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The Implementation of Problem Based Learning (PBL) Assisted by Video on Momentum and Impuls Material to Improve Students Critical Thinking Abilities

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Abstract: Problem-based learning is a student-centered educational method that aims to develop problem-solving, self-directed learning and teamwork also critical thinking abilities of students. This study aims to determine the effectiveness of applying the Problem Based Learning (PBL) model on momentum and impuls material in improving students critical thinking abilities. This research was conducted using the action research method which was divided into four stages and three learning cycles and also a single case study descriptive research with a critical thinking abilities test instrument. The results of the increasing critical thinking abilities test were analyzed using the N-gain test and paired sample t test. The test results showed that there was an increase in students critical thinking abilities with N-gain score is 0.46 and 0.56 in medium criteria and paired t-test results with a significance level of 5% = 0.000 < 0.05 which shows that there is a different level of critical thinking abilities of students before and after the implementation of the PBL. So, based on these results, it can be concluded that the implementation of the video-assisted Problem Based Learning (PBL) model assisted by videos can improve students critical thinking abilities on momentum and impuls material.

Keywords: Critical thinking abilities; PBL; Video

Introduction

Problem-based learning is a student-centered educational method that aims to develop problem-solving through self-directed learning and teamwork abilities (Ali, 2019; Foo et al., 2021). Some of the advantages of this model are that it makes learning useful for education, encourages and motivates learning, engages students in learning that is similar to the real world (Susilawati & Doyan, 2023). Students in PBL classes can improve a variety of abilities especially social and also their critical thinking as they have more opportunities to practice using language for authentic communication. In the 21st century, students should be proficient in critical thinking and problem-solving, creativity and invention, communication, and collaboration (Widiandari & Redhana, 2021). Critical thinking abilities are must be improved for students to survive at the global level (Puig et al., 2020).

Problem Based Learning is a relevant learning model within the Indonesian curriculum because it is a student-oriented learning system (Demirel & Dağyar, 2016). The Problem Based Learning (PBL) model has stages or syntax, which directs students to think, analyze, research, and prepare research reports (Y. I. Sari et al., 2021). Next is the core of the PBL model, namely the investigation phase which is carried out independently or in groups. The next phase of the PBL model is developing and presenting work. The syntax increases students motivation to present their work in front of other study groups well so that competence examines the problems in on-going learning (Herawati & Wilujeng, 2023). Students can develop complex abilities, especially their critical thinking abilities and

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learning independence through the syntax of PBL (Prahani et al., 2022; Sugiharto et al., 2019).

Critical thinking abilities measured in this study, namely making simple explanations, building basic skills, making inferences, further clarification, developing strategies and tactics (Reynders et al., 2020). These abilities can help students to deal effectively with social, scientific and practical problems. These abilities also play an important role in students learning success (Anggraeni et al., 2023; Halpern & Butle, 2019). Therefore, these abilities can be integrated into the learning process through practice (Hyytinen et al., 2019; Von Colln-Appling & Giuliano, 2017). In this study, students critical thinking abilities are enhanced through video-assisted exercises of momentum and impuls problems related to daily life. The success of students in learning is influenced by the main role, namely critical thinking abilities, especially in learning physics (Mahanal et al., 2019).

Teachers need to provide learning media that can help students to understand the subject material (Azairok & Fathurohman, 2023; Latumakulita et al., 2023; Mahuze et al., 2022). One of the things that teachers can do to make learning fun and increase student learning motivation is to use learning media (Doyan et al., 2022; Rachmavita, 2020). There are many learning media that can be used by teachers, such as books, modules, videos, websites, experimental tools, virtual simulations and others (Malik et al., 2023; Zuhdi et al., 2022). However, to bring up students' critical thinking, teachers can use learning media, namely by showing an introductory video before explaining the material. In this study, the video that triggers students to think about the introduction of momentum and impulse material (Kurdi et al., 2020). Momentum and impuls material are subchapters in the Dynamics of Motion in the 11th grade Phase F Merdeka Curriculum. The learning objective of momentum and impuls in this curriculum is to apply the concepts to everyday life (Yuberti et al., 2019). Therefore, it requires critical thinking abilities from students in learning this material so that the concepts learned can be applied in life (Manuaba et al., 2022; Sulhan et al., 2023).

The concept of momentum and impuls at the high school level tends to teach a lot of formulas, but the concept is still very lacking (Ntobuo et al., 2023; Sukmadewi & Jumadi, 2023). So consequently students will pay more attention to formulas than concepts or their nature (Mahardika et al., 2020). The media that can increase students learning motivation and critical thinking abilities is a learning video about momentum and impuls material (Susilawati et al., 2022; Yulianci et al., 2021). The first video contains a comparison of the mass of two cars that are the same, but have different speeds, the second video explains the law of conservation of momentum with a case study of balls colliding and producing perfect collisions. The third video explains the change in momentum (impuls) that occurs when an object is dropped onto two different planes.

The critical thinking abilities of students in physics learning, especially momentum and impuls material are still very lacking, even though there are so many questions that students can ask the teacher related to the material because it has a lot to do with life (Ma et al., 2023; Taimur & Sattar, 2020). This weakness of critical thinking abilities makes researchers interested in improving it using the video-assisted Problem Based Learning model.

The Problem Based Learning model allows students to have and develop students critical thinking abilities through challenging questions or problems (Hikmawati et al., 2020; Wasyilah et al., 2021). With this model, students also work together to build their own knowledge, construct ideas, think critically in analyzing problems, then try to solve them by discussing and exploring their learning abilities (Astriani et al., 2023; Ilfiana et al., 2021). Video assistance is also expected to spark critical thinking in students who will raise questions about the application of momentum and impuls material in life.

This research is important because it is based on the fact that high school graduates in Indonesia are still relatively weak in critical thinking abilities and working together with each other (Astra et al., 2019; Wale & Bishaw, 2020). Therefore, this study aims to improve students critical thinking abilities, especially on momentum and impuls material using the Problem Based Learning model assisted by video.

Method

This research was conducted at Senior High School 65 Jakarta, Indonesia. The subjects in this study were students of class 11-3 totaling 36 consisting of 16 male and 20 female students. The method used was classroom action research developed by Hopkins in 1993 (Ningrum, 2014). This research consists of four indicators of stages, namely planning, implementation, observation, reflection and is divided into three cycles to see the development of students learning.

Problems will arise after conducting the reflection indicator stage which includes synthesis and analysis in the first cycle (Evendi & Verawati, 2021; Prihandono et al., 2023). Therefore, it is necessary to repeat the four stages mentioned earlier to become the second and third cycles until it is considered that the problem in students is over (Collett et al., 2021).

Then, this study also used a one-group pretest-posttest design (Fidan & Tuncel, 2019). In this design, researchers measured students critical thinking abilities by giving a pretest before the momentum and impuls material was explained. Furthermore, this study uses a sampling technique, namely purposive sampling with instruments in the form of teaching modules for the Phase F Merdeka Curriculum, videos related to momentum and impuls, and questions related to critical thinking abilities used for pretest-posttest.

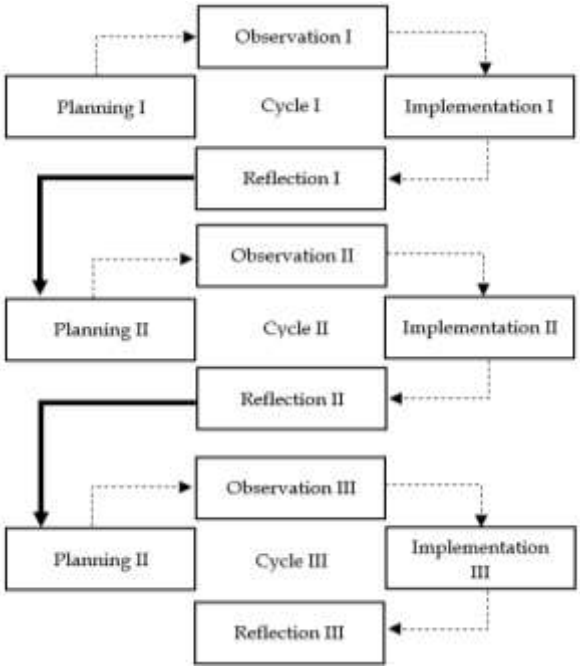

Figure 1. Hopkins' cycle of classroom action research

Data from the pretest-posttest results were analyzed using the N-gain value. The N-gain value serves to determine the improvement of students critical thinking abilities after applying the video-assisted Problem Based Learning model on momentum and impuls material. The N-gain values obtained were then interpreted in accordance with those in Table 1. In addition, the pretest-posttest data were tested for normality and homogeneity as one of the statistical tests using IBM SPSS software (Abu-Bader, 2021; Pallant, 2020).

Table 1. N-gain Criteria

N-gain	Criteria
$g > 0.7$	High
$0.3 < g \leq 0.7$	Medium
$g \leq 0.3$	Low

Result and Discussion

Cycle I Learning Action
Planning I

Before implementing cycle I learning, teachers prepare teaching modules, learning tools, videos that will be shown, and pretest-posttest questions to see the critical thinking abilities of students for the first time.

Implementation I

This first cycle began on October 9, 2023 in class 11-3 SMA Negeri 65 Jakarta, Indonesia. This cycle of learning uses the Problem Based Learning (PBL) model which consists of 3 lesson hours x 45 minutes. The learning actions carried out by the teacher in the classroom based on the stages of the PBL model are as follows:

Orienting Students to the Problem

The teacher pretests the students on the concept of momentum, especially on the mass and speed of vehicles. Then, after carrying out the pretest, students are given a video to spark questions that generate critical thinking (Kawuwung & Mamahit, 2023).

Figure 2. Comparison of the mass of two cars that are the same, but have different speeds

Organizing students

The teacher directs students to discuss and analyze the problems in the video.

Observation I
Guiding individual or group investigations

At this stage, many students began to ask questions about the concept of momentum and impuls from the video that had been presented.

Figure 3. The teacher guides the discussion and analysis of the momentum concept that students are investigating

Helping students to develop and present work

After guiding discussions to solve problems and build critical thinking skills, the teacher helps students to develop the work they have made in the form of discussion result sheets and at the next stage it is presented verbally, namely representatives of students convey the strategies and tactics they have systematically arranged (Kasli et al., 2022).

Helping students to analyze and evaluate the problem-solving process

At this stage students present their work, then the teacher confirms and corrects any errors regarding the concept of momentum that students interpret based on the video.

Reflection I

After carrying out the stages or syntax based on problem-based learning, the teacher then evaluates the cycle I. Then, researchers conducted this stage after observing student learning activities in cycle I, then planned the learning stages for cycle II.

Cycle II Learning Action

Planning II

Before implementing cycle II learning, teachers prepare again teaching modules, learning tools, videos that will be displayed, and test questions to see the development of students critical thinking abilities. This is almost the same as what was done in cycle I.

Implementation II

This cycle was held on October 11, 2023 in class 11-3 SMA Negeri 65 Jakarta, Indonesia. This cycle of learning uses the Problem Based Learning (PBL) model which consists of 2 lesson hours x 45 minutes. The learning actions carried out by the teacher in the classroom based on the stages of the PBL model are as follows:

Orienting students to the problem

Figure 4. The law of conservation of momentum with a case study of balls colliding and producing perfect collisions

At this stage, the teacher does the same thing as the previous cycle, namely giving students a pretest to find out the initial understanding of the law of conservation of momentum. Then, the teacher again provides problems sourced from different videos from cycle I to students about the law of conservation of momentum.

Organizing students

The teacher again directs learners to discuss and analyze the problems in the video.

Observation II

Guiding individual or group investigations

The teacher again guides the students discussion activities so that they can make inferences, make further clarifications, strategize and tactics so that critical thinking characters are formed (Tanta et al., 2023).

Helping students to develop, present work and evaluate the problem-solving process

The teacher again guides and triggers students to be able to make inferences, make further clarifications, develop strategies and tactics for learning the material of the law of conservation of momentum based on the video that has been given.

Figure 5. One of the students representatives presents the results of his teamwork and discussion in front of his friends

At this stage students present their work, then the teacher confirms and corrects any errors regarding the

law of conservation of momentum that students interpret based on the video.

Reflection II

After carrying out activities in cycle II, the teacher again conducted a posttest to measure the development of students critical thinking about the material of the law of conservation of momentum after being assisted by the video. Researchers conducted this stage after observing student learning activities in cycle II, then planned the learning stages for cycle III (Susetyarini et al., 2023; Sutri & Islami, 2023).

Cycle III Learning Action

Planning III

Cycle III is the last learning action and the teacher still prepares various teaching material, especially videos that contain problems to be analyzed by students. This cycle determines the success of the application of the Problem Based Learning (PBL) model in class 11-3 SMA Negeri 65 Jakarta, Indonesia.

Implementation III

This cycle was conducted on October 16, 2023 in class 11-3 SMA Negeri 65 Jakarta, Indonesia. This cycle of learning uses the Problem Based Learning (PBL) model which consists of 3 lesson hours x 45 minutes. The learning actions carried out by the teacher in the classroom based on the stages of the PBL model are as follows:

Orienting students to the problem

At this stage, the teacher does the same thing as the previous cycle, namely giving students a pretest to find out the initial understanding of change in momentum (impuls) (Khairani & Prodjosantoso, 2023; Nugroho et al., 2023).

Figure 6. Change in momentum (impuls) that occurs when an object is dropped onto two different planes

Organizing students

The teacher again directs learners to discuss and analyze the problems in the video.

Observation III

Guiding individual or group investigations

The teacher again guides the students discussion activities so that they can create simple explanation, build basic abilities, make inferences, make further clarifications, strategize and tactics so that critical thinking characters are formed (Putri et al., 2023).

Helping students to develop and present work

The teacher again guides and triggers students to be able to create work that will be presented in front of the class based on indicators of critical thinking abilities for learning the material of the change in momentum (impuls) based on the video that has been given (Rahayu Fitri et al., 2023; Wahyuni & Fajrina, 2023).

Helping students to analyze and evaluate the problem-solving process

At this stage students present their work, then the teacher confirms and corrects any errors regarding the change in momentum (impuls) that students interpret based on the video.

Reflection III

After carrying out activities in cycle III, the teacher again conducted a posttest to measure the development of students critical thinking about the material of the change in momentum (impuls) (Luo et al., 2022). Researchers conducted this stage as an effort to evaluate and analyze the improvement of students abilities to think critically in cycles I and II (R. A. Sari et al., 2023). Researchers applied the Problem Based Learning (PBL) model based on its stages (syntax) along with three cycles, then obtained learning results as shown in Table 2 below.

Table 2. Average Value of Critical Thinking Indicators

Critical thinking abilities indicators	Cycle I	Cycle II	Cycle III
Creating a Simple Explanation	59.17	76.56	88.90
Building basic abilities	57.38	76.00	90.80
Making inferences	56.00	76.22	89.55
More clarifications	57.41	79.13	90.77
Developing Strategy and Tactics	59.61	79.97	91.55
Average value	57.91	77.58	90.31

Based on the results obtained in table 2, there is an increase in the critical thinking abilities average value of students in each indicator. The video-assisted Problem Based Learning (PBL) model makes students more active in solving problems given by the teacher, especially on momentum and impuls material. Table 2 can also be depicted as a bar chart as shown in Figure 7.

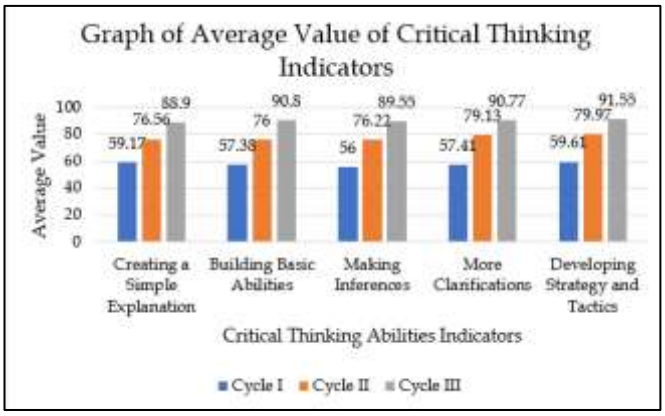

Figure 7. Bar chart of the average value of students critical thinking abilities

Validation Result

The learning tools used in these three cycles were validated by experts as shown in Table 3.

Table 3. Results of Validation of Learning Tools and Research Instruments

Type	Category
Teaching modules	Very valid
Video	Very valid
Pretest-posttest questions	Valid

Table 3 presents the validity of the tools used in the study with a very valid category for the teaching modules and video and a valid category for the critical thinking skills pretest-posttest questions. This means that the learning devices and research instruments are eligible for use (Clark & Watson, 2019).

Normality, Homogeneity, Paired Sample t-Test Results

The significance of the increase in students critical thinking abilities was measured through the normality test of the data processed using IBM SPSS software. Based on table 4, the results obtained from the Shapiro-Wilk normality test (data less than 50) using a significance level of 5% resulted in sig = 0.21 > 0.05. These results indicate that the data is normally distributed. After the normality test, the researcher conducted a homogeneity test with a significance level of 5% and produced sig = 0.37 > 0.05. The test results show that the data is homogeneous (Liang et al., 2019). Furthermore, a paired t-test was conducted with a significance level of 5% = 0.000 < 0.05 which showed that there was a level of difference in the critical thinking abilities of students before and after the application of the Problem Based Learning model on momentum and impuls material assisted by video (Adhelacahya et al., 2023; Syuzita et al., 2023).

Table 4. Normality, Homogeneity, and Paired Sample t-Test Results

Normality	Homogeneity	Paired t-test
Sig 0.21 > 0.05	Sig 0.37 > 0.05	Sig 0.000 < 0.05

Improving Students Critical Thinking Skills through the Implementation of video-assisted Problem Based Learning (PBL) on Momentum and Impuls Material

N-gain can be calculated with the following formula:

$$N\ gain = \frac{Postest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ Score} \quad (1)$$

Note: Ideal Score is the maximum score that can be achieved by students.

Based on Table 5, the average score of the pretest in cycle I-II was 57.91, and while the posttest was 77.58. In the cylce II-III was 77.58, while the posttest was 90.31. The pretest and posttest results of all students were then analyzed using the N-gain test to determine the increase in students critical thinking abilities after implementing Problem Based Learning (PBL) on momentum and impuls material assisted by video.

Table 5. N-gain Score of Critical Thinking Abilities Based on Average Pretest-Postest in Cycle I to III

Cycle	Average pretest	Average posttest	N-gain	Criteria
I – II	57.91	77.58	0.46	Medium
II – III	77.58	90.31	0.56	Medium

Conclusion

Based on the results obtained in the three cycles, it can be concluded that the critical thinking abilities of students can improve by implementing the video-assisted Problem Based Learning (PBL) model on momentum and impuls material.

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Author Contributions

Conceptualization, I M. A.; H. K.; Y. R.; methodology, I M. A.; validation, Y. R.; formal analysis, H. K.; investigation, H. K., and Y. R.; resources, P. M. Z. and T. R.; data curation, H. K.; writing—original draft preparation, H. K.; writing—review and editing, I M. A. and Y. R. visualization, H. K. and Y. R. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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