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The Effectiveness of The Implementation of The Independent Curriculum Based on TPACK on The Conceptual Understanding of High School Students on Momentum and Impulse Material

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ABSTRACT. This study explores the implementation of Merdeka Curriculum through the Technological Pedagogical and Content Knowledge (TPACK) approach to improve senior high school students' conceptual understanding of momentum and impulse. Merdeka Curriculum emphasizes innovative and flexible learning, but its practical application in improving students' conceptual knowledge, especially in physics, remains unexplored. thus highlighting the need for teaching strategies that integrate technology, pedagogy, and content effectively. This research was conducted at SMA Nurul Iman Tanjung Morawa with class XI MIA 1 as the experimental group and XI MIA 2 as the control group. A quasi-experimental design with non-equivalent control groups was used, where the experimental group received instruction using the TPACK approach, while the control group followed conventional teaching methods. Data analysis using SPSS version 25 showed that the experimental group achieved a mean score of 71.42 (71%), compared to 62.29 (62%) for the control group. These results indicate that the implementation of TPACK-based curriculum is effective in improving students' conceptual understanding. Statistical analysis yielded a significance value of 0.037 (<0.05), which confirmed the success of the approach. Thus, this study concludes that the implementation of the TPACK-based Merdeka Curriculum effectively improves senior high school students' conceptual understanding of momentum and impulse.

1. Introduction

Education is one of the most important things in human life. In Indonesian Law No. 20 article 1 of 2003 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 character, and skills needed by themselves, society, nation and state.

In national education, curriculum development is needed to improve the quality of education. According to the Ministry of Education and Culture, Merdeka Curriculum is a curriculum with diverse intracurricular learning where content will be optimized so that students have enough time to explore concepts and strengthen competencies. The Merdeka Curriculum is interpreted as a learning design that provides opportunities for students to learn calmly, relaxed, fun, stress-free and pressure-free to show the talents that exist within students. Merdeka learning focuses on freedom and creative thinking, one of which is the program presented by the Ministry of Education and Culture in launching the independent learning curriculum is to start a driving school program, which is a program designed for each school to create a generation of lifelong learners with the personality of Pancasila student students (Rahayu et al., 2022: 6314) .

The Merdeka Curriculum is implemented in all educational units with the aim of renewing the learning process in schools that are constrained by the pandemic. The government provides choices in the process of implementing the Merdeka Curriculum in schools, namely, (1) freedom to learn, (2) freedom to share, (3) freedom to change. (Rahimah, 2022: 93) . The implementation of the Merdeka Curriculum certainly brings significant effects and changes regarding teachers and educators in schools, both in terms of learning administration, learning strategies and approaches, learning methods, and even the learning evaluation process (Maulida, 2022: 131) .

In the Independent Curriculum, students can grow according to their abilities, because the independent curriculum gets critical learning, quality, commitment and serious implementation as stated by the Ministry of Education and Culture (Sugih et al, 2023: 2) . The Independent Curriculum also provides freedom and is student-centered, teachers and schools are free to ensure suitable learning (Warsidah et al., 2022) . In this Merdeka Curriculum, teachers and students are more free to explore, the Merdeka Curriculum emphasizes teachers to guide students (Hartoyo & Rahmadayanti, 2022: 4) .

Based on observations made at SMA Nurul Iman Tanjung Morawa by conducting interviews with teachers. From the results of the interview the teacher also explained that the average value of the odd semester final exam in physics was 60. These problems cause students to be less understanding of concepts in learning, especially physics learning.

Physics is a concept-oriented lesson (Sa'diyah & Sunarsih, 2021: 8). Suseno (2014: 10) explains that physics materials have abstract concepts. This is often an obstacle for teachers in delivering material to students, so that students are not optimal in understanding the concepts explained by the teacher (Puspitasari et al., 2020: 71) . Mardiana, et al., (2020: 513) explained that schools only produce students who study a material only basically, students do not expand their thinking and do not do deep thinking on a material.

Etikamurni et al., (2023: 180) explained that the obstacles that are often experienced when implementing theeka curriculum in physics subjects are, (1) teachers' difficulties in utilizing technology, (2) students are not independent in learning, (3) some learning materials are still teacher-centered, (4) students tend to be passive during learning, (5) low motivation to learn and understanding of the concept of physics material, (6) low mathematical ability, (7) students' ignorance of the application of physics becomes a problem.

Momentum and impulse material is one of the physics materials that requires a good understanding of the concept (Relia & Sodikin, 2018: 15) . Some teachers in teacher education programs have not implemented technology-based learning, causing teachers to lack sufficient knowledge and experience to integrate technology in the classroom teaching process (Agyei & Voogt, 2012: 548) . Technology in physics learning can be used as

an innovative, creative and interesting solution in teaching and learning activities (Mardiana et al., 2022: 91) . A teacher must be able to develop materials that demonstrate content knowledge by utilizing pedagogic knowledge and combining it with technology. These demands are described in a *Technological Pedagogical Content Knowledge* (*TPACK*) framework which consists of material, pedagogic and technological knowledge and skills to use the interaction between these components (Handal et al. 2013: 36).

Research by Yunus, et al., (2023) entitled *The Effectiveness of Implementing Merdeka Curriculum with the Application of the Project Based Learning Model on Biography Text Writing Skills*. The results showed that the average value of the control class *pre-test* was 60.55 and the average value of the *pre-test* was 71.82. As for the experimental class, the average *pre-test* score was 60.12 and the average *post-test* score was 78.58 with a percentage of 83.1% which reached a level of completeness above 80%. This shows that the application of the *project-based learning model* is very effective. For statistical analysis of the hypothesisH_1 is accepted based on the results obtainedt_{hitung} (2.801) >t_{tabel} (2.015) thenH_0 is rejected andH_1 is accepted so that both classes have different writing skills based on the treatment applied.

Then the research conducted by Setiawati et al., (2022) the study was entitled *Analysis of the Implementation of the Prototype Curriculum in High School Physics Subjects Implementing the Mover School Program in East Ogan Komering Ulu Regency*. The result of this study is that schools in the district have implemented Merdeka Curriculum well, although not perfect, including for physics subjects which can be seen from the application of teaching modules, learning outcomes, thematic approaches, additional work programs, students and assessments. The obstacles faced by teachers in these schools are adaptation and constraints on facilities and infrastructure.

Based on the description of the problems above, this study aims to determine the effectiveness of *TPACK-based* learning in terms of the independent curriculum on momentum and impulse material. From this, the researcher will conduct a study with the title "**The Effectiveness of *TPACK-based* Independent Curriculum Implementation on Conceptual Understanding of High School Students on Momentum and Impulse Material**" at Nurul Iman Tanjung Morawa High School.

2. Method

2.1 Type of Research

This research uses *quasi experiment* research (pseudo experiment) which is research to determine whether or not there is an effect of something that has been introduced to the subject, namely students. pseudo experiment is research with a design that has a control group, but cannot function fully to control outside variables that affect the implementation of the experiment. In this experimental research will be used by researchers to determine the effectiveness of TPACK-based learning on conceptual understanding of Nurul Iman Tanjung Morawa High School students.

2.2 Time and Place of Research

This research was conducted at Nurul Iman Tanjung Morawa High School which is located on Jl. Limau Manis Pasar 13, Tanjung Morawa District, Deli Serdang Regency, North Sumatra Province. Research activities were carried out in class X MIA in semester II (even) of the 2023/2024 academic year.

2.3 Population and Sample

The population of this study were all 11th grade students of SMA Nurul Iman Tanjung Morawa. This research was conducted using *purposive sampling*. According to Arikunto (1998: 127) *purposive* sampling is research by taking samples intentionally in accordance with the requirements or criteria needed. Taking the class as a research sample is based on the results of student test scores. the samples of this study were XI MIA-1 class of 32 students as the experimental class and XI MIA-2 class of 32 students as the control class.

2.4 Research Variables

In this study, there are two variables, namely TPACK-based learning as the independent variable and the effectiveness of the implementation of the Merdeka Curriculum on conceptual understanding as the dependent variable.

2.5 Operational Definition of Variables

a. Effectiveness is a measure of the success or failure of a treatment in a learning process.
b. Implementation of the Merdeka Curriculum is an activity of implementing a plan that is systematically and in detail designed, which in implementing the Merdeka Curriculum is flexible.
c. *Technological Pedagogical and Content Knowledge* (*TPACK*) is a *framework* that helps teachers to integrate technology in pedagogical and content knowledge.
d. Momentum is defined as the product of mass and velocity. Impulse is the average contact force F acting on an object that occurs in a very short interval of time.
e. Conceptual understanding is knowledge that includes schemas, mental models, or theories that represent human knowledge about how a study material is data and structured, how parts of information are systematically interrelated and how these parts function together.

2.6 Research Design

The design of this research is a *non-equivalent control group design* with the implementation of experimental research, experimental groups and control groups are arranged intensively so that both variables have the same or close to the same characteristics. The two classes were given different treatments, for the first class was treated using TPACK-based learning as the experimental class and the second class was treated using conventional learning as the control class.

2.7 Research Instrumen

The research instruments used in this study are test and non-test instruments.

2.8 Data Collection Tecnique

The test in this study was conducted twice, namely the pre-test and post-test. The tests used in this study were written tests given to both classes. The test used is a conceptual understanding test in the form of multiple choice individually.

3. Result and Discussion

3.1 Experimental class pretest analysis result

In this study, researchers obtained data from the results of the pre-test and post-test conducted in the experimental class and control class. *The pretest* was conducted at the beginning of the study to determine the extent to which students understand the concept of momentum and impulse material. While the final test or *posttest* was carried out at the end of the study with the aim of knowing the extent to which students understood the momentum and impulse material after the experiment. The results of the study will be described as follows:

The results of the *pretest* and *posttest of* the experimental class in the study can be seen in the following figure:

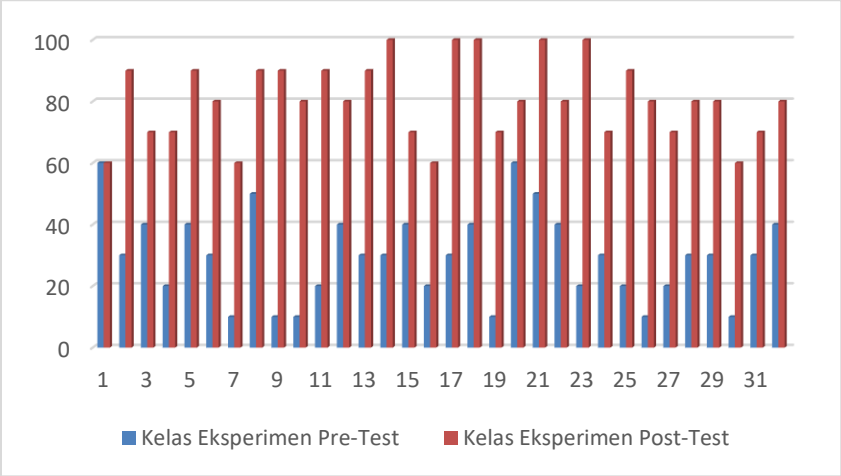

Figure 1. Experimental class pretest and posttest results

Based on the table above, it can be seen that the results of the *pretest* and *posttest* of the experimental class, in these results there is an increase from the results of the *pretest* and *posttest of* the experimental class before and after treatment.

3.2 Control class analysis result

The results of the *pretest* and *posttest of* the control class in the study can be seen in the following figure:

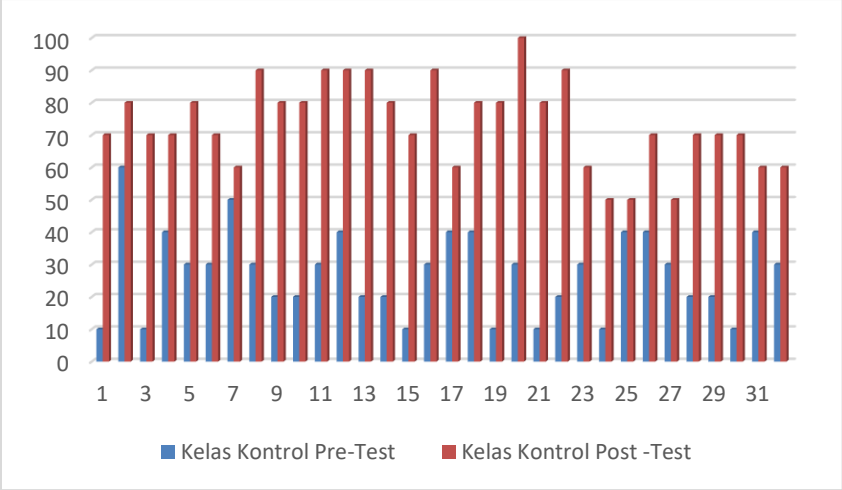

Figure 2. Control class pretest and posttest results

Based on the table above, it can be seen that the results of the *pretest* and *posttest* of the experimental class, in these results there is an increase.

3.3 Mean pretest ana posttest of control class

Here is the data on the experimental class and control class *pretest* and *posttest* below:

Tabel 1. Average pretest and posttest

Kelas	Rata-Rata	
	Pretest	Posttest
Eksperimen	30	81
Kontrol	27	74

Based on the data above, it shows that the experimental class had a higher *pre-test* average of 30 and the control class had an average of 27. For the *post-test* average value of the experimental class, the average was 81 and for the control class, the average was 74.

3. 4 Statistical Analysis

The implementation of the *TPACK-based* Merdeka Curriculum provides opportunities for teachers in the teaching and learning process in the classroom. Therefore, with the learning process using the *TPACK* approach, the atmosphere in the classroom is not boring, because it uses *TPACK* support tools in the learning process. Based on the results of the *independent sample t-test* test conducted, the results of the study revealed that the Implementation of the *TPACK-based* Merdeka Curriculum on students' conceptual understanding obtained a sig value, (2-tailed) of 0.037 <0.05. Thus,H_0 is rejected andH_a is accepted. So it can be concluded that the Implementation of the Independent Curriculum based on *TPACK* is effective on the conceptual understanding of high school students on momentum and impulse material.

Tabel 2. Independent sample t-test results table

Independent Sample Test						
			t-test for Equality of Means			
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
2,130	62	0,037	6,875	3,288	0,422	13,328
2,130	61,924	0,037	6,875	3,288	0,422	13,328

After the *pretest* and *posttest* scores are obtained from the scoring results, then further calculate the average student conceptual understanding test results with the N-Gain calculation. The implementation of the TPACK-based independent curriculum on students' conceptual understanding is reviewed based on the comparison of the normalized gain value N-Gain between the two groups, namely the experimental group and the control group. The N-Gain calculation uses the help of *SPSS version 25*. The N-Gain results are as follows.

Tabel 3. N-gain test results

Class	Average N-Gain Persen (%)
Experiment Class	71,42
Kelas Kontrol	62,29

Based on the table data above, the N-Gain test can be used to determine the effectiveness of using *TPACK* on students' conceptual understanding in implementing the Merdeka Curriculum. After obtaining the N-Gain calculation results, the experimental class obtained an average of 71, 42 or 71% in the moderately effective

category, while for the control class 62, 29 or 62% was quite effective. This shows that the implementation of the *TPACK-based* Merdeka Curriculum on students' conceptual understanding is more effective than learning without using the *TPACK* approach.

4. Conclusion

Based on the results of the research and discussion, it can be concluded that the implementation of the TPACK-based independent curriculum positively impacts students' conceptual understanding. The average test results for conceptual understanding in the experimental class were 71.42 (71%), compared to 62.29 (62%) in the control class. This indicates that the TPACK-based curriculum implementation is effective in improving students' understanding of momentum and impulse. The statistical analysis showed a significance value of 0.037, which confirms the effectiveness of the TPACK-based approach in enhancing conceptual understanding among high school students.

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