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The Impact of the Learning Cycle Model on Understanding the Concepts of Momentum and Impulse

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Abstract: This study aims to determine the impact of the Cycle Learning model toward understanding the concept of momentum and impulse. The study used a quantitative approach, quasi-experimental methods and a non-equivalent pretest-posttest control group design in two classes of high school students as the research sample. Data collection was carried out using a physics concept understanding test (PCUT) and data analysis using the t-test at a significance level of 0.05 to find out the difference between the control class and the experimental class. The results of the data analysis show that: The Learning Cycle 7e model has an effect on increasing understanding of concepts. The 7E Learning Cycle model is better than conventional techniques from the aspect of increasing understanding of concepts. The level of conceptual understanding through the Learning Cycle 7e model is obtained by the level of complete understanding (LCU), while conventional techniques are only obtained by the level of partial understanding (LPU). The application of the Learning Cycle 7e learning model in learning is proven to be able to influence students' conceptual understanding skills for the better.

Keywords: Concept Understanding; Concept Understanding Level; Learning Cycle 7e

Introduction

Education is very important in preparing the younger generation to face developments in the Industrial Revolution 4.0 era. Therefore, education must be implemented as well as possible to improve the quality of Human Resources. According to Law No. 20 of 2003 article 1 paragraph 1 concerning the National Education system (UUSPN) states: that, "Education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble morals, and skills needed by himself, society and the country." Learning activities can be carried out well and systematically if they refer to an appropriate learning model.

A learning model is a conceptual framework that describes systematic procedures in organizing learning experiences to achieve learning goals and functions as a guide in planning and implementing learning activities (Titu, 2015). Learning models have the following characteristics: 1) Based on educational theory and learning theories from certain experts. 2) Have a specific educational mission or goal. 3) Can be used as a guide for improving teaching and learning activities in the classroom, 4) Has model parts called: a. sequence of learning steps; b. the existence of reaction principles; c. social system; d. support system. 5) Has an impact as a result of applying the learning model. 6) Make teaching preparations (instructional design) with guidelines for the learning model chosen (Mirdad, 2020). Various learning models have been used during the learning process, including Problem Based Learning, Project Based Learning, cooperative learning, and Learning Cycle learning models. Each learning model has its advantages and disadvantages.

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The Learning Cycle is a model that has a series of organized activities (stages) so that students can master the competencies that must be achieved during the learning process. This model is a constructivism-based learning model and emphasizes the importance of the student process in discovering important concepts through active student involvement in the learning process (Febriana & Arief, 2013). Apart from being based on constructivism, the learning cycle is in accordance with Piaget's learning theory, known as Piaget's theory of cognitive development. Abraham (1992) stated that, "the learning cycle model is derived from constructivist ideas of the nature of science, and the development theory of Jean Piaget". (Adilah & Budiharti, 2015).

The development of the learning cycle was carried out 32 years ago by J. Myron Atkin, Robert Karplus and the SCIS (Science Curriculum Improvement Study) Class, at the University of California, Berkeley, United States since the 1970s (Subroto & Karimah, 2014). Initially the learning cycle consisted of 3 phases, namely the exploration phase, concept introduction (concept introduction), and concept application (application introduction). Then it was further developed into 5 phases, known as 5E, namely Engagement, Exploration, Explanation, Elaboration/Extention, and Evaluation (Farina, 2019). This model continued to develop until it was developed by Arthur Eisenkraft into 7 stages, adding the Elicit and Extend phases (Ayudhita et al., 2022). The 7E learning cycle model is a learning model that consists of seven learning phases, namely: Elicit (elicit), Engage (involve), Explore (investigate), Explain (explain), Elaborate (elaborate), Evaluate (assess), and Extend (expand) (Utami et al., 2022).

The advantages of the 7E learning cycle learning model according to (Adilah & Budiharti, 2015) are 1. Students are actively involved in the learning process and are able to learn material meaningfully by working and thinking, creatively and responsibly. 2. Increase students' motivation to be more active and increase their sense of curiosity. 3. Helps develop students' scientific attitudes. 4. New information is linked to schemes that students already have. The new information that students have comes from the students' own interpretations. 5. Train students in discovering concepts through direct activities such as experiments and train students to convey the concepts they have learned orally.

The weaknesses of the 7e learning cycle learning model according to Soebagio (2000) quoted in (Adilah & Budiharti, 2015) include: 1. The effectiveness of learning is low if the teacher does not master the material and learning steps. 2. Requires seriousness and creativity from teachers in designing and implementing the learning process 3. Requires more planned and organized classroom management 4. Requires more time and energy in preparing plans and implementing learning.

To overcome the weaknesses of this model, teachers can allocate time as efficiently as possible, with the material presented not being too extensive so that all stages in the 7E learning cycle can be achieved. Another thing that needs to be considered is that when using this model there is a need to consider the subject matter, allocation of available time and supporting facilities so that learning can take place effectively (Adilah & Budiharti, 2015).

The results of applying the 7e learning cycle model show that this learning model is able to improve critical thinking skills (Iman et al. 2022), science process skills (Andaru, Sentosa & Septian, 2019), cognitive abilities (Alqudsi, 2020), increase motivation and learning outcomes (Candra, 2017) and understanding of physics concepts (Rafiqah et al., 2019).

Comprehension is a cognitive ability to obtain meaning from the material that has been studied (Prasetyarini et al., 2013). Concepts are the result of each individual's thoughts expressed through definitions, laws and theories (Azizah et al., 2020). Understanding concepts is the ability to understand and comprehend a concept and interpret the material studied well and requires adaptation of knowledge (Ramadani, & Nana, 2020). Understanding concepts is important during the learning process because understanding concepts is a stage in understanding abstract information, where in the process of understanding you have to classify an object or phenomenon (Hikmah et al., 2017). Increasing understanding of concepts can be done through the guided inquiry method, according to (Kurniawan, 2013). Biology science learning at SMP N 3 Kubu Raya using the guided inquiry method can improve students' understanding of concepts, especially class VIII students. In the first cycle, a classical completeness score of 78 was obtained. .05% and in cycle II it was 97.56%. Meanwhile, according to Lisma et al. (2018), the increase in students' understanding of concepts after applying the LC 7E model to heat material in class X experienced an increase with an N-gain of 0.78 in the high category.

Based on a questionnaire via Google Form with one of the physics teachers at SMA Negeri 1 Pangkalan Susu, it was stated that during the learning process only a small number of students took an active role, such as asking questions or opinions. Apart from that, students think that physics is just a collection of complicated formulas, so students have difficulty understanding physics concepts. Based on the problems above, the researcher applied the Learning Cycle 7E model to increase students' understanding of concepts at SMA Negeri 1 Pangkalan Susu.

Understanding Concepts is the ability to grasp understanding such as the ability to express material presented in a form that is easier to understand, able to interpret and able to apply it (Andriyani & Prihandono, 2017). In this research, understanding the concept in question is knowing the increase in understanding of the concept in the subject of impulse momentum at a certain level obtained by students after being taught using the Learning Cycle 7E model. Indicators of the level of understanding of the concepts used in this research are Explaining Momentum and Impulse Phenomena (C2), identifying physical phenomena (C1), Exemplifying Momentum and Impulse Phenomena (C2) and Defining Momentum and Impulse Concepts (C1). The categories of level of understanding the concept used in this research are MSU (Complete Understanding), namely the answer given reflects all aspects and is completely correct, MSB (Partial Understanding), namely the answer given contains all the expected aspects but not all of them are correct, MSK (Understanding Wrongly). i.e. the answer does not comply with the concept of impulse momentum, TMH (Does Not Understand) i.e. the answer given is not clear and TMJ (Doesn't Answer) i.e. does not provide an answer.

The phenomenon or new information that is expected to be obtained through this research is the effectiveness of the Learning Cycle Model in increasing students' understanding, not only being able to understand and define each concept, but also being able to understand the relationship between concepts. This is one of the main objectives of the research that has been carried out and resulted in this article.

Method

The research method used in this research is the Quasi Experimental design method with a quantitative approach. This research involved two classes, namely the control class and the experimental class. The control class is a class that does not receive treatment applying the Learning Cycle 7E model, while the experimental class is a class that receives treatment applying the Learning Cycle 7E model. The use of this method is based on ensuring that learning research takes place naturally and students do not feel like they are being experimented on, so that this situation is expected to contribute to the level of validity of the research (Junaedi, 2013). The design used was a non-equivalent pretest-posttest control group design. In this design, the experimental and control classes are chosen randomly, after ensuring that both classes have the same cognitive abilities. The initial stage of different cognitive ability tests for sample selection uses the t-test formula. The independent sample t-test is a statistical test used to determine whether there is a significant difference between the averages of two independent groups (Palupi, R 2021). According to (Sudijono, A. 2011) the non-equivalent pretest-posttest control group design is shown in Table 1.

Tabel 1. Desain non-equivalent pretest-posttest control group design

Class	T1	Treatment	T2
Experiment	0_1	X_1	0_2
Control	0_1	X_2	0_2

The population in this study were all students of class X MIA SMA Negeri 1 Pangkalan Susu T.A 2022/2023. Sampling in this study used the independent sample t-test, obtained a sig (2-tailed) of 0.71, meaning there was no significant difference in learning outcomes, so class X MIA 3 was the experimental class sample using the Learning Cycle 7E model, and class X MIA 1 as a control class with a conventional learning model.

The instrument in this research uses a concept understanding test. Concept understanding tests are used to measure students' understanding of the material provided. The test given is in the form of a description test consisting of 12 pretest-posttest questions on the subject of impulse and momentum. The questions in the concept understanding test include indicators of explaining, identifying, exemplifying and defining. To determine whether the data in both classes are normally distributed or not, researchers use the Chi-Square formula:

$$\chi^2_{count} = \sum \frac{(f_0 - f_h)^2}{f_h} \quad (1)$$

To determine the similarities between two conditions or populations, researchers use a homogeneity test with the formula:

$$F_{count} = \frac{biggest\ variant}{smallest\ variant} \quad (2)$$

To determine significant differences between two samples, researchers used the t-test with the formula:

$$t_{count} = \frac{\overline{X_1} - \overline{X_2}}{S_{gab}\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \quad (3)$$

To determine the effectiveness of increasing conceptual understanding in both samples, the n-gain test was used:

$$g = \frac{quick\ posttest - pretest\ score}{Maximum\ score - pretest\ score} \quad (4)$$

Table 2. N-Gain Criteria

g score	Category
$g \geq 0.70$	Tall
$0.30 \leq g < 0.70$	Currently
$g < 0.30$	Low

Source: Hake (1998)

Based on the n-gain criteria Table 2. To measure the level of conceptual understanding, both pretest and posttest are classified based on the level of conceptual understanding which refers to the assessment rubric developed by Abraham (1992) as follows. The flow of this research in a Figure 1.

Table 3. Level of understanding and assessment rubric

Concept Understanding Level	Answer Criteria
Didn't Answer (TMJ)	Didn't give an answer.
Not Understanding (TMH)	The answers given are unclear and do not match the questions given.
Misunderstanding (MSK)	The answer does not match the physics concepts in the material taught
Partial Understanding (MSB)	The answer is only correct in one aspect, other aspects are not given answers.
Complete Understanding (MSU)	The answers given contain all the expected aspects, but not all of them are correct

Source: Abraham (1992)

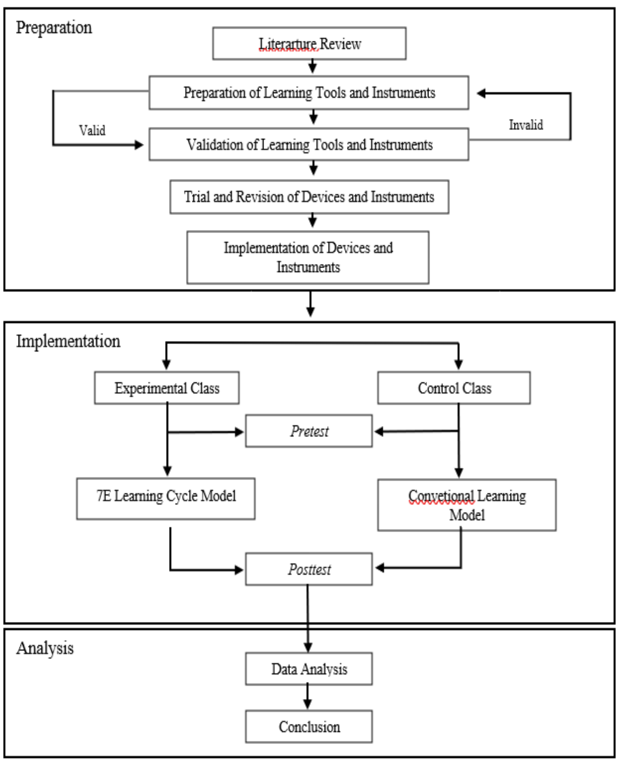

Figure 1. Flow diagram used in this research

Result and Discussion

The results of normality and homogeneity tests carried out in both classes based on the average value and standard deviation, it was obtained that the experimental class using the Learning Cycle 7E model obtained a value of $(\bar{X}_1) = 49.97$ and $S_1 = 8.31$, in the control class using conventional learning model obtained a value of $(\bar{X}_2) = 41.20$ and $S_2 = 8.49$. Based on the data distribution of experimental class and control class values, it was found that both data were normally distributed and homogeneous.

Based on the results of the independent sample t-test (t-test), it was found that $t_{count} > t_{table}$ ($4.38 > 1.67$), so that H_o was rejected and H_a was accepted. From this data, there is an influence of using the 7E Learning Cycle model to increase students' understanding of concepts.

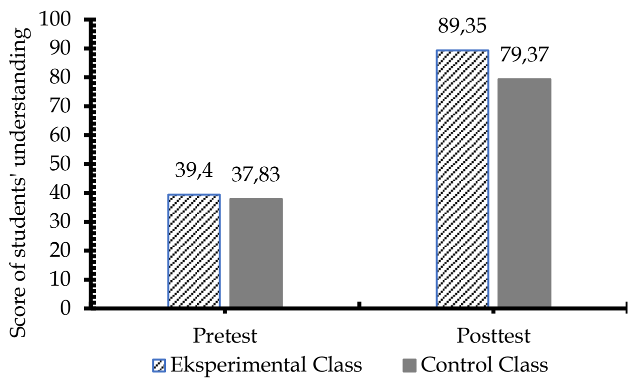

Figure 2. Average score of students' conceptual understanding

Based on the figure 2, the difference between the pretest and posttest scores for the experimental class is 49.95, while the difference between the pretest and posttest scores for the control class is 41.54. Based on the figure 2, it shows that the average score of students in the experimental class and control class has increased, it's just that the average increase in the experimental class is higher than the control class.

The graph in figure 2 shows the gain of the experimental class and control class. It can be seen that the average gain value of the experimental class is higher than the gain of the control class with the average gain of the experimental class and control class being $0.82 > 0.67$. Increasing students' conceptual understanding in the experimental class is influenced by the application of the 7E Learning Cycle model. Thus, it shows that the 7E Learning Cycle model can improve students' conceptual understanding compared to conventional learning models. This is in accordance with the statement Lisma et al. (2018), that the 7E Learning Cycle model is able to significantly increase students' understanding of concepts. According to (Nurmalasari et al. 2014), the average score of students who apply the 7E learning cycle is higher than the average score of students who apply the conventional learning model.

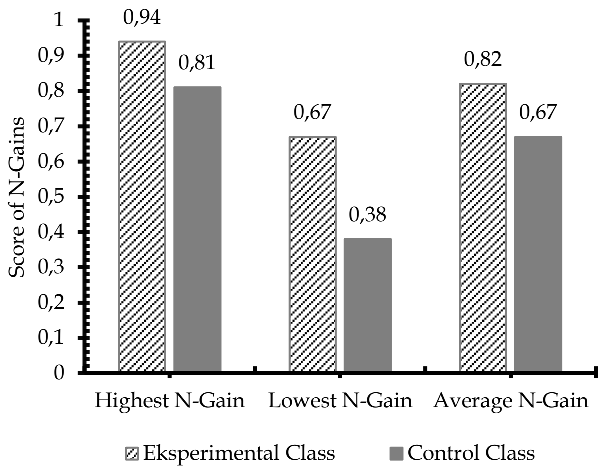

Figure 3. N-gain of Experimental Class and Control Class

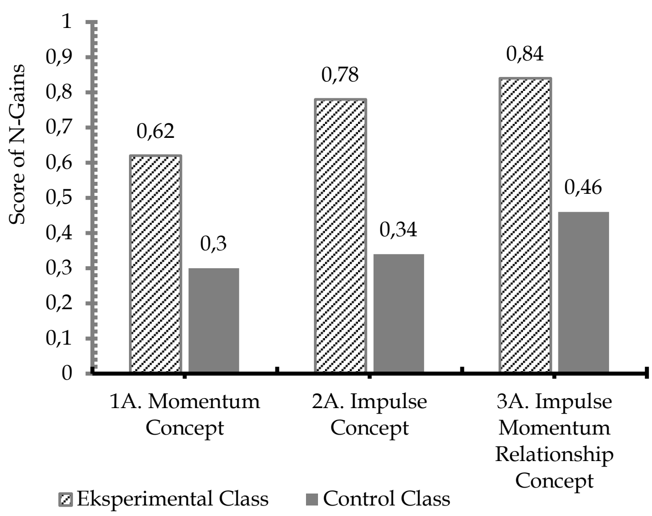

Figure 4. Ability to explain the phenomenon of momentum and impulse

Increasing the ability to explain physical phenomena is influenced by several stages, namely the Explore and Explain stages. The Explore and Explain stages in the learning cycle model have an important role in improving students' ability to explain physical phenomena. Through the Explore stage, students can experience learning directly through experiments and other active actions (Rafiqah et al., 2019), Apart from that, it is in line with the article (Suhanda & Suryanto, 2020) that the explore phase is where students are able to record ideas while carrying out experiments which can improve explaining the phenomenon of momentum and impulse. Meanwhile, the Explain stage allows students to hone their speaking skills and present their understanding, thereby stimulating deeper thinking about the physics concepts being studied (Agustyaningrum, 2011).

Thus, the combination of these two stages can help improve students' understanding of physical phenomena and their ability to communicate these concepts. This is proven by the experimental class students getting a percentage of 48% Complete Understanding (MSU), while those in the control class got a percentage of 21% Complete Understanding (MSU). This shows that the 7e learning cycle model is able to increase students' conceptual understanding in explaining physical phenomena.

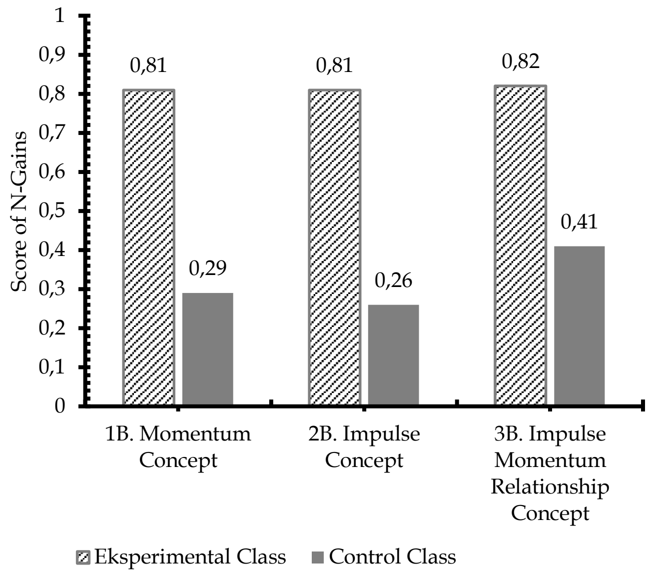

Figure 5. Ability to identify the concepts of momentum and impulse

Increasing the ability to identify physics concepts is influenced by several stages, namely the Elicit, Engage, Elaborate and Evaluate stages. According to Nurmalasari et al. (2014), at the Elicit stage, students are stimulated to remember their initial knowledge by asking questions related to the material to be studied. Meanwhile, at the Engage stage, students are expected to be interested and actively involved in learning through the use of questions, images or activities that attract their attention (Agustyaningrum, 2011). At the Elaborate stage, the main goal is to deepen students' understanding and increase their ability to transfer knowledge to real life situations (Dewi, 2012). In line with research (Putriardi, 2023) that at the elaborate stage students are required to be able to express everyday phenomena by identifying the given topic.

Evaluate is to find out the effectiveness of the learning process that has been carried out and provide feedback to both students and teachers (Nurmalasari et al., 2014). By following this series of learning stages, students can improve their ability to better identify physics concepts and be able to relate them to real life situations, so that learning becomes more relevant and meaningful for students. This is proven by the experimental class students getting a percentage of 60% Complete Understanding (MSU), while those in the control class got a percentage of 28.60% Complete Understanding (MSU). This shows that the 7e learning cycle model is able to increase students' conceptual understanding in identifying physics concepts.

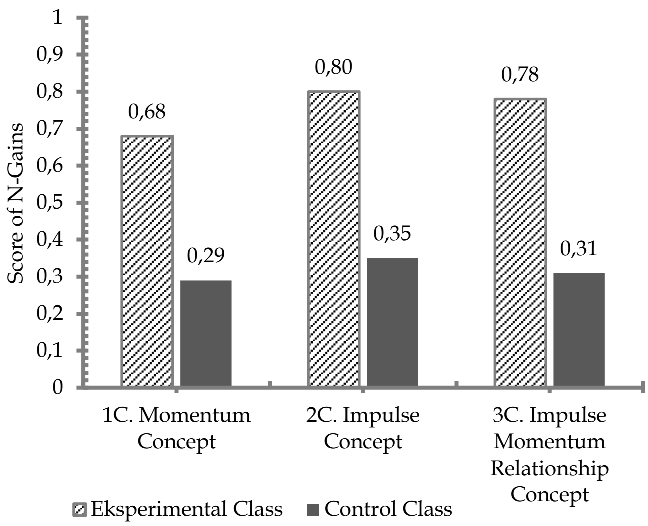

Figure 6. Ability to Exemplifying Momentum and Impulse Phenomena

Increasing the ability to exemplify physics concepts is influenced by several stages, namely the Elaborate and Extended stages. Based on research conducted at the elaborate stage, students were asked to try to give examples of different cases, this was able to generate students' ideas about phenomena regarding the material being taught. By combining the Elaborate and Extended stages in physics learning, students have the opportunity to deepen their understanding, connect concepts with real life situations, and develop higher order thinking skills (Dewi, 2012). This has the potential to improve their ability to identify, understand and apply physics concepts better and more effectively. This is proven by experimental class students who obtained a percentage of 49.5% Complete Understanding (MSU), while those in the control class obtained a percentage of 31.4% Complete Understanding (MSU). This shows that the 7e learning cycle model is able to increase students' conceptual understanding in exemplifying physical phenomena.

Increasing the ability to define physics concepts is influenced by several stages, namely the Explore and Explain stages. Through a combination of the Explore and Explain stages, students have the opportunity to be actively involved in the physics learning process. They can experience physics concepts for themselves through experiments, record their ideas, and then communicate their understanding by presenting the results of the discussion (Lestari, 2017). This allows students to deepen their understanding of physics concepts and improve their ability to better define concepts, resulting in a deeper and more robust understanding of the physics phenomena studied.

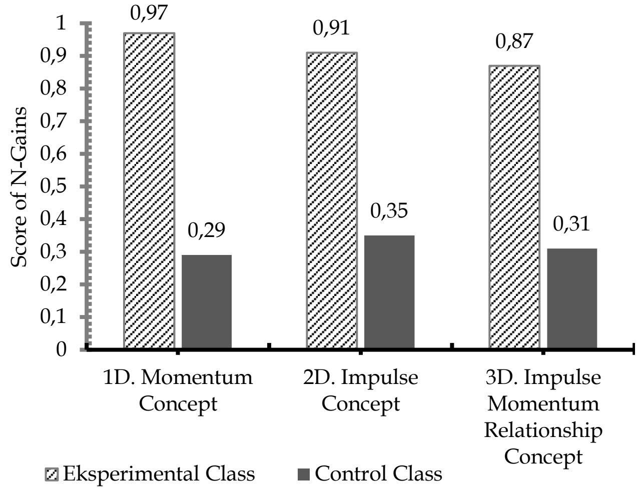

Figure 7. Ability to Defining the Concepts of Momentum and Impulse

This is proven by experimental class students who obtained a percentage of 81.9% Complete Understanding (MSU), while those in the control class obtained a percentage of 36.2% Complete Understanding (MSU). This shows that the 7e learning cycle model is able to increase students' conceptual understanding in defining physics concepts. Based on the explanation above on learning momentum and impulse material, it can be concluded that there is an increase in students' understanding of concepts through the implementation of the Learning Cycle 7E model at SMA Negeri 1 Pangkalan Susu.

Increased understanding of concepts can not only be improved by using the Learning Cycles 7E model, but can also be improved by using PhET-based modules (Nafaida et al. 2015), Experiment-based PBL methods (Halim et al. 2016), Inquiry-based CTL (Sastriani & Halim A., 2016; Darmawant et al., 2013), Multi representative (Hasbullah et al. 2019), and Shoology-based E-Module (Rezeki et al, 2021). Apart from that, reducing misconceptions is also understood as an effort to increase understanding of concepts and methods that have been used including Lectora Inspire and PhET (Putra et al. 2016), interactive media (Zukhruf et al.

2017), experimental methods (Zulvita et al. 2017), and Children Learning in Science (Saputra et al., 2013). Following is some documentation during the research:


Figure 8. conventional learning in the control class


Figure 9. conventional learning in the control class


Figure 10. application of learning cycle 7e in the experimental class

Figure 11. application of learning cycle 7e in the experimental class

Conclusion

Based on the results of research and data analysis, it was found that learning using the Learning Cycle 7e model had an effect on increasing students' understanding of concepts at SMA Negeri 1 Pangkalan Susu, Langkat Regency. Especially related to students' ability to define the concepts of momentum and impulse. The best level of conceptual understanding is Complete Understanding (MSU), whereas after using conventional learning models only Partial Understanding (MSB) is obtained. The research results are still general in nature and have not been able to detect what concepts (on the topic of Momentum and Impulse) are most appropriate to use in the Learning Cycles 7E model. This is an issue that needs to be addressed in future research.

In accordance with the main objective of this research as formulated in the introduction. What is new in this research is that through the Learning Cycle Model, students not only understand and define each concept but are able to link the concepts in the Impulse and Momentum topics. This fact has been shown in figure 2-7.

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Author Contributions
Conceptualized research ideas, methodology design, data analysis, investigation process, writing original drafts, visualization, and coordination responsibilities for planning and implementing research activities: R. P. H.; wrote-reviewed, edited and supervised: A. H., N.; reviewed the research results; A. H; validated the instruments used in the research; F. H.

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Conflicts of Interest
The authors declare no conflict of interest. The funders also had no role in the study design; in the collection, analysis, or interpretation of data; in script writing; or in the decision to publish results.

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