score was 89.63%, so that over all the conceptual model of learning materials assessed to get a category is very valid and can be continued field tests to determine its practicality and effectiveness in physics learning in high school.

IV. CONCLUSION

The validity of the conceptual model of learning materials oriented to the dimensions of knowledge and cognitive processes in balance and rotational dynamics for high school physics learning developed after product refinement obtained validation values on lesson plans, textbook, and evaluation instruments according to the expert team with an average of 84.67% and according to the practitioner team with an average of 94.58%. Overall, a score of 89.63% in the category is very valid and can be continued field tests to determine its practicality and effectiveness in physics learning in high school.

REFERENCES

- [1] S. L. Zorluoglu and A. Kizilaslan, "Analysis of 10 th Chemistry Curriculum According to Revised Bloom

- Taxonomy,” *J. Educ. e-Learning Res.*, vol. 6, no. 2, pp. 88–95, 2019, doi: 10.20448/journal.509.2019.62.88.95.
- [2] R. Humaira, A. Putra, and Syafriani, “PENGARUH PENGGUNAAN LKPD BERORIENTASI TAKSONOMI BLOOM REVISI DALAM SETTING PENDEKATAN SAINTIFIK TERHADAP PENCAPAIAN KOMPETENSI FISIKA PESERTA DIDIK KELAS X SMA NEGERI 7 PADANG,” *Pillar Phys. Educ.*, vol. 9, no. April, pp. 153–160, 2017.
 - [3] S. A. Hanum, Asrizal, and F. Mufit, “PENGEMBANGAN LKS BERBASIS KONFLIK KOGNITIF TERINTEGRASI LITERASI BARU PADA MATERI FLUIDA UNTUK SISWA KELAS XI SMA,” *Pillar Phys. Educ.*, vol. 12, no. 4, pp. 793–800, 2019.
 - [4] H. Yanto and A. Putra, “ANALISIS HASIL BELAJAR FISIKA SISWA DITINJAU DARI PERSEPSINYA TERHADAP PEMBELAJARAN PADA MATERI HUKUM NEWTON TENTANG GERAK DI KELAS X SMA DI KOTA PADANG,” *Pillar Phys. Educ.*, vol. 13, no. 1, pp. 105–112, 2020.
 - [5] A. Putra, “Physics Learning Oriented Content Complexity and Cognitive Process for Improving Student Scientific Competence on High School in Padang,” in *The International Conference on Mathematics, Science, Education and Technology*, 2015, pp. 1–3.
 - [6] S. Asmara and A. Putra, “ANALISIS KEBUTUHAN BAHAN AJAR FISIKA DITINJAU DARI KOMPLEKSITAS PROSES KOGNITIF MENURUT TAKSONOMI BLOOM REVISI PADA MATERI HUKUM NEWTON TENTANG GERAK DI SMAN KOTA PADANG,” *Pillar Phys. Educ.*, vol. 13, no. 3, pp. 364–370, 2020.
 - [7] M. Fahrurrozi and Mohzana, *Pengembangan Perangkat Pembelajaran, Tinjauan Teoritis Dan Praktis*. Lombok Timur: Universitas Hamzanwadi Press, 2020.
 - [8] S. A. Peranginangin, S. Saragih, and P. Siagian, “Development of Learning Materials through PBL with Karo Culture Context to Improve Students’ Problem Solving Ability and Self-Efficacy,” *Int. Electron. J. Math. Educ.*, vol. 14, no. 2, pp. 265–274, 2019.
 - [9] A. Putra, *Buku Ajar Perencanaan Pembelajaran Fisika*. Padang: Sukabina Press, 2017.
 - [10] A. I. Safitri, Festiyed, A. Putra, and F. Mufit, “DESAIN MODUL INTERAKTIF MENGGUNAKAN APLIKASI COURSE LAB BERBASIS PENDEKATAN SAINTIFIK PADA MATERI USAHA, ENERGI, DAN MOMENTUM,” *Pillar Phys. Educ.*, vol. 12, no. 3, pp. 433–440, 2019.
 - [11] A. Walid, S. Sajidan, M. Ramli, and R. Gamal, “Construction of The Assessment Concept to Measure Students’ High Order Thinking Skills,” *J. Educ. Gift. Young Sci.*, vol. 7, no. June, pp. 237–251, 2019.
 - [12] A. Koswara and M. Mundilarto, “Pengembangan handout fluida dinamik terintegrasi metakognisi untuk meningkatkan kemampuan aplikasi siswa Developing handout of fluid dynamics integrated by metacognition to improve application ability of students,” *J. Inov. Pendidik. IPA*, vol. 4, no. 1, pp. 11–25, 2018.
 - [13] M. A. Adami, A. Putra, and Yurnetti, “BAHAN AJAR BERORIENTASI PEMECAHAN MASALAH UNTUK MENCAPAI HIGHER ORDER THINKING SKILLS (HOTS),” *Pillar Phys. Educ.*, vol. 11, no. 2, pp. 17–24, 2018.
 - [14] D. Susanti, V. Fitriani, and L. Y. Sari, “Validity of module based on project based learning in media biology subject,” *J. Phys. Conf. Ser.*, vol. 1521, no. 4, pp. 0–6, 2020, doi: 10.1088/1742-6596/1521/4/042012.