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The Analysis of Experiment Video on Cognitive Conflict-Based Teaching Materials to Enhance Momentum-Impulse Concepts Understanding

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Abstract

Video analysis experiments can be used to construct physics concepts and equations. Integrating video analysis experiments into cognitive conflict learning allows students to increase their understanding of concepts. Some research results show that students need clarification about momentum and impulse material, low conceptual understanding, and misconceptions occur. The problem of misconceptions can hinder student learning progress. One solution to overcome these problems is the application of physics teaching materials based on cognitive conflict integrated with real experiment video analysis. This study aims to analyze the effectiveness of these teaching materials in improving students' understanding of the concept of momentum and impulse. This study used a quasi-experimental method with a nonequivalent control group design. The sample consisted of 72 high school students with two sample classes, the experimental and the control classes, which were selected using the cluster random sampling technique. The instrument in this study was a concept test that was valid and reliable. Data were analyzed using Mann-Whitney test nonparametric statistics with the help of IBM SPSS Statistic 25. The results obtained by Sig. Asim < 0.05, in the rejection area of H0, means that teaching materials influence students' understanding of concepts on momentum and impulse. Thus, conflict-based teaching materials integrating real experiment video analysis have been effective in increasing students' conceptual understanding.

Keywords: cognitive conflict, momentum and impulse, real experiment video analysis, tracker software, effectiveness

INTRODUCTION

The development of science and technology in the 21st century has brought significant changes in the world of education, especially the learning process. 21st-century learning expects the integrity of technology in learning. The previous study (Sugihartono et al. 2012) define learning as individual interaction with the environment to gain experience and knowledge. The importance of technology so that learning becomes exciting and follows the characteristics of students in the 21st century. The previous research (Sutikno 2007) explains that learning is an educational process based on teacher and student interactions that lead to specific goals. From the two meanings of learning, learning is a reciprocal relationship between students, teachers, and their environment so that the learning process occurs within students to achieve specific goals.

Ideally, the purpose of learning physics in the 2013 curriculum is that students need to understand the physics concept (Kemendikbud 2014). Observations and experiments are needed in learning physics, just like scientists. In physics learning, the concepts that exist in students must follow scientifically accepted concepts, not deviant ones, better known as misconceptions (Sheftyawan et al. 2018). Research (Audina et al. 2017) mentions that textbooks/teaching materials are also one of the factors that cause misconceptions. Misconceptions must be remedied as soon as possible because they will hinder learning progress and make it difficult for students to understand advanced physics concepts (Mufit & Fauzan 2019).

Students' understanding of physics concepts is still low, and misunderstandings often occur (Capriconia & Mufit 2022; Puspitasari et al. 2021; Mufit et al. 2020). Poor conceptual understanding and misconceptions on impulse-momentum are often experienced by students (Anggraini & Suliyanah 2017; Lusiana et al. 2016; Defrianti et al. 2021). Momentum and impulse are physical studies in mechanics, with sub-materials including momentum, impulses, the law of conservation of momentum, and collisions (Relia & Sodikin 2018). The previous study (Lusiana et al. 2016) stated that the number of students who experienced misconceptions about momentum and impulse materials was 31% to 97% of 32 students. Previous researchers (Anggraeni & Suliyanah 2017) stated that the highest percentage of students experienced 42.86% misconceptions about the conservation of energy and momentum sub-materials. Another study explained that students have a misconception about momentum and impulse material 81.25% (Hikmatunnisa et al. 2019). Besides that, through interviews with physics teachers to find out the conditions of learning in schools, it was found that learning was still dominated by teachers (teacher-centered), so students were not actively involved in concept discovery during learning. In addition, the teaching materials used in schools still need to integrate technology according to the expectations of 21st-century learning. From several articles above and the actual conditions at school, it can be concluded that misconceptions about momentum and impulse materials were found from 2016 to 2021. The percentage of students' misconceptions is quite large, and the teacher dominates the learning process is still applied in schools.

The use of teaching materials to integrate technology is not widely available, including experiments on momentum and impulse materials. One solution is integrating real experiment video analysis on cognitive conflict-based teaching materials. Real experiment video analysis analyses the recorded results of physics experiment events/activities with the help of tracker software. Tracker software is a video analysis application to find physics concepts through experimental activities (Monalisa 2018). Tracker software is the application of 21st-century technology in physics learning so that students cannot only find concepts and equations of physics but also become technology literate. Previous researchers explained that the advantages of real experimental video analysis are that the concepts and equations of physics can be proven, and the results are in accordance with the theory (Fadholi et al. 2018). Then the physics material will also become more understandable because it is understood contextually.

Cognitive conflict is a situation where a student is faced with concepts/information that conflict with the concepts/information that exists in his cognitive structure (Mufit et al. 2020). Therefore, cognitive conflict is defined as the conflict that arises in one's mind through the observation of a phenomenon in finding a correct concept. The teacher's task is to make students aware of their misconceptions and provide physical phenomena that cause cognitive conflict so that students can finally rebuild scientifically correct concepts. Cognitive conflict-based teaching materials are a support system for cognitive conflict-based learning (CCBL) models, in which the CCBL model is a learning model specially designed by (Mufit & Fauzan 2019) to remediate misconceptions. Several studies have been conducted to develop physics teaching materials based on cognitive conflict (Saputri et al. 2021; Delvia et al. 2021; Luthfi et al. 2021), both in the form of student worksheets (Fadhilah et al. 2020; Hanum et al. 2019), as well as in the form of interactive multimedia IT teaching materials (Anggraini et al. 2022; Aini & Mufit 2022; Dhanil & Mufit 2021; Arifin et al. 2021; Ilahi et al. 2021). The cognitive conflict-based momentum and impulse teaching materials used in this study have been previously developed by (Defrianti et al. 2021), which are valid and practical, but their effectiveness is unknown.

There are four syntaxes in the CCBL model, including the activation of preconceptions and misconceptions, the presentation of cognitive conflicts, the discovery of concepts and equations, and reflection. The integration of real experimental video analysis in cognitive conflict-based teaching materials is through the activity of 'discovering concepts and equations' contained in the three CCBL models' syntax. Improved understanding of concepts is one of the advantages of the CCBL model (Mufit et al. 2020; Viki et al. 2021). Learning with cognitive conflict can improve conceptual understanding, reduce misconceptions, help understand, properly implant new concepts, and be stored in memory (Akmam et al. 2022; Arifin et al. 2021). So, cognitive conflict is very appropriate for constructing students' physics knowledge in learning.

Therefore, it is important to conduct quasi-experimental research on the integration of real experimental video analysis in cognitive conflict-based teaching materials to improve understanding of the concepts of momentum and impulse. This study aims to analyze the effectiveness of teaching materials in improving conceptual understanding. The research question is, "is there an effect on the use of cognitive conflict-based physics teaching materials integrating real experiment video analysis of momentum and impulse material on students' level of conceptual understanding?"

METHODS

This research is a quasi-experimental study with a nonequivalent control group design. The use of a quasi-experimental method by researchers on the grounds that this research subject is human. Therefore, extraneous variables that affect the treatment cannot be tightly controlled, as is typical of quantitative research with pure experimental designs.

O_1	X	O_2
O_3		O_4

FIGURE 1. Nonequivalent Control Group Design Research Design

Information:
O_1&O_3 : initial test (pre test)
O_2&O_4 : final test (post test)
X: treatment, namely the application of cognitive conflict-based physics teaching materials integrating real experimental video analysis

The subjects of this study were high school students, which consisted of two sample classes, namely the experimental class and the control class. The treatment in the experimental class was in the form of applying cognitive conflict teaching materials that were integrated with real experimental video analysis. In the control class, teaching materials were applied in the form of reference books commonly used by schools. Pre test and post test are given to both classes (FIGURE 1). The steps in this study are to apply teaching materials based on cognitive conflict integrated real experiment video analysis. Then in the learning, the teacher organizes students to discover concepts and mathematical equations of the momentum-impulse concept of an object through experimentation. After learning is complete, a posttest is given as concept test questions to determine students' conceptual understanding of the momentum-impulse material. The appearance of the tracker software when analyzing the experimental video can be seen in FIGURE 2.

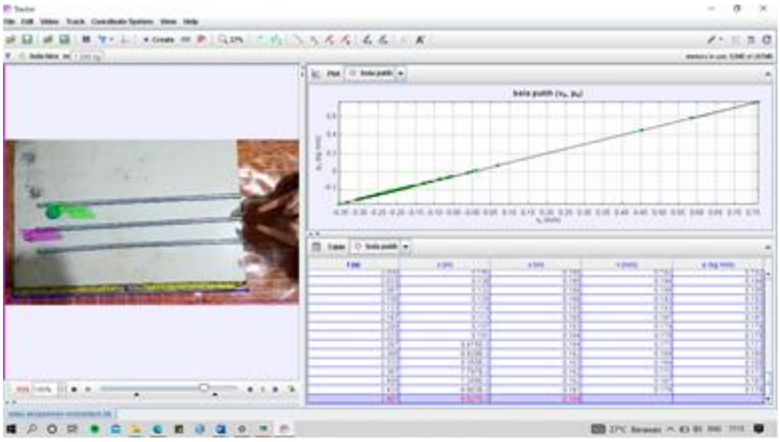


FIGURE 2. Display of Real Experiment Video Analysis Integration Using Tracker Software

The sample consisted of 72 students from two classes X Science at SMAN 5 Pekanbaru and enrolled in the 2021/2022 school year. The sample is part of the population taken to represent part of the research population. Sampling in this study used a cluster random sampling technique. Cluster random sampling is a technique where all population members have the same opportunity to be used as sampling, with the population coming from clusters/groups of individuals, not from individuals. Previous data explains that this technique avoids selecting samples from only one or two characteristics and is also suitable for large enough populations (Gramedia 2021).

The instrument in this study is a concept test on momentum and impulse. Concept test questions in the form of a two-tier multiple-choice diagnostic are equipped with answers to reasons, namely with a combination of objective choice answers, followed by the level of confidence, and ending with a column in the form of reasons for choosing an answer. The two-level multiple choice concept test instrument can be seen in FIGURE 3.

12. A ball with momentum *P* hits the wall and bounces. The collision is perfectly elastic and the direction is perpendicular. The change in momentum of the ball is …
    A. 0
    B. Become 1/2 times (different direction)
    C. Become 1/4 times (different direction)
    D. Become 2 times (different directions)
    E. Become 4 times (different directions)
    Are you sure that your answer is correct?
    a. Very sure b. Pretty sure c. Less sure d. Not Sure

Give reasons for your answer & write down the equation used: ………………………………...
…………………………………………………………………………………………
…………………………………………………………………………………………
……

FIGURE 3. Display of the two-tier multiple choice concept test instrument

The concept tests are made so that the student's conceptual understanding level can be grouped into three categories, as shown in TABLE 1.The level of student understanding can be categorized into three categories, namely the category of students who understand the concept (SU), the category of students who experience specific misconceptions (SM), and the category of students who do not understand (NU) about the concept. The combination of the student's answer choices, the level of confidence, and the reasons for the answers on the concept test instrument will indicate the student's category. Before being used as research instruments, the concept test questions were tested in one class XI MIPA totaling 36 students, to see the validity, reliability, difficulty index, and distinguishing power of the concept test. The concept test has been feasible as a research instrument based on the test results.

TABLE 1. Category of Concepts Understanding with Two Level Diagnostic Test

Option	Confidence	Reason	Category
True	Very sure/ pretty sure	Answer that shows covered all components or at least one of the components of validated answer	Sound Understanding (SU)
True or false	Very sure/ pretty sure	Answer that indicated understanding of a concept, but are also accompanied by statements containing misconceptions. Or Answer that contained illogical or incorrect information	Specific Misconception (SM)
True or false	Less sure/ not sure	Reprised the question; irrelevant answer; or not answered	No Understanding (NU)

(Modified Mufit et al. 2020)

Concept test results data were analyzed using Mann-Whitney test nonparametric statistics, with the help of IBM SPSS Statistics 25. Before being analyzed by the Mann-Whitney test, normality and homogeneity tests were carried out. The basis for making the decision of the Mann-Whitney Test is if the Asymp.Sig value is obtained. (2-tailed) > 0.05, then H_0 is accepted, while if it is obtained otherwise, then H_0 is rejected (Ghozali 2018). Hypothesis testing was conducted to determine whether or not the use of physics teaching materials based on cognitive conflict integrates real experiment video analysis of momentum and impulse materials on the level of understanding of students' concepts.

RESULTS AND DISCUSSION

Results

The test of the effectiveness of teaching materials has been carried out on two sample classes. The experimental class learning uses teaching materials based on cognitive conflict integrated with real experiment video analysis, while the control class uses teaching materials available at school. Before and after learning, the two sample classes were given a concept test, hereinafter referred to as pretest and posttest. The pretest data shows the level of understanding of the initial concepts possessed by the two sample classes before being given treatment, and the posttest data shows the level of understanding of the final concepts possessed by the two sample classes after being given treatment. The plot comparison of students' pretests for the two sample classes is shown in FIGURE 4.

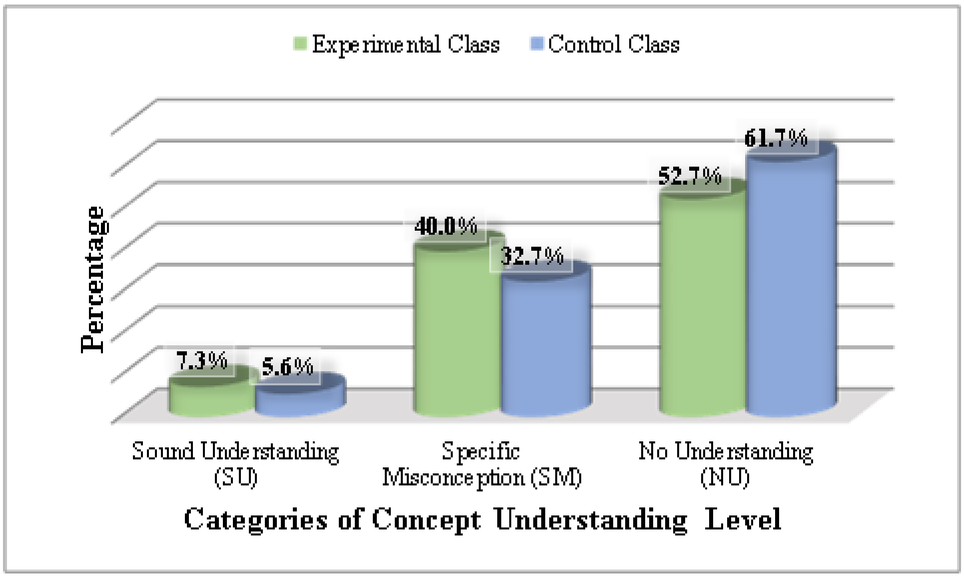


FIGURE 4. Comparison of Pretest Sample Classes in SU, SM and NU Categories

FIGURE 4, when compared directly, we can see that the momentum and impulse materials for the SU, SM and NU categories show that the level of understanding of the two classes is not too different. The difference in the percentage of students in the SU category is only 1.7%, the difference in the SM category is 7.3%, and the difference for the NU category is 9.0%. All percentage differences are below 10%. Of course, this result cannot only be seen on a graphical basis. Statistical tests are necessary to prove that the two sample classes have the same initial ability on momentum and impulse materials. The pretest data in FIGURE 4 obtained, SU and SM categories must be analyzed using the Mann-Whitney test because the prerequisites for the different test has been met, namely, the data is not normally distributed, while for the NU category it must be analyzed using the t-test because the prerequisites for the different test have been met, namely the data is normally distributed. The following analysis results using IBM SPSS Statistics 25 for the SU and SM categories are shown in TABLE 2, while for the NU category in TABLE 3.

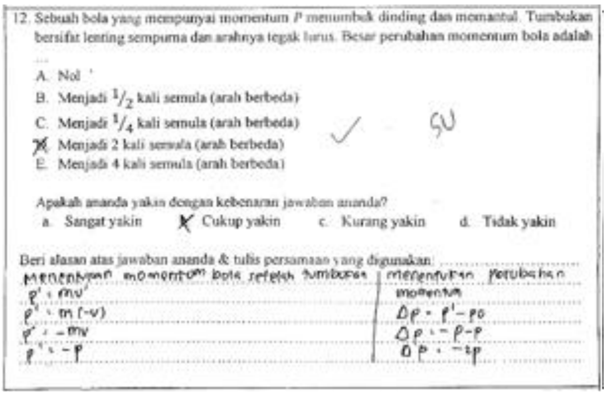
TABLE 2. Mann-Whitney Test Results Pretest SU and SM Categories

No	Aspect	Value	
		P	M
1	Mann-Whitney U	609.000	589.000
2	Wilcoxon W	1312.000	1292.000
3	Z	-0.901	-1.037
4	Sig. Asim. (2-tailed)	0.368	0.300
Information		(2-tailed) > 0.05 H_o accepted	

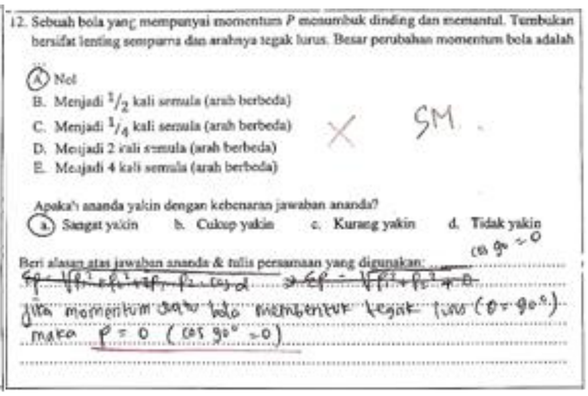
TABLE 3. T-Test Results Pretest for NU category

		F	Sig.	t	df	Sig. (2-tailed)	Information
NU	Equal variances assumed	0.014	0.905	-1.789	72	0.078	(2-tailed) > 0.05 H_o accepted
	Equal variances not assumed			-1.789	71.967		

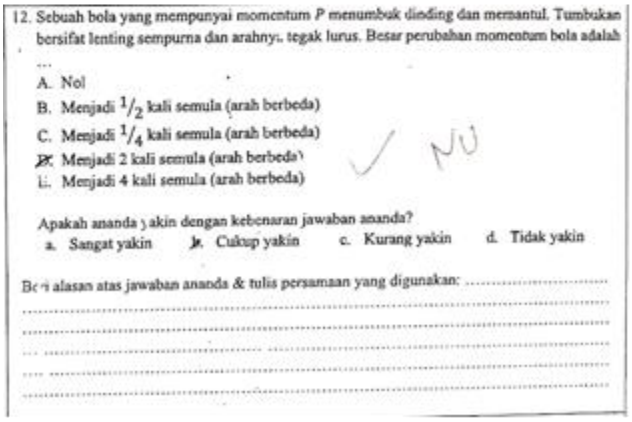
Based on the data of TABLE 2 and TABLE 3, it can be seen that for all categories, the level of understanding, both SU, SM and NU, has a value (2-tailed) smaller than 0.05, so the null hypothesis is accepted. This means that it can be stated that the sample class has the same initial average ability in the SU, SM and NU categories before being given treatment. The following on FIGURE 5 are student answers when working on a concept test which is given.


12. Sebuah bola yang mempunyai momentum P menumbuk dinding dan memantul. Tumbukan bersifat lenting sempurna dan arahnya tegak lurus. Besar perubahan momentum bola adalah ...
A. Nol
B. Menjadi $^1/_2$ kali semula (arah berbeda)
C. Menjadi $^1/_4$ kali semula (arah berbeda)
D. Menjadi 2 kali semula (arah berbeda)
E. Menjadi 4 kali semula (arah berbeda)
SU
Apakah ananda yakin dengan kebenaran jawaban ananda?
a. Sangat yakin b. Cukup yakin c. Kurang yakin d. Tidak yakin
Beri alasan atas jawaban ananda & tulis persamaan yang digunakan:
Menentukan momentum bola setelah tumbukan | menentukan perubahan momentum
$p' = mv'$ | $\Delta p = p' - p_0$
$p' = m(-v)$ | $\Delta p = -p - p$
$p' = -mv$ | $\Delta p = -2p$
$p' = -p$

(a)


12. Sebuah bola yang mempunyai momentum P menumbuk dinding dan memantul. Tumbukan bersifat lenting sempurna dan arahnya tegak lurus. Besar perubahan momentum bola adalah
A. Nol
B. Menjadi $^1/_2$ kali semula (arah berbeda)
C. Menjadi $^1/_4$ kali semula (arah berbeda)
D. Menjadi 2 kali semula (arah berbeda)
E. Menjadi 4 kali semula (arah berbeda)
SM
Apakah ananda yakin dengan kebenaran jawaban ananda?
a. Sangat yakin b. Cukup yakin c. Kurang yakin d. Tidak yakin
Beri alasan atas jawaban ananda & tulis persamaan yang digunakan:
jika momentum suatu bola membentuk tegak lurus ($\theta = 90°$)
maka $p = 0$ ($\cos 90° = 0$)

(b)


12. Sebuah bola yang mempunyai momentum P menumbuk dinding dan memantul. Tumbukan bersifat lenting sempurna dan arahnya tegak lurus. Besar perubahan momentum bola adalah ...
A. Nol
B. Menjadi $^1/_2$ kali semula (arah berbeda)
C. Menjadi $^1/_4$ kali semula (arah berbeda)
D. Menjadi 2 kali semula (arah berbeda)
E. Menjadi 4 kali semula (arah berbeda)
NU
Apakah ananda yakin dengan kebenaran jawaban ananda?
a. Sangat yakin b. Cukup yakin c. Kurang yakin d. Tidak yakin
Beri alasan atas jawaban ananda & tulis persamaan yang digunakan:

(c)

FIGURE 5. Sample answer sheets of students who sound SU, SM and NU

In FIGURE 5, you can see examples of the answers of several students belonging to the SU, SM and NU categories for the same question. The question is as follows. For FIGURE 5 (a), the student chooses the correct answer option, the level of confidence is sure, and the reason is in accordance with the complete concept. Therefore, the level of understanding of the student is in the category of Sound Understanding (SU) for the question. For FIGURE 5 (b), students choose the wrong answer option, the level of confidence is sure, and the reason contains wrong information. Therefore on the question, the level of students' understanding is in the category of Spesific Misconceptions (SM). For FIGURE 5 (c), the student chooses the correct answer option, the level of confidence is sure, and does not answer the reason column, so the student is in the category of No Understanding (NU) the concept for the question.

Because the sample class has the same ability/level of understanding of the initial concept, the data on the effectiveness of teaching materials is taken only from posttest data. Of course, the student posttest comparison plots for the two sample classes are shown in FIGURE 6.

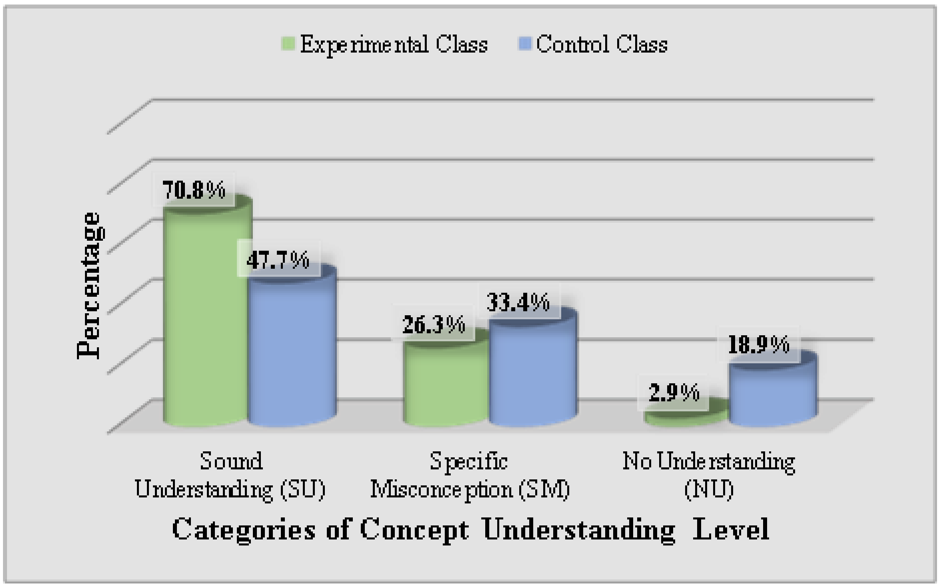


FIGURE 6. Comparison of Posttest Sample Classes in SU, SM and NU Categories

From FIGURE 6, when compared directly, we can see that the momentum and impulse materials for the SU, SM and NU categories show that the experimental class is superior to the control class with a difference of about 23.1%, 7.1%, and 16%. These results show that the experimental class is 23.1% superior in improving students' conceptual understanding and 7.1% superior in remediating students' misconceptions compared to the control class. From the posttest data obtained in FIGURE 6, it must be analyzed using the Mann-Whitney test because the prerequisites for the different tests have been met; namely, the data is not normally distributed. The following analysis results using IBM SPSS Statistics 25 for the SU, SM and NU categories are shown in TABLE 4.

TABLE 4 . Mann-Whitney Test Results Posttest SU, SM and NU Categories

No	Aspect	Value		
		P	M	TP
1	Mann-Whitney U	134.500	419.000	288.500
2	Wilcoxon W	837.500	1122.000	991.500
3	Z	-6.009	-2.930	-4.781
4	Sig. Asim. (2-tailed)	0.000	0.003	0.000
	Information	Sig. Asim < 0.05 H_0 rejected		

Based on TABLE 4 it can be seen that for all categories of understanding levels, both understanding the concept (SU), misconceptions (SM), and not understanding the concept (NU) have asymptotic significance values (Sig. Asim.) <0.05 which is in the rejection area of H_0 or acceptance of H_a . So that the research results show that there is an effect of using physics teaching materials based on cognitive conflict integrating real experiment video analysis of momentum and impulse materials on the level of understanding of students' concepts.

Discussion

Based on the results of hypothesis testing, it can be seen that there is an influence of teaching materials on the level of understanding of students' concepts. Cognitive conflict-based teaching materials integrated with real experiment video analysis have been effective in improving students' conceptual understanding. Effectiveness is indicated by the rejection of the hypothesis test, the increasing percentage of understanding the concepts of the experimental class, the decreasing percentage of misconceptions in the experimental class, and the decreasing percentage of students not understanding the concepts of the experimental class. The level of understanding of students' concepts is superior when using teaching materials based on cognitive conflict integrating real experiment video analysis compared to using teaching materials from schools. Other studies also analyzed incident videos with trackers, including (Fadholi et al. 2018) using a tracker on impulse-momentum material, and the results can improve students' critical thinking skills. The previous study use a tracker on viscosity of material, and the results can be determined the viscosity of nira water (Islami et al. 2021). Another study uses a tracker on heat material, and the results get accurate results of measuring the coefficient of thermal expansion so that an experimental set has been developed (Yogaswara 2018). Besides, using a tracker on oscillatory motion material, the results can motivate students and stimulate independent investigations like scientists (Trocaru et al. 2020). Based on this, it means that the use of a tracker is suitable and feasible to use in physics learning with its advantages that it can improve understanding of concepts, prove concepts according to theory, motivate students, and encourage students to conduct independent investigations like scientists.

The treatment using teaching materials based on cognitive conflict, real experiment video analysis, momentum and impulse materials provides a real experience for students to conduct experiments like a scientist and are required to conclude the experiment. According to previous research (Mufit & Fauzan 2019), students who use cognitive conflict-based teaching materials are given the opportunity to think more deeply, build ideas, reconstruct new knowledge and give birth to new concepts that are in accordance with scientific concepts. The real experimental video analysis applied in the CCBL model has the potential to increase conceptual understanding and remediate students' misconceptions about the topic of motion (Mufit et al. 2019). As we know, momentum and impulse are physics concepts of motion. In line with this, in the research of (Mufit et al. 2018; Dhanil & Mufit 2021), it was also found that the cognitive conflict-based teaching materials they developed were effective in increasing students' understanding of concepts. In addition, the existence of teaching materials makes it easier for students to understand the material in learning physics. Therefore, the researcher highly recommends these teaching materials for students to use as alternative teaching materials to improve their understanding of concepts in the 21st-century.

CONCLUSION

This research can be concluded that there is an influence of teaching materials on the level of understanding of students' concepts. The use of cognitive conflict-based teaching materials integrated with real experiment video analysis is effective for improving conceptual understanding of students, this is evidenced by H_0 being rejected in the Mann -Whitney test. The researcher highly recommends that this teaching material can be an alternative teaching material used by physics teachers in the learning process of momentum and impulse material in the classroom because the teaching material is based on cognitive conflict. This can improve students' understanding of concepts. To other researchers, in order to conduct further research using cognitive conflict-based teaching materials and apply them to different learning materials.

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