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COGNITIVE CONFLICT-BASED E-BOOK WITH REAL EXPERIMENT VIDEO ANALYSIS INTEGRATION TO ENHANCE CONCEPTUAL UNDERSTANDING OF MOTION KINEMATICS

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ABSTRACT

Students find it challenging to understand motion concept or mechanics in physics learning and often experience misconceptions. There is also a lack of teaching materials that promote conceptual understanding. This study aims to produce a valid, practical, and effective e-book based on cognitive conflict to enhance conceptual understanding. This research used explanatory sequential mixed methods. The effectiveness test was carried out through an experimental method with a pretest-posttest control group design. Using the cluster random sampling, 61 science students performed as the samples. The research instruments used were interview guides, observation sheets, questionnaires, and two-level multiple-choice concept tests. The data were analyzed qualitatively and quantitatively using Aiken's V formula, the percentage technique, and the Mann-Whitney hypothesis test. This study produced an e-book according to the four syntaxes of the cognitive conflict-based learning model (CCBL). Real experiment video analysis was integrated into the third syntax. The e-book is valid in content, construct, language, and graphics, with an average of 0.83 in the high category. This e-book is practical in terms of user convenience, attractiveness, and benefits, with an average of 79.6 in the strong category. This e-book is effective, with a significant effect of $0.001 < 0.05$ on conceptual understanding and misconceptions. We concluded that the cognitive conflict-based e-book with real experiment video analysis integration is valid, practical, and effective in enhancing students' conceptual understanding of motion kinematics.

Keywords: cognitive conflict; conceptual understanding; e-book; real experiment video analysis

INTRODUCTION

The rapid growth of technology, information, and communication (ICT) and global competition has resulted in numerous significant developments in education in the 21st century (Mufit et al., 2020b; Puspitasari et al., 2021). Due to this circumstance, both students and teachers must possess 21st-century skills like collaboration, communication, and critical thinking (Asrizal et al., 2018; Reaves, 2019; Dhanil & Mufit, 2021; Heldina & Alberida, 2021). These skills can be built through the integration of ICT in learning, such as the use of IT-based learning media (Liesa-Orús et al., 2020; Oguguo et al., 2020). It makes teachers more creative in preparing learning tools and creating diverse learning media (Alobaid, 2021; Ziden et al., 2022). This integration will enable a more efficient and enjoyable learning process (Gaol & Sitepu, 2020; Hasin & Nasir, 2021) to increase conceptual understanding and reduce misconceptions in learning (Karakaya et al., 2021).

However, in reality, misconceptions are a problem that often occurs in physics learning (Mufit et al., 2018). The reason is that physics is a conceptual and abstract science field (Urey, 2018;

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Akanbi et al., 2021). For example, motion kinematics material has a rather complicated concept and equations and requires solving analysis (Arredondo & Valdés, 2022). Kizilcik et al. (2021) found that misconceptions occur in frictional material, where friction is often thought to hinder motion. Another example of misconception is the research by Mufit and Syamsidar (2022), which showed that misconceptions often occur in motion material when students' intuition, which frequently conflicts with scientific ideas, allows them to understand the concept of motion.

This problem is that teachers' use of lecture methods and teacher-centered learning is dominant (Mufit et al., 2020b; Ivánková et al., 2022), allowing misconceptions. The use of concepts that do not correspond to those of experts or scientists is known as misconceptions (Chen et al., 2020; Kurtuluş & Tatar, 2021; Capriconia & Mufit, 2022). Suparno (2013) stated that building students' knowledge from scratch is more manageable than changing knowledge; it is a misunderstanding (Taufiq et al., 2020). In the material of straight motion, there are many misconceptions about distance and displacement. Students believe that when the velocity is constant, the object's acceleration is also constant (Liu & Fang, 2019). Many studies revealed misconceptions in mechanics, including in the concept of motion kinematics.

Preliminary research was conducted on 31 superior-grade students and three physics teachers at Padang Pariaman Senior High School to reveal conceptual understanding and learning conditions (Puspitasari et al., 2021). FCI (Force Concept Inventory) test instruments and questionnaires were given to students and teachers. The FCI instrument is a standardized multiple-choice test to reveal the levels of students' conceptual understanding of motion and force. In this preliminary study, FCI tests were modified into 20 two-tier multiple-choice questions by adding a tier about self-confidence in answering and reasons. Despite having studied the subject, the results indicated that 36% of students had misconceptions, 34% did not understand the concept, and only 30% did so. It means that 70% of students have problems understanding the concept of motion in the category of misconceptions and do not understand the concept (low conceptual understanding). A solution is needed to enhance students' conceptual understanding. In addition, problems were also found in the learning process. Teachers rarely carry out activities to identify students' misconceptions, and the lecture method is still dominantly used. They also rarely conduct experimental activities, discussions, and presentations to construct students' knowledge about the concept of motion. Even so, there is a lack of IT-based teaching materials that promote conceptual understanding (Puspitasari et al., 2021). Therefore, the problem of low conceptual understanding, misconceptions, teacher-centered learning, and the lack of ICT integration are gaps that need to be solved, especially in the concept of motion kinematics

One alternative solution is to apply real experiment video analysis in cognitive conflict learning. Researchers or educators have widely used cognitive conflict learning to enhance the quality of science learning since 1990 (Başer, 2006; Madu & Orji, 2015; Mufit et al., 2020a). Researchers stated that cognitive conflict learning involves models, approaches, strategies, or learning methods, with different learning stages (Mufit et al., 2020a). Applying cognitive conflict strategies can change the concept of proper learning (Rahim et al., 2015). In addition, cognitive conflict strategies can train students' communication and social skills, reduce misconceptions, and enhance their mathematical problem-solving skills (Parwati & Suharta, 2020). The cognitive conflict approach also enhances students' critical thinking skills and conceptual understanding (Makhrus & Hidayatullah, 2021). The statement is in line with the opinion of Sadia (2014) that the cognitive conflict model changes students' misconceptions into scientific concepts. Cognitive conflict strategies stimulate or direct students to change and enhance concepts (Mufit & Fauzan, 2019; Achor & Abuh, 2020).

One cognitive conflict-based learning designed to stimulate or direct students to change and enhance concepts is the Cognitive Conflict-based Learning Model (CCBL) (Mufit et al., 2019). The application of the CCBL model in learning is one suitable alternative for constructing students' concepts through learning activities. The syntax of the CCBL model in this study consisted of four stages: (1) activation of preconceptions and misconceptions, (2) presentation of cognitive conflicts, (3) discovery of concepts and similarities, and (4) reflection (Mufit et al., 2018; Mufit & Fauzan, 2019; Mufit et al., 2020b). The CCBL model can be implemented well in learning if there are teaching materials as a support system.

Cognitive conflict-based e-books are IT-based teaching materials designed to support the CCBL model. The e-book is structured according to the four CCBL model syntaxes. The first syntax is the activation of preconceptions and misconceptions to identify students' initial concepts and misconceptions. The second syntax is the presen-

tation of cognitive conflict, which aims to bring up conflicts and students' thoughts by displaying anomalous phenomena that often become misconceptions for students. The third syntax is the discovery of concepts and equations, which is done through discussion and experimentation. The fourth syntax is reflection, which attempts to evaluate how well students have progressed in their conceptual understanding after having completed the previous three stages.

In the third syntax, real experiment video analysis is integrated. It is an experiment that displays motion traces of objects through video recording analysis (Mufit et al., 2019). Students are led systematically through this experiment as they look for ideas and equations related to moving objects, such as kinematic motion. Students relate ideas to kinematic physical motion parameters, which are displayed graphically and include displacement, velocity, acceleration, momentum, and energy (Mufit et al., 2019). Real experiment video analysis can increase students' confidence in actual concepts compared to virtual simulations (Ventura et al., 2017; Hochberg et al., 2020). Real experiment video analysis can be performed using tracker software.

The Java Open-Source Physics (OSP) framework was used to create the free video modeling application known as "Tracker." It has characteristics that allow it to track the positions of objects. Many studies have revealed the advantages of using tracker software in learning, especially displaying motion profiles for students' conceptual understanding. In addition, it displays velocity and acceleration graphs, special effects filters, calibration points, line profile displays for spectrum and interference pattern analysis, and dynamic particle models (Oktova, 2019; Martyniuk et al., 2020). Students can acquire a broad set of educational skills through the tracker software by discussing technical issues, discovering scientific concepts, and gaining experience (Chiriacescu et al., 2020). A tracker software can produce more accurate motion parameter data on kinematic motion, parabolic motion, and circular motion.

Tracker software is an innovation for teachers in conducting experiments on motion, which has been difficult to do so far. Some teachers only demonstrate motion material, so students only observe without experimenting to find the concept of kinematic motion. Video analysis guides students to conduct experiments on kinematic motion material that can be carried out efficiently, and the data obtained is more accurate (Jesus & Sasaki, 2018). Another thing is that if we analyze the kinematic motion of objects with the naked eye, it will not be easy to detect. Real experiment video analysis is integrated into e-books to optimize this.

E-Books are books converted into electronic form. These e-books can be supplemented with text, graphics, images, animations, simulations, and videos (Sezgin & Ulus, 2017; Liao et al., 2018). It has many advantages: practical, durable, easy to carry, not easily weathered, and easy to publish (Qazi et al., 2018; Asrowi et al., 2019; Al-Jarf, 2021). E-books are more accessible to produce than regular printed books (Çetİn et al., 2016). E-Books provide easy access advantages and effectively support learning (Tang, 2021). In addition, e-books can make it easier for students to find additional information about learning materials anywhere and anytime (Hwang & Lai, 2017). Many libraries provide e-book access because they are accessible with smartphones, computers, and laptops (Majid et al., 2019).

E-books can be developed using professional page flip software. This software can convert teaching materials from PDF, OpenOffice, Microsoft Office, and images into an e-book (Cahyanti et al., 2021). The structure of the e-book developed refers to the guidelines for teaching materials from the Ministry of Education of the Republic of Indonesia, which consists of titles, competencies, learning materials, practice questions, and assessments. This study aims to describe the design characteristics and determine the validity of the cognitive conflict-based e-book by integrating video analysis of real experiments to enhance students' conceptual understanding of the kinematics motion material.

This research has several advantages and differences from previous studies. First, the teaching materials developed are in the form of e-books, which can be used online or offline. Second, an e-book was developed using a cognitive conflict-based learning model, whose syntax can increase conceptual understanding and remediate misconceptions. Third, this e-book integrates real experiment video analysis, which facilitates students to understand the motion concept through real experiments with a combination of video and Tracker software.

To address the issue of poor conceptual understanding and misconceptions in motion kinematics, this research is crucial. In addition, it also overcomes the problem of the lack of availability of interesting IT-based teaching materials and specifically can increase conceptual understanding of kinematics motion. The syntax of the CCBL model in the e-book is designed to

lead students to identify their initial concepts and misconceptions and make conceptual changes. Integrating real experiment video analysis into e-books is an effort to change students' conceptual thinking by correctly constructing the concept of motion kinematics. To avoid the dominance of the teacher in using the lecture method. Cognitive conflict-based e-book products that integrate real video analysis experiments are a solution to overcome these problems. This e-book is an innovation that supports 21st-century science learning so that students understand concepts through real experiments using technological facilities. This study aims to produce cognitive conflict-based e-books integrated with valid, practical, and effective real-experiment video analysis to enhance students' conceptual understanding.

METHODS

The research used a mixed method and an explanatory sequential design (Creswell, 2014). Explanatory sequential design is a combination method that is carried out sequentially. This research was conducted qualitatively and continued quantitatively. The research procedure consists of three stages: 1) Preliminary research to collect qualitative data and the prototyping phase and assessment phase to collect quantitative data; 2) Preliminary research to find problems and propose solutions to solve problems; 3) Preliminary research has been carried out previously in the form of needs analysis and literature review (Puspitasari et al., 2021). A solution design was carried out in the prototyping and assessment phases, and the solution was tested. In the prototyping phase, validity and practicality tests were carried out in several stages: self-evaluation, expert review, one-to-one evaluation, and small group evaluation. An effectiveness test (field test) was conducted in the assessment phase through experimental research with a pretest-posttest control group design (Sugiyono, 2014). The series of validity, practicality, and effectiveness tests refer to the Tessmer diagram in Figure 1.

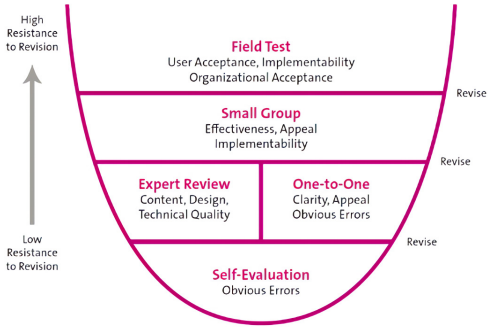

Figure 1. Tessmer Diagram (Plomp, 2013)

The researchers self-evaluated by checking for errors in the e-book prototype design. The expert review was carried out by five validators who are physics lecturers at Universitas Negeri Padang. Three low, medium, and high-ability students participated in the one-to-one evaluation. Nine students divided into three groups with low, medium, and high ability levels participated in a small group evaluation. At the field test stage, experimental research was carried out in tenth-grade science classes, with a total sample of 61 high school students. Two sample classes (control and experimental classes) were selected using the cluster random sampling technique. Practicality and effectiveness tests had high school students in Padang Pariaman as the subjects. The data in this study consisted of the results of validity, practicality, and effectiveness. There were two instruments used: a questionnaire with a Likert scale to test the validity and practicality of the product and a pretest and posttest to test its effectiveness. The questions given are in the two-tier multiple-choice with answers to reasons, which consist of 10 valid and reliable questions about the concept of circular motion.

The data analysis technique in the validity test uses Aiken's V formula, which is guided by three categories: low validity ($V < 0.4$), moderate validity ($0.4 \leq V \leq 0.8$), and high validity ($V > 0.8$). Practicality test data were analyzed using the percentage technique, with practicality criteria: very weak (0-20), weak (21-40), enough (41-60), strong (61-81), very strong (81-100) (Riduwan, 2012). The effectiveness test began with analyzing the concept test results with coding techniques. Three categories of students' conceptual understanding levels were obtained based on objective answers, confidence levels, and the reasons for the concept test instrument. The three categories are understanding concepts (U), misconceptions (M), and not understanding concepts (NU), referring to Mufit et al. (2020b). The conceptual understanding level codes were converted into numbers and analyzed using the Kolmogorov-Smirnov and Mann-Whitney Rank tests. The formulation for each test at the effectiveness stage is as follows:

First, Kolmogorov-Smirnov Test. This test is a requirement for the similarity test of two averages. This requirement test consists of the normality test and the homogeneity test. This requirement test was analyzed by SPSS 21 using the Kolmogorov-Smirnov test with a significance level of 5% or 0.05. The basis for decision-making is in Table 1.

Table 1. Provisions for Normality/Homogeneity Test

Significance	Criteria
Sig > 0.05	Normal/Homogeneous
Sig < 0.05	Abnormal/Inhomogeneous

Second, Mann-Whitney Test. This test is a test of the similarity of two non-parametric means used to test the hypothesis. This test is also known as the U test to analyze the significance of the effect of e-books based on cognitive conflict with real experiment video analysis integration to enhance students' conceptual understanding of motion. This hypothesis test was analyzed by SPSS 21 using the Mann-Whitney Rank with a significance level of 5% or 0.05. The basis for decision-making is in Table 2.

Table 2. Mann-Whitney Rank Test Terms

Significance	Criteria
Sig > 0.05	Ho is accepted, and Ha is rejected
Sig < 0.05	Ho is rejected, and Ha is accepted

Description of the Ho and Ha Hypotheses.
Ho: There is no significant effect of cognitive conflict-based e-books on students' conceptual understanding.
Ha: There is a significant effect of cognitive conflict-based e-books on students' conceptual understanding

RESULTS AND DISCUSSION

The e-book product was created to solve the issues found in the preliminary research. The four syntaxes of the cognitive conflict-based learning model (CCBL model) are the foundation for the e-book. Real experiment video analysis was integrated into the CCBL model's third syntax. Figure 2 displays the results of the product design.

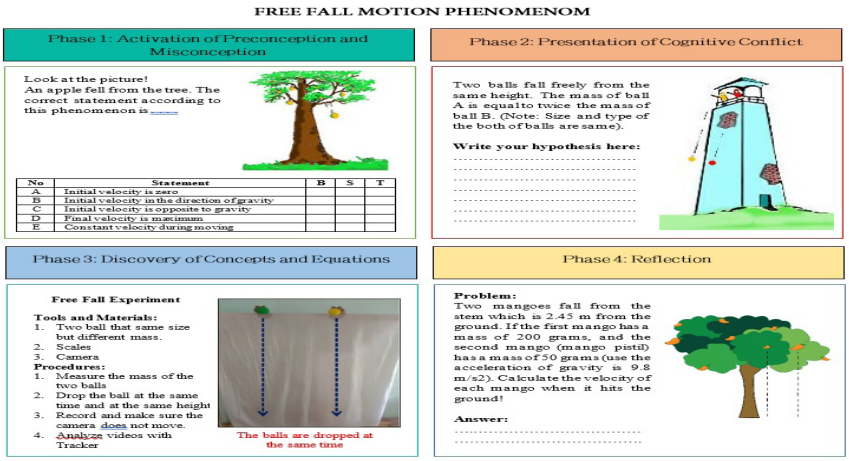

Figure 2. E-book Design based on Cognitive Conflict Model

Figure 2 presents the design of the four syntaxes of the CCBL model for e-books. The first syntax is the activation of preconceptions and misconceptions. Questions about the concept of motion that students meet in daily life are provided to the class. This stage aims to determine students' initial knowledge about the kinematic motion before learning begins. The question begins by giving a physical phenomenon and is given five statements about the phenomenon. Students can respond to statements by ticking columns B (true), S (false), and T (do not know). Students who answer all statements correctly are categorized as having understood the concept. Students who answer only part of the statement correctly are categorized as misconceptions because of incomplete students' conceptual understandings. Students who answer all statements with 'do not know' are categorized as not understanding the concepts of the given motion phenomenon. Through this syntax, teachers can find initial knowledge or concepts and identify

students' misconceptions about the kinematics of straight, parabolic, and circular motions presented in the e-book.

The second syntax design presents a cognitive conflict by providing kinematic motion phenomena that can trigger students' cognitive conflicts. Students are triggered to think profoundly and answer hypotheses on a given phenomenon. The kinematics of two objects with different masses falling from the same height becomes the choice of this second syntax design because this phenomenon often leads to a misconception for students.

The design in the third syntax, the discovery of concepts and equations, aims to find answers to students' hypotheses. In this syntax, a real experiment video analysis step is designed. Students experiment by recording the kinematic motion of two balls with different masses falling simultaneously from the same height (Figure 3a). The video recording results are then analyzed using Tracker software. There are three experimental designs in the e-book: kinematics of straight motion, parabolic motion, and circular motion (Figure 3). The results of the analysis are presented in the form of tables and graphs for students to discuss. In the e-book, students are guided to find concepts and equations about the kinematics of motion.

In the design of the fourth syntax, reflection, students are invited to review their answers in the first syntax and their hypotheses in the second syntax. After carrying out the concept and equation discovery activities, students were given questions about the kinematic motion to determine how far their understanding progressed. The questions are designed in essay form, consisting of questions about the concept of motion and its application using the kinematics equation of motion. The real experiment video analysis design on straight, parabolic, and circular motions is in Figure 3.

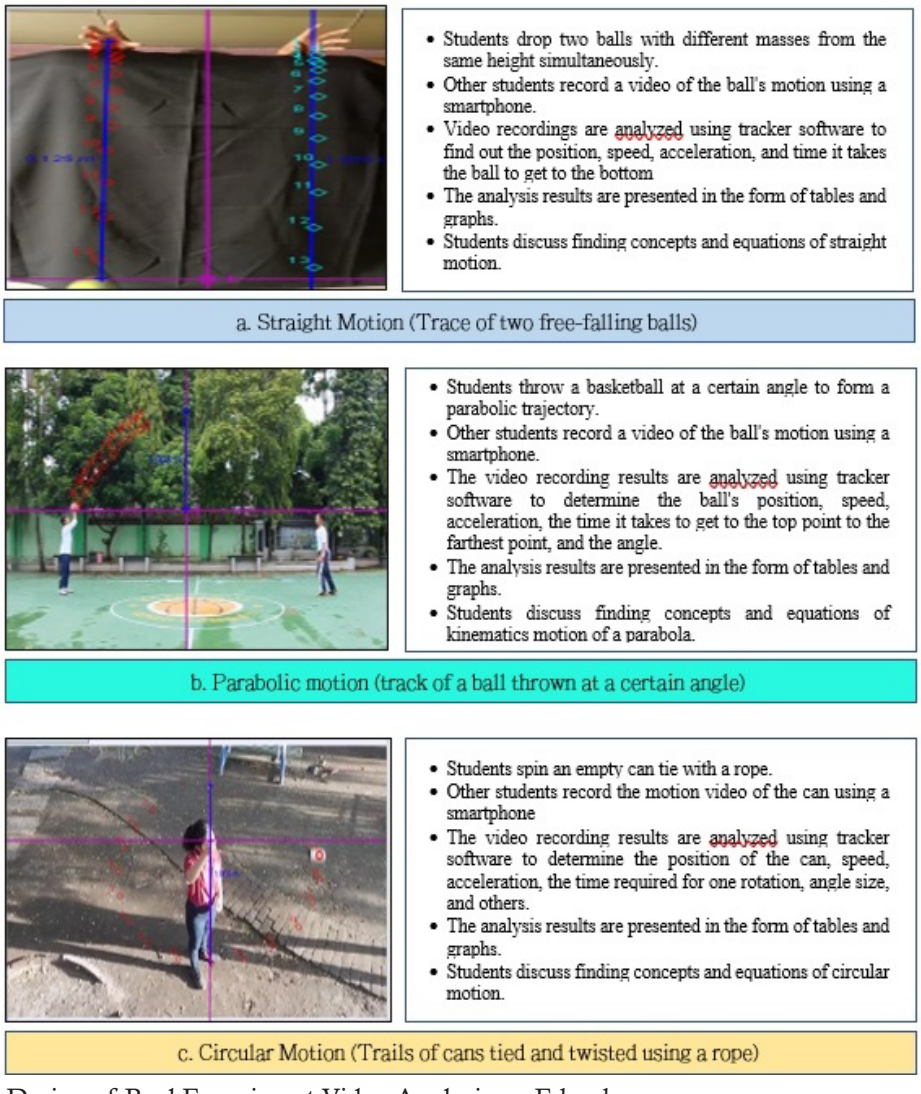

Figure 3. Design of Real Experiment Video Analysis on E-books

Cognitive conflict-based e-book products are then self-evaluated before the expert review. The researchers themselves did a self-evaluation to see obvious errors. This stage evaluates, checks completeness, and revises the product. The self-evaluation instrument has a checklist sheet with a Likert scale. There are five indicators in self-evaluation: the completeness of the structure of the e-book according to the guidelines of the Indonesian Ministry of Education, the completeness of the CCBL model syntax on the e-book, the suitability of the analysis of real experiment videos integrated into the e-book, the suitability of language, and the suitability of the display of the e-book. The results of the self-evaluation analysis are in Figure 4.

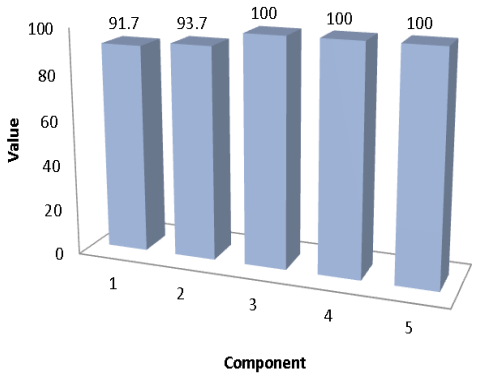

Figure 4. Self-Evaluation Results

Based on Figure 4, the five indicators of the self-evaluation assessment are in a very high category. The e-book has fully integrated real experiment video analysis for straight, parabolic, and circular motions. Language and appearance, in general, are also good. The completeness of the e-book structure and the syntax of the cognitive conflict-based learning model are also in the good category. However, there is a revision in the evaluation/reflection section. The overall self-evaluation assessment obtained an average of 97.08, with a very high category. Thus, the e-book was tested for validity through an expert review.

The validity test results based on the expert review consist of four aspects of the assessment: content validity, construct validity, language validity, and e-book appearance validity. The analysis results of evaluating the validity of the four cognitive conflict-based e-books are presented in Table 3.

Table 3. Results of E-Book Validity Analysis

Assessment Indicators	Aiken's V	Description
Content Validity	0.80	High
Construct Validity	0.85	High
Language Validity	0.82	High
Display Validity	0.83	High
Average	**0.83**	**High**

Table 3 explains the results of the analysis of the validity of the cognitive conflict-based e-book. The e-book validity of various indicators is in the range of values from 0.80 to 0.85. The average validity value is 0.83 and is categorized as high. Thus, the cognitive conflict-based e-book is valid.

Cognitive conflict-based e-books were then tested for practicality in the following stages. One-to-one and small-group evaluations were conducted on tenth-grade high school students. A one-to-one evaluation was conducted on three students with high, medium, and low abilities. Three aspects of the practicality of e-book products are seen: the usability aspect, the attractiveness aspect, and the benefit aspect. The results of the one-to-one evaluation practical test analysis are presented in Table 4.

Table 4. Results of One-to-One Evaluation Analysis

Assessment Indicators	Average	Description
Usability	67.86	Strong
Attractiveness	62.50	Strong
Benefit	66.67	Strong
Average	**65.68**	Strong

Table 4 describes the practical analysis of e-books on one-to-one evaluation. The values from the three indicators range from 62.50 to 67.86. The average value of the practicality of the e-book in the one-to-one evaluation was 65.68 and categorized as strong. It shows that the use of e-books in one-to-one evaluation has a strong practicality, meaning that the prototype is practical.

Next, a practical test was conducted on a small group evaluation of nine students. The nine people consisted of three people with high abilities, three with moderate abilities, and three with low abilities. Three aspects of practicality in the analyzed small group evaluation are usability, attractiveness, and benefits. The results of the practical analysis of the small group evaluation are in Table 5.

Table 5. Results of the Small Group Evaluation Analysis

Assessment Indicators	Average	Description
Usability	78.97	Strong
Attractiveness	76.39	Strong
Benefit	83.33	Strong
Average	**79.56**	Strong

Table 5 shows the results of the practical analysis of e-books on the small group evaluation. The values from the three indicators range from 76.39 to 83.33. The average value of the practicality of the e-book in the small group evaluation was 79.56 and categorized as strong. It shows that using e-books in small groups has strong practicality. Therefore, cognitive conflict-based e-books with real experiment video analysis integration are practical to use in learning.

Furthermore, e-book products based on cognitive conflict were tested for effectiveness using experimental research. The effectiveness of the e-book is seen in the increase in students' conceptual understanding. The level of students' conceptual understanding is divided into three levels: understanding concepts (U), misconceptions (M), and not understanding concepts (NU). The effectiveness of the e-book was analyzed from the pretest and posttest gain scores. The statistical test was the Mann-Whitney test because the data in the two sample classes were not normally distributed, and the second variant was not homogeneous in the three categories, U, M, and NU. The analysis results of the effectiveness of cognitive conflict-based e-book are in Table 6.

Table 6 describes the effectiveness of the cognitive conflict-based e-book. From the data, the gain value of the experimental class was higher than the control class. From the data, students who understand the concept gained 157 in the experimental class and 55 in the control class. These data showed a drastic increase in students' conceptual understanding in the experimental class after using an e-book based on cognitive conflict with real experiment video analysis integration. In the students' misconception data, the experimental class gain was 65, more significant than the gain in the control class, which was 18. It means there was a drastic decrease in students' misconceptions in the experimental class because it used an e-book based on the cognitive conflict with real experiment video analysis integration. Using this cognitive conflict-based e-book can also reduce students' lack of conceptual understanding in the experimental class. It was proven by the experimental class gain (139) higher than the control class (120). Thus, cognitive conflict-based e-books can encourage students to understand concepts and reduce misconceptions and lack of understanding of physics concepts.

The gain was then analyzed using statistical tests to see the significance of the effectiveness of the e-book on the levels of students' conceptual understanding. Before that, normality and homogeneity tests were carried out first. The results

of data analysis showed that students' conceptual understanding at the three levels had data that were not normally distributed and not homogeneous. For this reason, doing a non-parametric test with the Mann-Whitney test was necessary. The Mann-Whitney test result analysis showed that cognitive conflict-based e-books significantly influenced students' conceptual understanding and misconceptions (Table 6). Thus, cognitive conflict-based e-books with real experiment video analysis integration effectively enhance students' conceptual understanding.

Table 6. Analysis of Effectiveness Test Using Cognitive Conflict-based E-book

Level of Concept Understanding	Test used	Experimental class	Control class
Understand the concept (U)	Pretest	33	40
	Posttest	190	95
	Gain	157	55
	Normality Test & Homogeneity Test		
	Sig	<0.05	
	Description	Not normally distributed & not homogeneous	
	Mann-Whitney Test		
	Asymp.Sig	.001	
	Sig	<0.05	
	Description	There is an influence	
Misconception (M)	Pretest	120	77
	Posttest	55	59
	Gain	65	18
	Normality Test & Homogeneity Test		
	Sig	<0.05	
	Description	Not normally distributed & not homogeneous	
	Mann-Whitney Test		
	Asymp. Sig	.001	
	Sig	<0.05	
	Description	There is an influence	
Do not understand the concept (NU)	Pretest	190	215
	Posttest	51	95
	Gain	139	120
	Normality Test & Homogeneity Test		
	Sig	<0.05	
	Description	Not normally distributed & not homogeneous	
	Mann-Whitney Test		
	Asymp.Sig	.110	
	Sig	>0.05	
	Description	There is no influence	

Based on a series of studies, the cognitive conflict-based e-book with real experiment video analysis integration is valid, practical, and effective in enhancing students' conceptual understanding. The e-book is valid in content, construction, language, and appearance. Regarding content, the e-book integrated real experiment video analysis with a cognitive conflict-based learning model that follows the characteristics of 21st-century learning (Mufit et al., 2019). In terms

of constructs, this e-book is designed to enhance students' conceptual understanding of motion kinematics and train students' 4C skills through the four syntaxes of the CCBL model (Santi et al., 2019; Verawati et al., 2019; Septiyanti & Fajriah, 2021). Regarding language, e-books follow good and correct Indonesian writing rules (Tharmar & Kalidasan, 2019; Nurhasnah et al., 2020). In terms of appearance, the e-book has clear navigation buttons and exciting animations to create an interactive and engaging learning atmosphere (Jannah et al., 2020). This validity study are supported by the results of many previous researchers (Arifin et al., 2021; Delvia et al., 2021; Dhanil & Mufit, 2021; Saputri et al., 2021). Dhanil and Mufit (2021) showed that interactive multimedia is designed with four CCBL syntax models to enhance students' understanding of 4C concepts and skills in the high validity category. In the third syntax of the CCBL model, experiments can also be integrated into a virtual laboratory form (Delvia et al., 2021; Saputri et al., 2021). However, the integration of real experiment video analysis is superior in providing real experiences for students. In addition, Arifin et al. (2021) also explained that interactive multimedia based on cognitive conflict is integrated with students' new literacy, which is also valid and practical. Thus, the e-book based on cognitive conflict integrated with real experiment video analysis in this study is valid.

The e-book is practical in terms of usability, attractiveness, and benefits. As in several previous studies, practical teaching materials are needed in learning activities (Septiana, 2018; Fardani et al., 2019; Arifin et al., 2021). The cognitive conflict-based e-book in this study is practical because it contains instructions and straightforward-presented materials that students easily understand. The syntax of the cognitive conflict learning model is clear so that students easily understand it, and there is a real experiment video analysis that can make it easier for students to find physics concepts (Sutopo, 2014; Fardani et al., 2019; Mufit et al., 2019). This e-book also has the appeal to make students interested in studying physics. The right color combination, moving animations, audio, exciting pictures, and videos to explain abstract concepts can be considered interesting (Septiana, 2018). Besides being easy to use and attractive, this e-book also benefits its users. The benefits of using e-books are that it makes it easier for students to find physics concepts independently and minimize time. It can also be used anywhere and anytime and can build students' conceptual understanding (A'yun et al., 2020; Setiawan & Razak, 2020). Thus, the cognitive conflict-based e-book is practical because it fulfills three practicality aspects: usability, attractiveness, and benefits.

The cognitive conflict-based e-book in this study effectively increases students' conceptual understanding, as it is also relevant to several previous researchers. E-books are said to be effective if they can enhance students' learning outcomes, including conceptual understanding (Asrowi et al., 2019; Sun & Pan, 2021). This e-book contains a cognitive conflict model. This model contains meaningful information, challenges students to form concepts, and provides motivation to solve problems to enhance students' conceptual understanding (Bedford et al., 2018). This model can also help students to remediate misconceptions (Akmam et al., 2022). It is in line with Rahim et al. (2015), who showed that cognitive conflict learning can reduce students' misconceptions in physics lessons.

Low conceptual understanding and misconceptions about motion kinematics have been resolved by this research. The results of data analysis on the effectiveness test show the significance of cognitive conflict-based e-books in increasing conceptual understanding and remediating students' misconceptions about motion kinematics. The syntax of the cognitive conflict model in e-books can make learning more meaningful and clarify physics concepts to reduce misconceptions.

The novelty of this research is the E-book design which uses the four CCBL model syntax and integrates real experiment video analysis. The integration of real video analysis can form a real understanding of students' concepts (Michalsky, 2020; Sun & Pan, 2021). It is because real video analysis contains experiment videos to analyze motion videos. The integration of real video analysis will be more accurate if it is made with the help of a software tracker (Eadkhong et al., 2012; Nurfadilah et al., 2020). Using tracker software, it is possible to know the position of objects, object speed, object acceleration, XY coordinates, and the time it takes for the object to move (MacLachlan, 2005; Janwadkar et al., 2017; Saho, 2018). Data analyzed with the naked eye will be difficult to detect, so it can cause misconceptions, especially in motion material (Liu & Fang, 2019; Nurfadilah et al., 2020; Liu et al., 2022). It is because motion is one of the materials with many concepts and equations that the naked eye can detect. Therefore, real experiment video analysis with the help of tracker software needs to be integrated into the development of cognitive conflict-based e-books.

Real experiment video analysis has been used by previous researchers on the concepts of viscosity, kinematics, dynamics, and pendulum oscillation motion (Ondruš & Hockicko, 2015; Mariati et al., 2017; Trocaru et al., 2020; Islami et al., 2021). With video analysis using Tracker software, students become motivated to explore high-quality material, even using ordinary smartphones (Khan et al., 2019; Becker et al., 2020; Trocaru et al., 2020). The use of video recording and tracker analysis software can enhance students' cognition and metacognition by providing authentic experiences for students (Wee et al., 2015; Mariati et al., 2017). In addition, the CCBL model syntax assisted by experiment video analysis can make learning more meaningful and fun. The findings in this study are that there is innovation in producing e-books with the four CCBL syntax models and the integration of real experiment video analysis, which has significantly enhanced students' conceptual understanding.

CONCLUSION

This research has produced a cognitive conflict-based e-book with real experiment video analysis integration, which is valid, practical, and effective in enhancing students' conceptual understanding. The e-book is valid regarding content, construct, language, and appearance. It is practical in terms of usability, attractiveness, and benefits. The main finding in this study is that the cognitive conflict-based e-book with real experiment video analysis integration is effective and significantly enhances students' conceptual understanding and reduces their misconceptions. This study implies that the cognitive conflict-based e-book with real experiment video analysis integration can be used as teaching materials to enhance conceptual understanding of motion kinematics. It is suggested that educators use this e-book as an IT-based 21st-century physics teaching material.

REFERENCES

Achor, E. E., & Abuh, Y. P. (2020). Fostering students' academic performance in physics using cognitive conflict instructional strategy and conceptual change pedagogy. *International Journal of Education and Learning*, *2*(1), 42–57.

Akanbi, A. O., Olayinka, Y. W., Omosewo, E. O., & Mohammed, R. E. (2021). Effect of Mind Mapping Instructional Strategy on Students' Retention in Physics in Senior Secondary Schools. *Anatolian Journal of Education*, *6*(1), 145–156.

Akmam, A., Hidayat, R., Mufit, F., Jalinus, N., & Amran, A. (2022a). Factor Analysis Affecting the Implementation of the Generative Learning Model with a Cognitive Conflict Strategy in the Computational Physics Course during the COVID-19 Pandemic Era. *Kuram ve Uygulamada Eğitim Yönetimi Educational Administration: Theory and Practice*, *2309*(1), 64–74.

Akmam, A., Hidayat, R., Mufit, F., Jalinus, N., & Amran, A. (2022b). Need analysis to develop a generative learning model with a cognitive conflict strategy oriented to creative thinking in the Computational Physics course. *Journal of Physics: Conference Series*, *2309*(1).

Al-jarf, R. (2021). Collaborative Mobile eBook Reading for Struggling EFL College Readers. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *11*(6), 32–42.

Alobaid, A. (2021). ICT multimedia learning affordances: role and impact on ESL learners' writing accuracy development. *Heliyon*, *7*(7), e07517.

Arifin, F. A., Mufit, F., & Asrizal. (2021). Validity and practicality of interactive multimedia based on cognitive conflict integrated new literacy on thermodynamic and mechanical waves material for class xi high school students. *Journal of Physics: Conference Series*, *1876*(1).

Arredondo, L. L., & Valdés, H. (2022). M-learning adapted to the ARCS model of motivation and applied to a kinematics course. *Computer Applications in Engineering Education*, *30*(1), 77–92.

Asrizal, Amran, A., Ananda, A., Festiyed, F., & Sumarmin, R. (2018). The development of integrated science instructional materials to improve students' digital literacy in scientific approach. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 442–450.

Asrowi, Hadaya, A., & Hanif, M. (2019). The impact of using the interactive e-book on students' learning outcomes. *International Journal of Instruction*, *12*(2), 709–722.

Başer, M. (2006). Fostering Conceptual Change By Cognitive Conflict Based Instruction On Students' Understanding Of Heat And Temperature Concepts. *Eurasia Journal of Mathematics, Science and Technology Education*, *2*(2), 96–114.

Becker, S., Klein, P., Gößling, A., & Kuhn, J. (2020). Using mobile devices to enhance inquiry-based learning processes. *Learning and Instruction*, *69*(August 2019), 101350.

Bedford, D. S., Bisbe, J., & Sweeney, B. (2018). Performance Measurement Systems as Generators of Cognitive Conflict in Ambidextrous Firms. *Energy Economics*, *75*, 1–33.

Cahyanti, A. D., Sudibyo, E., & Rahayu, Y. S. (2021). Effectiveness of Insect Encyclopedia E-Book With Mind Mapping Strategy to Train Students' Creative Thinking Skills. *IJORER : International Journal of Recent Educational Research*, *2*(4), 432–443.

Çetİn, G., A, O. Ö., Güvenç, E., & Sakal, M. (2016). The Development Of An EBook With Dynamic Content For The Introduction Of Algorithms And Programming. In *Mugla Journal of Science and Technology* , *2*(2), 199–203.

Chen, C., Sonnert, G., Sadler, P. M., & Sunbury, S. (2020). The impact of high school life science teachers' subject matter knowledge and knowledge of student misconceptions on students' learning. *CBE Life Sciences Education*, *19*(1).

Chiriacescu, F. S., Chiriacescu, B., Miron, C., Berlic, C., & Barna, V. (2020). Dynamic study of torsion using tracker software. *Romanian Reports in Physics*, *77*(904), 1–10.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches (4th ed)*. Sage.

Delvia, T. F., Mufit, F., & Bustari, M. (2021). Design and Validity of Physics Teaching Materials Based on Cognitive Conflict Integrated Virtual Laboratory in Atomic Nucleus. *Pillar of Physics Education*, *14*(1), 05.

Dhanil, M., & Mufit, F. (2021). Design and Validity of Interactive Multimedia Based on Cognitive Conflict on Static Fluid Using Adobe Animate CC 2019. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *7*(2), 177–190.

Eadkhong, T., Rajsadorn, R., Jannual, P., & Danworaphong, S. (2012). Rotational dynamics with Tracker. *European Journal of Physics*, *33*(3), 615–622.

Fardani, R. N., Ertikanto, C., Suyatna, A., & Rosidin, U. (2019). Practicality and Effectiveness of E-Book Based LCDS to Foster Students' Critical Thinking Skills. *Journal of Physics: Conference Series*, *1155*(1).

Gaol, R. L., & Sitepu, A. (2020). The Influence of Used Good-Based Learning Media on the Value of Chracter Education and Student's Motivation to Study. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, *3*(4), 1696–1703.

Hasin, I., & M Nasir, M. K. (2021). The effectiveness of the use of Information and Communication Technology (ICT) in rural secondary schools in Malaysia. *Journal of Education and E-Learning Research*, *8*(1), 59–64.

Heldina, T., & Alberida, H. (2021). Students' Creative Thinking Skills at SMAN 1 Basa Ampek Balai. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, *24*(2), 472–475.

Hochberg, K., Becker, S., Louis, M., Klein, P., & Kuhn, J. (2020). Using Smartphones as Experimental Tools—a Follow-up: Cognitive Effects by Video Analysis and Reduction of Cognitive Load by Multiple Representations. *Journal of Science Education and Technology*, *29*(2), 303–317.

Hwang, G. J., & Lai, C. L. (2017). Facilitating and bridging out-of-class and in-class learning: An interactive E-book-based flipped learning approach for math courses. *Educational Technology and Society*, *20*(1), 184–197.

Islami, R. B., Didik, L. A., & Bahtiar, B. (2021). Determine of the nira water viscosity by using video based laboratory falling ball method with tracker software. *Gravity : Jurnal Ilmiah Penelitian Dan Pembelajaran Fisika*, *7*(2), 8–20.

Ivánková, P., Halakova, Z., & Čolláková, D. (2022). The Influence of a Science Camp Experience on Pupils Motivating to Study Natural Sciences. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(3).

Jannah, M., Prasojo, L. D., & Jerusalem, M. A. (2020). Elementary School Teachers' Perceptions of Digital Technology Based Learning in the 21st Century: Promoting Digital Technology as the Proponent Learning Tools. *Al Ibtida: Jurnal Pendidikan Guru MI*, *7*(1), 1.

Janwadkar, S., Bhavar, D., & Kolte, M. T. (2017). Design and implementation of a GPS based personal tracking system. *1st IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems, ICPEICES 2016*, *July*.

Jesus, V. L. B. de, & Sasaki, D. G. G. (2018). A Simple Experiment to Determine the Moments of Inertia of the Fidget Spinner by Video Analysis. *The Physics Teacher*, *56*(9), 639–642.

Karakaya, F., Yilmaz, M., & Ince Aka, E. (2021). Examination of Pre-Service Science Teachers' Conceptual Perceptions and Misconceptions about Photosynthesis. *Pedagogical Research*, *6*(4), em0104.

Khan, T., Johnston, K., & Ophoff, J. (2019). The Impact of an Augmented Reality Application on Learning Motivation of Students. *Advances in Human-Computer Interaction*, *2019*.

Kizilcik, H. Ş., Aygün, M., Şahin, E., Önder-Çelikkanll, N., Türk, O., Taşkln, T., & Güneş, B. (2021). Possible misconceptions about solid friction. *Physical Review Physics Education Research*, *17*(2).

Kurtuluş, M. A., & Tatar, N. (2021). An analysis of scientific articles on science misconceptions: A bibliometric research. *Elementary Education Online*, *20*(1), 192–207.

Liao, S., Hong, J. C., Wen, M. H., Pan, Y. C., & Wu, Y. W. (2018). Applying Technology Acceptance Model (TAM) to explore Users' Behavioral Intention to Adopt a Performance Assessment System for E-book Production. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(10), 1–12.

Liesa-Orús, M., Latorre-Cosculluela, C., Vázquez-Toledo, S., & Sierra-Sánchez, V. (2020). The technological challenge facing higher education professors: Perceptions of ICT tools for developing 21st Century skills. *Sustainability (Switzerland)*, *12*(13).

Liu, G., & Fang, N. (2019). Student misconceptions about force and acceleration in physics and engineering mechanics education. *International Journal of Engineering Education*, *32*(1), 19–29.

Liu, Y., Liao, Y., Lin, C., Jia, Y., Li, Z., & Yang, X. (2022). Object Tracking in Satellite Videos

Based on Correlation Filter with Multi-Feature Fusion and Motion Trajectory Compensation. *Remote Sensing*, *14*(3), 1–23.

MacLachlan, R. (2005). Tracking moving objects from a moving vehicle using a laser scanner. *Robot. Inst., Carnegie Mellon Univ., Pittsburgh, PA, Tech. Rep. CMU-RI-TR-05-07*.

Madu, B. C., & Orji, E. (2015). Effects of Cognitive Conflict Instructional Strategy on Students' Conceptual Change in Temperature and Heat. *SAGE Open*, *5*(3).

Majid, S., Chenqin, Y., Chang, Y., & Zilu, C. (2019). Perceptions and E-book Use Behavior of University Students. *International Journal for Digital Society*, *10*(4), 1534–1540.

Makhrus, M., & Hidayatullah, Z. (2021). The Role of Cognitive Conflict Approach to Improving Critical Thinking Skills and Conceptual Understanding in Mechanical Waves. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *11*(1), 63–70.

Mariati, P. S., Betty, M. T., & Sehat, S. (2017). the Problem Solving Learning Model By Using Video Recording on Experiments of Kinematics and Dynamics To Improve the Students Cognition and Metacognition. *Jurnal Pendidikan Fisika Indonesia*, *13*(1), 25–32.

Martyniuk, O. O., Martyniuk, O. S., & Muzyka, I. O. (2020). Formation of informational and digital competence of secondary school students in laboratory work in physics. *CEUR Workshop Proceedings*, *2879*, 366–383.

Michalsky, T. (2020). Integrating video analysis of teacher and student behaviors to promote Preservice teachers' teaching meta-strategic knowledge. *Metacognition and Learning*.

Mufit, F., Asrizal, A., & Puspitasari, R. (2020a). Meta-Analysis of the Effect of Cognitive Conflict on Physics Learning. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *6*(2), 267–278.

Mufit, F., Asrizal, Hanum, S. A., & Fadhilah, A. (2020b). Preliminary research in the development of physics teaching materials that integrate new literacy and disaster literacy. *Journal of Physics: Conference Series*, *1481*(1), 0–12.

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

Mufit, F., Festiyed, F., Fauzan, A., & Lufri, L. (2018). Impact of Learning Model Based on Cognitive Conflict toward Student's Conceptual Understanding. *IOP Conference Series: Materials Science and Engineering*, *335*(1).

Mufit, F., Festiyed, Fauzan, & Lufri. (2019). The application of real experiments video analysis in the CCBL model to remediate the misconceptions about motion's concept. *Journal of Physics: Conference Series*, *1317*(1).

Mufit, F., & Syamsidar. (2022). Development of Four-Tier Multiple Choice Test Instrument to Identify Students' Concept Understanding of Newton' s Law Material. *Jipf (Jurnal Ilmu Pendidikan Fisika)*, *7*(2), 134–144.

Nurfadilah, Sulisworo, D., & Maruto, G. (2020). *Tracker Application to Determine the Moment of Inertia in a Video-Based Laboratory to Improve Students' Learning Activity*. *477*(Iccd), 538–541.

Nurhasnah, N., Kasmita, W., Aswirna, P., & Abshary, F. I. (2020). Developing Physics E-Module Using "Construct 2" to Support Students' Independent Learning Skills. *Thabiea : Journal of Natural Science Teaching*, *3*(2), 79.

Oguguo, B. C. E., Okeke, A. O., Dave-Ugwu, P. O., Ocheni, C. A., Ugorji, C. O., Nwoji, I. H. N., & Ike, I. C. (2020). Assessment of ict skills relevant for effective learning possessed by undergraduate students at university of nigeria. *International Journal of Higher Education*, *9*(4), 206–215.

Oktova, R. (2019). Tracker-aided experiments for the determination of viscosity coefficients of liquids using the communicating vessels method with weighted regression analysis. *Turkish Journal of Physics*, *43*(4), 383–392.

Ondruš, J., & Hockicko, P. (2015). Braking deceleration measurement using the video analysis of motions by Sw tracker. *Transport and Telecommunication*, *16*(2), 127–137.

Parwati, N. N., & Suharta, I. G. P. (2020). Effectiveness of the implementation of cognitive conflict strategy assisted by e-service learning to reduce students' mathematical misconceptions. *International Journal of Emerging Technologies in Learning*, *15*(11), 102–118.

Puspitasari, R., Mufit, F., & Asrizal. (2021). Conditions of learning physics and students' understanding of the concept of motion during the covid-19 pandemic. *Journal of Physics: Conference Series*, *1876*(1).

Qazi, W., Raza, S. A., & Shah, N. (2018). Acceptance of e-book reading among higher education students in a developing country: The modified diffusion innovation theory. *International Journal of Business Information Systems*, *27*(2), 222–245.

Rahim, R. A., Noor, N. M., & Zaid, N. M. (2015). Meta-analysis on element of cognitive conflict strategies with a focus on multimedia learning material development. *International Education Studies*, *13*, 73–78.

Reaves, J. (2019). 21St-Century Skills and the Fourth Industrial Revolution: a Critical Future Role for Online Education. *International Journal on Innovations in Online Education*, *3*(1).

Riduwan (2012), 'Pengantar Statistika (Untuk Penelitian Pendidikan, Sosial, Ekonomi, Komunikasi Dan Bisnis)', Alfabeta: Bandung

Sadia. (2014). *Model-Model Pembelajaran Sains Konstruktivistik.* Graha Ilmu.

Saho, K. (2018). Kalman Filter for Moving Object Tracking: Performance Analysis and Filter Design. *Kalman Filters - Theory for Advanced Applications*, *Cv*.

Santi, A., Nusrotus, S., & Hayu, D. Y. (2019). *Construct*

Validity on Teaching Materials of Language Assessment Based on Problem-Based Learning. *287*(Icesre 2018), 22–26.

Saputri, R., Mufit, F., Gusnedi, G., & Sari, S. Y. (2021). Design and Validity of Cognitive Conflict-Based Teaching Materials Integrating Virtual Laboratories to Improve Concept Understanding of Waves. *Berkala Ilmiah Pendidikan Fisika*, *9*(3), 244.

Septiana, B. (2018). the Validity and Practicality of E-Book Flipbook-Based on Tissues Structure and Organ Function of Plant in 11Th Grades High School Material.

Septiyanti, N. A., & Fajriah, Y. N. (2021). The Challenge Encountered by EFL Teachers in developing Students 4C Skills in 21st Century Education. *Journal of English Pedagogy and Applied Linguistics*, *1*(2), 106–121.

Setiawan, D., & Razak, A. (2020). Validity And Practicality E-Book Based On Android Of Materials Structure And Function Of Animal Tissue Class 11th Senior High School. *IJIS Edu : Indonesian Journal of Integrated Science Education*, *2*(2), 99.

Sezgin, E. Y., & Ulus, L. (2017). The early literacy at preschool education: The book or the E-book? In *Turkish Online Journal of Educational Technology*, *16*(4), 77–83.

Sugiyono. (2014). *Metode Penelitian Kombinasi (Mixed Methods)*. Alfabeta.

Sun, L., & Pan, C. E. (2021). Effects of the Application of Information Technology to E-Book Learning on Learning Motivation and Effectiveness. *Frontiers in Psychology*, *12*(September), 1–5.

Suparno. (2013). *Miskonsepsi & Perubahan Konsep Pendidikan Fisika.* Grasindo.

Sutopo, S. (2014). Counterexample in Cognitive Conflict As Factor Influencing Conceptual Change. *QIJIS (Qudus International Journal of Islamic Studies)*, *2*(2), 198–218.

Tang, K. Y. (2021). Paradigm shifts in e-book-supported learning: Evidence from the Web of Science using a co-citation network analysis with an education focus (2010–2019). *Computers and Education*, *175*(August), 104323.

Taufiq, M., Muntamah, S., & Parmin, P. (2020). Remediation of misconception on straight line motion concept using guided inquiry model assisted by student worksheet based on science technology engineering and mathematics (STEM) on junior high school students. *Journal of Physics: Conference Series*, *1521*(4).

Tharmar, K., & Kalidasan, R. (2019). *Impact of Self Study With and Without E-Learning Modules Among Physical Education Students*. *XI*(936), 936–945.

Trocaru, S., Berlic, C., Miron, C., & Barna, V. (2020). Using Tracker As Video Analysis And Augmented Reality Tool For Investigation Of The Oscillations For Coupled Pendula. *Romanian Reports in Physics*, *72*(902), 1–16.

Urey, M. (2018). Defining the relationship between the perceptions and the misconceptions about photosynthesis topic of the preservice science teachers. *European Journal of Educational Research*, *7*(4), 813–826.

Ventura, D. R., de Carvalho, P. S., & Dias, M. A. (2017). Standing Waves in an Elastic Spring: A Systematic Study by Video Analysis. *The Physics Teacher*, *55*(4), 232–234.

Verawati, N. N. S. P., Prayogi, S., Gummah, S., Muliadi, A., & Yusup, M. Y. (2019). The effect of conflict-cognitive strategy in inquiry learning towards pre-service teachers' critical thinking ability. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 529–537.

Wee, L. K., Tan, K. K., Leong, T. K., & Tan, C. (2015). Using Tracker to understand "toss up" and free fall motion: A case study. *Physics Education*, *50*(4), 436–442.

Ziden, A. A., Ziden, A. A. A., & Ifedayo, A. E. (2022). Effectiveness of Augmented Reality (AR) on Students' Achievement and Motivation in Learning Science. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(4).