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Meta-Analysis of the Effect of Cognitive Conflict on Physics Learning

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Abstract

Problems often experienced by students in learning physics are misconceptions and low understanding of concepts. One solution to this problem is to apply conflict cognitive learning. The purpose of this study was to analyze: (1) the problems that lead to the application of cognitive conflict learning, especially in physics learning, (2) the stages of cognitive conflict learning that are often used, (3) the effect of cognitive conflict learning on education levels, (4) the effect of cognitive conflict learning on eye lessons, and (5) the effect of cognitive conflict learning on learning competencies. This study uses a meta-analysis method, namely analyzing similar scientific article documents. The sample consisted of 25 national and international articles published in 2012-2020. Data analysis used the effect size equation, percentage techniques, and descriptive analysis. The results and findings of the study indicate: (1) The problems that often cause cognitive conflict learning to be applied to physics learning are poor understanding of concepts and misconceptions, (2) Learning conflict cognitive has different stages, but the most widely used consists of three main steps, (3) Cognitive conflict learning has a high effect on being applied in high school, (4) high effect cognitive conflict learning is applied to physics lessons, and (5) Learning conflict cognitive has a high influence in increasing understanding of concepts and overcoming misconceptions, especially physics. This study indicates that cognitive conflict learning has a good influence in overcoming conceptual understanding problems, especially in learning physics in high school.

Keywords: meta-analysis, cognitive conflict, learning of physics

INTRODUCTION

National education has a significant role in the progress of the nation. Education's noble function and purpose state that national education functions to develop students' abilities and shape the nation's dignified character and civilization to educate the nation's life. Education also aims to develop students' potential to become human beings who believe and be devoted to an almighty, noble, healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizen (UU No 20, 2003). Based on the functions and objectives of national education, the educational process is very instrumental in shaping the character and developing students' potential. Whether it builds intelligence or aspects of knowledge, forms attitudes, and developing students' skills. Educational objectives can be achieved by designing learning that can develop students' skills, attitudes, and knowledge, build creative thinking patterns, and understand concepts (Kemendikbud 2013). The achievement of educational objectives is influenced by the learning process carried out at academic institutions.

Educational institutions' learning process must be held interactively, inspirational, fun, challenging, motivating students to participate actively. Learning must also provide opportunities for the growth of

initiative, creativity, and independence following students' talents, interests, and physical and psychological development (PP No 22, 2016). Likewise, learning must be fun with science education by actively involving students, both at primary, secondary, and higher education. Quality education and science learning will produce people who have the knowledge, understanding, processes, and attitudes of good science. Besides, science learning must also answer the times' challenges, especially the demands of learning in the 21st century that is developing today. The teaching carried out must foster mastery of generic competencies, including collaboration, creativity, communication, character education, literacy, and critical thinking (Asrizal et al. 2018a). The 2013 curriculum requires students to be more active, independent, and competent in learning. In dealing with 21st-century learning, students also need to be equipped with study skills, literacy skills, and life skills (Asrizal et al. 2018b). Learning physics as one part of science also requires students to be active according to the curriculum.

Physics is studying the universe, including matter and energy on a small scale such as atoms (microscopic) and large-scale solar systems (macroscopic). Physics lessons related to natural phenomena are obtained through a series of processes known as scientific processes and interactions with nature. Understanding the concept of physics is one aspect of measuring student learning outcomes. The idea of physics is abstract, so that it often becomes an obstacle for educators in delivering material to students. Besides, learning physics in schools have not fully enabled students to find concepts and equations. Physics learning still tends to explain physics concepts and formulas to students. It has not involved students in constructing knowledge (Mufit et al. 2020). Physics learning that does not involve students actively discovering concepts can lead to a poor understanding of concepts and misconceptions.

The misconception is the use of concepts that are not following the concepts of experts or scientists that have been accepted scientifically. In physics learning, the phenomenon of misconception cannot be avoided by students because, in general, misunderstandings occur when they interact with the environment and build their concepts based on their intuition (Mufit & Fauzan 2019). Besides, many physical ideas are expressed in mathematical equations that students tend to memorize without understanding the physical meaning contained in them (Mufit 2016). It is well known that physics subjects consist of abstract physical concepts. Many use equations and representations of practice questions. This has become physics as a subject that is considered difficult by most students (Putra 2013). Wilardjo (2009) also states that students' agility in changing the mathematical form of physics equations in solving problems, as if to cover up their misconceptions. These conceptual changes can occur due to mismatches between events that have been experienced with their intellectual expectations (Makrus et al. 2015). The phenomenon of misconception occurs at almost all levels of education, namely elementary, junior high school, high school and university levels (Mufit et al. 2018). Misconceptions also occur in every field of science learning, such as physics, chemistry, biology, and even mathematics (Mufit & Fauzan 2019). Therefore, conceptual understanding and misconceptions need to be found a solution, including by implementing cognitive conflict learning.

In applying classroom learning, researchers use several terms, including the terms model (Haryadi & Pujiastuti 2020; Nulhakim et al. 2020), strategy (Pratiwi & Nanto 2019; Siswoyo 2019), and approach (Yulkifli et al. 2019; Eveline et al. 2019). Models, strategies, and approaches to learning have an important role, especially in directing educators and students in the learning process. Some references use these three terms in the same sense. That is, they both indicate a stage or component in learning. Several other references define the three terms with different meanings. The learning model is a picture of the environment that conditions students to learn and at the same time, describes the behavior of educators in creating learning environments or conditions. Mufit & Fauzan (2019). In general, the model has a broader meaning because there are strategies, methods, approaches, and learning procedures in the model. Each learning model consists of syntax or phases to achieve specific learning goals.

Cognitive conflict learning aims to help students in the process of changing concepts (Long et al. 2020). This learning can overcome the problem of understanding the concepts experienced by students by involving deep thinking (Shen et al. 2020). Presentation of cognitive conflict will shake students' initial conception, and there is a modification in the cognitive structure to rebuild new scientific concepts (Mayer et al. 2015). Sadia (2014) states that the cognitive conflict model is a learning model for changing students' misconceptions into scientific concepts by presenting conflicts to the minds of

students who experience misconceptions. Cognitive conflict-based learning models can enhance concept understanding and mediate students' misconceptions (Mufit et al. 2019; Mufit & Fauzan 2019). Cognitive conflict learning is quite widely used by researchers/educators in improving the quality of science learning, including physics.

Based on the many similar studies on the application of cognitive conflict in physics learning, it is necessary to re-analyze it in a meta-analysis study to summarize how much influence cognitive conflict is (Sheu et al. 2010), especially in physics learning. This study's results can be a reference for researchers and educators in applying cognitive conflict in overcoming the problem of understanding concepts in physics learning. The objectives of this meta-analysis study are (1) to analyze what problems are the causes of the application of cognitive conflict learning, especially in physics learning, (2) analyzing the cognitive conflict learning stages that are widely used, (3) knowing the effect of cognitive conflict learning on education levels, (4) knowing the effect of cognitive conflict learning on subjects, and (5) knowing the effect of cognitive conflict learning on learning competencies. This research is the basis for developing a cognitive conflict-based ebook to improve students' understanding of physics concepts in high school.

METHODS

This research uses the method meta-analysis, which is a study by analyzing data from several primary data. Meta-analysis integrates several similar individual research results to produce a finding to understand the rapid development of research (Glass 1981). The data collection technique uses a document analysis of national and international journal articles. The objects in this study were all written documents in the form of articles about applying cognitive conflict learning that had been tested in class. The research sample was taken using the purposive sampling technique, a technique that is non-random to obtain data or information according to the research theme. The sample consisted of 25 articles about learning conflict cognitive published years 2012 - 2020. The data analysis used is quantitative and qualitative. Quantitative analysis uses numerical and statistical calculations for practical purposes by collating and extracting vast amounts of information and data that are impossible with other methods. Qualitative research was carried out for data from the results of a narrative study of the studies encountered.

TABLE 1. List of Meta-Analysis Articles

Journal Code	Year	Journal Type
[1]	2019	International
[2]	2016	National
[3]	2013	International
[4]	2017	National
[5]	2018	National
[6]	2018	National
[7]	2013	National
[8]	2018	National
[9]	2016	National
[10]	2016	National
[11]	2018	International
[12]	2017	National
[13]	2012	National
[14]	2018	International
[15]	2017	National
[16]	2019	National
[17]	2014	National
[18]	2018	International
[19]	2018	National
[20]	2019	National
[21]	2020	National
[22]	2018	National
[23]	2018	National
[24]	2015	National
[25]	2015	International

Data collection in this study was carried out by coding. The instrument used was a coding category sheet. The variables used in coding to produce information are the article code, year of publication, education level, subjects, and student learning competencies. The list of 25 articles analyzed can be seen in TABLE 1.

Based on the 25 articles analyzed, 16 articles (64%) examine cognitive conflicts in physics learning. The articles compiled in TABLE 1 are analyzed based on the problems that cause the application of cognitive conflict learning by researchers and the stages of cognitive conflict learning used. Besides, the analysis was also carried out on three main categories of the influence of cognitive conflict learning through the calculation of the effect size. The three main types are based on the level of education, subjects, and learning competencies of students. The distribution of articles based on these categories can be seen in TABLE 2.

TABLE 2. Distribution of Journal Categories Under Study

No.	Aspect	Educational stage	Subjects	Learning Competencies
1	Elementary school	1		
2	Middle school	4		
3	High school	14		
4	College	6		
5	Science		2	
6	Physics		16	
7	Mathematics		6	
8	Educational statistics		1	
9	Improve mathematical understanding			3
10	Improve understanding of concepts and overcome misconceptions			13
11	Improve learning outcomes			5
12	Improve the ability to think critically			4
	Amount	25	25	25

Based on TABLE 2.Cognitive conflict models are applied to four education levels: Elementary School, Middle School, High School, and College. Four subjects use cognitive conflict learning, namely: Science, Physics, Mathematics, and Educational Statistics. The objectives of applying cognitive conflict learning found five learning competencies of students to be achieved: increasing mathematical understanding, increasing understanding of concepts and overcoming misconceptions, improving learning outcomes, and increasing critical thinking skills.

TABLE 3. Effect Size Value

Score	Category
Effect size ≤ 0.15	Can be ignored
0.15 <Effect size ≤ 0.40	Small
0.40 <Effect size ≤ 0.75	Medium
0.75 <Effect size ≤ 1.10	High
1.10 <Effect size ≤ 1.45	Very high
1.45 <Effect size	Very high effect

The steps in calculating the effect size in this study are as follows (1) identifying the research variables and then entering them into the appropriate variables, (2) identifying the mean and standard deviation of the post-test and pretest group averages for each research subject, (3) calculate the effect size using the Glass equation (Glass, 1981). The effect size value category can be seen in TABLE 3. The Glass equation used is:

$$\Delta = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{pre}} \quad (1)$$

Information :

Δ = Effect Size

$\bar{X}_{post}$ = Group means of posttest

$\bar{X}_{pre}$ = Pretest Group Mean

SD_{pre} = Pretest Group Standard Deviation

RESULTS AND DISCUSSION

Problems that Cause the Application of Cognitive Conflict Learning

The results of this study indicate that the application of cognitive conflict learning is caused by 4 main problems, as can be seen in TABLE 4.

TABLE 4. Findings of Problems Causes Cognitive Conflict Model

No	Problem	Amount	Percentage
1	Low mathematical understanding	3	12%
2	Low understanding of concepts and misconceptions	13	52%
3	Low learning outcomes	5	20%
4	Low critical thinking skills	4	16%

TABLE 4.shows that the problem of poor understanding of concepts and misconceptions in learning is the leading cause (52%) of the application of cognitive conflict. The next question is followed by poor learning outcomes and low critical thinking skills. The lowest cause (12%) was caused by low mathematical understanding. Mathematical understanding is the ability of students to solve mathematical problems (Mujib 2018). Learning outcomes (learning outcomes) are students' ability in knowledge, attitudes, and skills within a certain period. Concept understanding (understanding) emphasizes the ability of students to master certain materials. Among the indicators that students have understood the concept are; (1) defining the concept verbally and in writing, (2) identify and make examples and not examples, (3) using models, diagrams, and symbols to represent a concept, (4) changing one form of representation to another, (5) recognize the various meanings and interpretations of concepts, (6) identify the properties of a concept and recognize the conditions that define a concept, (7) compare and contrast the concepts (NCTM 2000). Students are said to have understood something if they can provide a more detailed explanation or description of various aspects in their own words. Students with high learning outcomes do not necessarily have a good understanding of the concept.

Problems with low conceptual understanding and misconceptions are more commonly found as the basis for applied cognitive conflict models in learning, especially in physics learning. Cognitive conflict learning has stages that are specifically designed so that students can make conceptual changes. Therefore, low conceptual understanding is the main problem for educators and researchers in implementing cognitive conflict learning.

Cognitive Conflict Learning Phase

Based on the articles compiled, there are 13 journal listing the stages or phases of cognitive conflict learning. Five of these articles [5, 8, 12, 18 and 25] using the same phase, namely referring to the phase of Lee et al. (2003) as in TABLE 5, but there are differences in what researchers say, namely 'model' cognitive conflict [5], 'approach' cognitive conflict [8] , and cognitive conflict 'strategies' [12, 18 and 25].

TABLE 5. Cognitive Conflict Learning Phase

Code Articles	Phase
[5] [8] [12] [18] [25]	Lee et al: (1) Preliminary phase (preliminary stage) (2) Conflict stage (3) The resolution phase.

The three terms, both 'model', 'approach', and 'strategy' are often used on the same object in several international references. The three terms are considered the same because they both describe the stages in the learning process. In the 2013 curriculum, the terms model and approach imply different meanings. This can be seen from the government's suggestion that teachers use several models (such as problem-based models, inquiry, etc.) with a scientific approach. However, it is possible to use other approaches. Mufit & Fauzan (2019) states that the learning model has standardized syntax or learning stages, while the approach consists of components that do not have to be carried out sequentially.

In general, in this study, researchers use three terms of cognitive conflict learning: strategies, approaches, and models. TABLE 6. shows several phases of cognitive conflict learning. Based on TABLE 6, it is found that cognitive conflict learning has various phases but consists of 3 main parts. The parts are (1) the introduction section by presenting anomalous phenomena about the concepts to be studied, (2) the conflict presentation section so that students realize their misconceptions, and (3) the conflict resolution section so that students find new concepts that are correct. The three main phase are at the phases suggested by Lee et al. (2003), namely; (1) the preliminary phase, (2) the conflict phase, and (3) the resolution phase. Five articles use the syntax of Lee et al. the rest researchers use the development phase of Lee

TABLE 6. Variations in the Cognitive Conflict Model Phases

Code Articles	Syntax
[6] [22]	Hewson & Hewson, 1984: (1) Identifying the condition of student abilities (2) Exposing students to contradictory information (3) Evaluating the level of conceptual change.
[7]	Sadia et, al, 2004: (1) Identify student misconceptions (2) Confronting students' ideas (misconceptions) (3) The conflict phase
[11]	Students' orientation to conflict Organizing students to learn Guiding individual or group investigations Developing and presenting the work Analyzing and evaluating
[13]	Sadia, 1998 (1) Problem identification (2) Identification and clarification of prior knowledge and student misconceptions (3) Planning a learning program (4) Implementation of the learning program (5) Evaluation
[14]	Mufit, 2019 Activation of preconceptions and misconceptions Presentation of cognitive conflict Discovery of concepts and equations Reflection
[15]	Presentation of cognitive conflict Establish a result or position Exposing trust Confronting beliefs / creating conflict cognitive Accommodating concepts Extending the concepts Problem solving / testing Evaluation
[24]	(1) Identify students' initial conceptions (2) Generating conflict situations (3) Establish a concept

In general, the standard learning stages are said to be a learning model. Each learning model uses different stages or syntax. According to Joyce & Weil (1980), the basic components of the learning model are; (1) syntax, (2) social system, (3) principle of reaction, (4) support system, (5) the instructional & nurturant effect. Syntax or stages in a learning model are sequences or operational steps in each learning model. According to Suyono (2014), syntax is interpreted as a system or orderly arrangement based on the proper series that must be done. Based on these explanations, it can be said that syntax is an arrangement or operational steps taken in the learning model that serves to direct the teacher in carrying out learning and direct student learning activities in achieving learning objectives. Educators can use the cognitive conflict model syntax, which is considered the most appropriate for learning physics.

The Influence of Cognitive Conflict Learning on Education Levels

Based on the education level category, cognitive conflict learning has a higher effect on the high school, as shown in the effect size results in TABLE 7.

TABLE 7. Effect Size Based On Education Level

No.	Educational stage	*Effect size*	Category
1	Elementary School	0.24	Small
2	Middle School	0.63	Medium
3	High School	2.40	High
4	College	0.60	Medium

Based on TABLE 7, cognitive conflict learning has the highest effect applied to high school education with an effect size of 2.40, which is in the high category. Successively, this learning influences the education level of college and middle school with the medium category, and elementary school education with the small category. Learning conflict cognitive has a low effect applied to elementary education with an effect size of 0.24.

This study indicates that at the high school level, there are more problems associated with low understanding of concepts and misconceptions. Several studies have shown that misunderstandings occur in high school students (Maulida et al. 2013; Adyani et al. 2014). Meanwhile, at the elementary education level, learning prioritizes the improvement of students' character (aspects of attitudes & skills), has not emphasized understanding the concept (aspects of knowledge), so that the problem of misconception is not widely found at the elementary level of education. Meanwhile, in tertiary institutions, misconceptions are also found in undergraduates, including student teacher candidatesstudent-teacher 2011), but not as many in higher education as in high school. Students' level of thinking is more structured. Therefore, cognitive conflict learning is mainly used in learning of physics in high school.

The Effect of Cognitive Conflict Learning on Subjects

Based on the subjects, cognitive conflict learning has a high effect on physics, as can be seen from the results of the effect size in TABLE 8.

TABLE 8. Effect Size Based on Subjects

No.	Subjects	*Effect size*	Category
1	Science	0.35	Small
2	Physics	1.64	Very High
3	Mathematics	0.65	Medium
4	Educational Statistics	0.23	Small

Based on TABEL 8, cognitive conflict learning has a high influence on physics material with an effect size of 1.64, the highest compared to other subjects. Physics lessons consist of abstract material (Gunawan et al. 2013) so that students tend to have difficulty understanding physics concepts. Besides being abstract, physics material also uses many equations or formulas that are difficult for students to understand. According to Setyowati et al. (2011) learning physics is difficult for students because most students have not been able to connect the material to the knowledge used, including research by Hidayatullah et al. (2018), Nasrudin et al. (2016), Supliyadi (2017). Meanwhile, in mathematics, it was found that cognitive conflict learning influences the medium category with an effect size of 0.65.This study indicates that physics lessons have more problem understanding concepts so that cognitive conflict models are applied as a solution. Besides, mathematics lessons, which are also exact, also have problems in understanding the concept, but only moderate influence. For Science and Education Statistics subjects, cognitive conflict learning has little effect because there are not many abstract concepts in this subject than the two previous topics. Therefore, the mental conflict model really needs to be applied to topics, especially physics lessons.

The Effect of Learning Cognitive Conflict on Learning Competence

Based on the learning competency aspects, cognitive conflict learning is more widely applied to improve students' conceptual understanding. This can be seen from the results of the effect size as seen in TABLE 9.

TABLE 9. Effect Size Based on Learning Competence

No.	Competence	*Effect size*	Category
1	Improve mathematical understanding	0.16	Small
2	Improve understanding of concepts and overcome misconceptions	1.41	Very high
3	Improve learning outcomes	1.09	High
4	Improve the ability to think critically	0.45	Medium

Based on TABLE 9, cognitive conflict learning has a significant influence on improving conceptual understanding and overcoming misconceptions, compared to other competencies. This is because the cognitive conflict learning stages emphasize students' conceptual changes, from wrong initial concepts (misconceptions) to correct concepts. Cognitive conflict learning has a 'moderate' effect on improving learning outcomes and critical thinking skills. In general, each learning model or strategy aims to improve learning outcomes. Still, each model or strategy has specific goals that are more specific, such as problem-based learning, emphasizing increasing students' ability to solve problems (problem-solving) and inquiry learning to improve investigation skills.

Cognitive conflict learning provides students opportunities to realize their misconceptions and provides opportunities to correct them through demonstration activities or experiments. Students are exposed to phenomena contrary to their concepts through the presentation of cognitive conflict, which triggers dissatisfaction (Trumper 2016). Students are then guided to find the correct concept through demonstration activities and experiments. In the settlement section, through discussion activities, students have a scientifically valid understanding of the concept and feel satisfied and understand after going through cognitive conflict learning. The results of this meta-analysis study indicate that cognitive conflict learning has a higher effect on learning physics, especially to improve conceptual understanding and remediate the misconceptions of physics in senior high school.

SUMMARY

Based on the data analysis, it can be concluded that; 1) The main problem that causes the application of cognitive conflict learning is the low understanding of students' concepts, especially in physics learning, 2) Learning conflict cognitive has various stages, but in general, there are 3) main stages, namely the preliminary phase to find out the understanding / initial concept of students; conflict phase to invite students to think deeply to realize the misconceptions they experience; and the completion phase to guide students to have a correct understanding of the concept. The cognitive conflict learning stage that is widely used is the stage suggested by Lee, which consists of these three main stages: (1) Cognitive conflict learning has a higher effect on high school education than at the elementary, junior high, and tertiary education levels, (2) Cognitive conflict learning has a higher impact on physics than other subjects, and (3) Learning conflict cognitive has the highest effect in increasing understanding of concepts and reducing student misconceptions, especially in learning physics.

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REFERENCES

Adyani, NW, Sadia, IW & Natajaya, IN 2013, 'Pengaruh Strategi Pembelajaran Konflik Kognitif Terhadap Penurunan Miskonsepsi Fisika Ditinjau dari Gaya Kognitif Siswa Kelas X SMA Negeri 1 Bebandem', *Jurnal Administrasi Pendidikan Indonesia*, vol. 4, no. 1.

Asrizal & Ananda A, Khairani 2018b, 'Effectiveness Of Integrated Science Instructional Material On Pressure In Daily Life Theme to Improve Digital Age Literacy of Students'. *IOP Publish. Journal of Physics: Conf. Series*, vol. 1006, no. 012031.

Asrizal, A, Amran, A, Ananda, A & Festiyed 2018a, 'Effectivenes of Adaptation Contextual Learning Model of Integrated Science by Integrating Digital Age Literaracy On Grade VII Student', *IOP Conf. Series: Materials Science and Engineering*, vol. 335, no. 012067.

Eveline, E, Suparno, S, Ardiyati, TK, & Dasilva, BE 2019, 'Development of Interactive Physics Mobile Learning Media for Enhancing Students' HOTS in Impulse and Momentum with Scaffolding Learning Approach', *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, vol. 5, no. 2, pp. 123-132.

Glass, Gene, V, Graw, M & Smith, ML 1981, 'Meta-analysis in Social Research. Beverly Hills', CA.: Sage Publications.

Gunawan, G, Setiawan, A & Widyantoro, DH 2013, 'Model Virtual Labolatory Fisika Modern untuk Meningkatkan Keterampilan Generik Sains Calon Guru', *Jurnal Pendidikan dan Pembelajaran (JPP)*, vol. 20, no. 1.

Haryadi, R & Pujiastuti, H 2020, 'The Science Literacy Capabilities Profile Using Guided Inquiry Learning Models', *Jurnal Penelitian & Pengembangan Pendidikan Fisika*,vol. 6, no. 1, pp. 81-88.

Hidayatullah, Z, Makrus, M & Gunada, IW 2018, 'Pengaruh Pendekatan Konflik Kognitif terhadap Hasil Belajar Gelombang Mekanika Peserta Didik MAN 2 Mataram', *Jurnal Ilmiah Profesi Pendidikan*, vol. 3, no. 2.

Joyce, B & Weil, M 1980, 'Models Of Teaching (Second Edition Ed)', Englewood Cliffs: Nj Prentice-Hal.

Kemendikbud 2013, 'Peraturan Menteri Pendidikan dan Kebudayaan RI No. 70 Tahun 2013 tentang Kerangka Dasar dan Struktur Kurikulum Sekolah Menengah Kejuruan/ Madrasah Aliah Kejuruan', Jakarta: Kemendikbud.

Long, Z, Luo, D, Kiu, K, Gao, H, Qu, J, & Hu, X 2020, 'Raising Academic Performance in Socio-cognitive Conflict Learning Through Gamification'. *Artificial Intelligence in Education. AIED 2020. Lecture Notes in Computer Science*, vol. 12164.

Makrus, M, Nur, M & Widodo, W 2015, 'Model Perubahan Konseptual dengan Pendekatan Konflik Kognitif (MPK-PKK)', *Jurnal Pijar MIPA*, vol. 9, no. 1.

Margunayasa, IG 2014, 'Pengaruh Petunjuk Praktikum IPA Bermuatan Perubahan Konseptual Terhadap Peningkatan Pemahaman Konsep IPA Pada Mahasiswa PGSD', *Jurnal Pendidikan Indonesia*, vol. 3, no. 1.

Maulida, EL & Abdullah, AA 2013, 'Pengaruh Pendekatan Konflik Kognitif dengan Metode Demonstrasi Terhadap Miskonsepsi Siswa Ditinjau Dari Hasil Belajar dalam Pembahasan Pemantulan Cahaya pada Cermin Kelas VIII SMP Buduran Sidoarjo', *Jurnal Inovasi Pendidikan Inovasi*, vol. 2, no. 3.

Mayer, T, Haefeli, WE, & Seidling, HM 2015, 'Different methods, different results—how do available methods link a patient's anticholinergic load with adverse outcomes?', *Eur J Clin Pharmacol*, vol. 71, pp. 1299–1314.

Mufit, F & Asrizal, Hanum, SA & Fadhilah, A 2020, 'Preliminary Research in the Development of Physics Teaching Materials that Integrate New Literacy and Disaster Literacy', *IOP Conf. Series: Journal of Physics,* vol. 1481, no. 012041.

Mufit, F & Fauzan, A 2019, 'Model Pembelajaran Berbasis Konflik Kognitif (PbKK) Disertai Penerapan untuk Remediasi Miskonsepsi pada Sains dan Matematika', Malang: CV. IRDH.

Mufit, F 2016, 'A Study about Understanding the Concept of Force and Attitude towards Learning Physics on First-Year Students in the Course of General Physics; as Preliminary Investigation in Development Research', *Proceeding of SEA-DR 4th Conference.*

Mufit, F, Festiyed, A, Fauzan, Lufri 2018, 'Impact of Learning Model Based on Cognitive Conflict toward Student's Conceptual Understanding', *IOP Conf. Series: Materials Science and Engineering,* vol. 335, no. 012072.

Mufit, F, Festiyed, A, Fauzan, Lufri 2019,'The Application of Real Experiments Video Analysis in the CCBL Model to Remediate the Misconceptions about Motion's Concept', *IOP Conf. Series: Journal of Physics,* vol. 1317, no. 012156.

Mujib, A 2018, 'Konflik Kognitif dalam Pembelajaran Kalkulus II', *Seminar Nasional Hasil,* vol. 1, no. 1.

Nasrudin, D, Suhendi, HY, Hamidah, I & Hasanah, L 2016, 'Model Siklus Belajar 5E Berbasis Konflik Kognitif dengan Metode Eksperimen Pada Materi Suhu dan Kalor Untuk Meningkatkan Penguasaan Konsep Siswa', *Prosiding SNIPS.*

NCTM 2000, 'Principles and Standards for School Mathematics', Reston, Virginia: The National Council of Teachers of Mathematics, Inc.

Nulhakim, L, Setiawan, FR, & Saefullah, A 2020, 'Improving Students' Creative Thinking Skills Using Problem-Based Learning (PBL) Models Assisted by Interactive Multimedia', *Jurnal Penelitian & Pengembangan Pendidikan Fisika,* vol. 6, no. 1, pp. 9-16.

Peraturan Pemerintah No 22 Tahun 2016, 'tentang Standar Proses Pendidikan Dasar dan Menengah'.

Pratiwi, U & Nanto, D 2019, 'Students' Strategic Thinking Ability Enhancement in Applying Scratch for Arduino of Block Programming in Computational Physics Lecture', *Jurnal Penelitian & Pengembangan Pendidikan Fisika,* vol. 5, no. 2, pp. 193-202.

Putra, A 2013, 'Persepsi Mahasiswa tentang Faktor-Faktor yang Menyebabkan Materi Fisika Sulit dan Bagaimana Cara Membuat Fisika Menjadi Lebih Mudah', *Proseding Seminar Nasional Pendidikan MIPA,* pp. 186-94.

Sadia, IW 2014, 'Model-Model Pembelajaran Sains Konstruktivistik', Yogyakarta: Graha Ilmu.

Setyowati, A, Subali, B & Mosik 2011, 'Implementasi Pendekatan Konflik Kognitif Dalam Pembelajaran Fisika Untuk Menumbuhkan Kemampuan Berpikir Kritis Siswa SMP kelas VIII', *Jurnal Pendidikan Fisika Indonesia,* vol. 7, no. 2, pp. 89-96.

Shen, Z, Man, Z, Cao, Z, & Zheng J 2020, 'A new intelligent pattern classifier based on deep-thinking', *Neural Comput & Applic,* vol. 32, pp. 14247–14261.

Sheu, H, Lent, RW, Brown, S, Miller, M, Hennessy, K, & Duffy, RD 2010, 'Testing the choice model of social cognitive career theory across Holland themes: A meta-analytic path analysis', *Journal of Vocational Behavior,* vol. 76, pp. 252–264.

Siswoyo, S 2019, 'Development of Teacher Guidebook for Photoelectric Effects Instructional Using Predict-Observe-Explain Strategy with PhET Interactive Simulation', *Jurnal Penelitian & Pengembangan Pendidikan Fisika,* vol. 5, no. 2, pp. 133-144.

Supliyadi 2017, 'Penerapan Strategi Konflik Kognitif dalam Pembelajaran Listrik Dinamis', *Jurnal Pendidikan dan Profesi Pendidikan (JP3).*

Suyono 2014, 'Belajar dan Pembelajaran', Bandung : PT Remaja Rosdarya.

Trumper, R 2016, 'Appliying Conceptual Conflict Strategies in the Learning of the Energy Concept', *Research of Science & Technology Education,* vol. 15, no. 1.

Undang-Undang Nomor 20 Tahun 2003, 'Tentang Sistem Pendidikan Nasional'.

Wilardjo, L 2009, 'Secercah Pandangan tentang Pengajaran Sains', dalam P.J. Suwarno (Eds): Pendidikan Sain yang Humanistis, Yogyakarta: Kanisius.

Yulkifli, Y, Ningrum, MV, & Indrasari, W 2019, 'The Validity of Student Worksheet Using Inquiry-Based Learning Model with Science Process Skill Approach for Physics Learning of High School', *Jurnal Penelitian & Pengembangan Pendidikan Fisika,* vol. 5, no. 2, pp. 155-162.