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Application of Investigation Based Multiple Representation Learning Model Assisted by Virtual Simulation on Direct Current Circuit Material to Enhance Cognitive Learning Outcome of High School Students

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Abstract- This research aims to describe the cognitive learning outcomes of students after learning physics with Investigation Based Multiple Representation Learning model assisted by virtual simulation, especially on the direct current circuit material. The research used a quasi-experimental design with a post-test only control group. This research was conducted in the MA Darul Hikmah Pekanbaru, with the sample being students of experimental and conventional classes. The experimental class was taught using the Investigation Based Multiple Representation Learning model assisted by virtual simulation, while the control class received a conventional learning model. The data were obtained from students' cognitive learning outcomes, and data collection provided a post-test question. The descriptive analysis results show that students' cognitive learning outcome of the experimental class achieved an average score of 80.04 (Good Category), and students' cognitive learning outcomes from the control class achieved an average score of 50.78 (Very Less Category). The inferential analysis results show a difference between students' cognitive learning outcomes in the experimental class and those in the cognitive learning outcomes. This is proven by the results of inferential analysis with independent sample t-tests and confirming a difference between the two classes with a significance value of 0.000 < 0.005. This research demonstrates that the Investigation Based Multiple Representation Learning model assisted by virtual simulation enhances students' cognitive learning outcomes of direct current circuit material, providing an alternative teaching strategy that can enhance students' cognitive learning outcomes.

Keywords: Investigation Based Multiple Representation Learning Model, IBMR, Virtual Simulation, Cognitive Learning Outcome, Direct Current Circuit Material.

1 Introduction

Education is a conscious effort to pass on cultural heritage from one generation to another. Education makes this generation a role model for the teaching of previous generations. To date, education has no boundaries in explaining its full meaning due to its complex nature, as its target is human beings. Meanwhile, educational science is a continuation of education. Education and educational science are

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interrelated in terms of practice and theory. Thus, throughout human life, the two collaborate (Rahman et al., 2022:2).

The development of the education system in Indonesia has always undergone changes over time in accordance with the demands of educational issues and is the developments in science and technology. The current educational issue is the low quality of education at every level of education. Every aspect of life is required to undergo reconstruction, and this condition poses a challenge for the world of education. Education must prepare students to be critical so that they can respond to developments in science and technology (Sandora et al., 2022:13).

Learning activities at school are the main activities in the educational process, and the success of a learning process is determined by the extent to which students participate in learning activities, which can be observed from two aspects, namely the level of understanding and mastery of the material provided by the teacher. A learning model is a method used to implement a plan that has been developed in real activities so that learning objectives are achieved (Gay et al., 2022:113). The quality and success of student learning are influenced by the ability and accuracy in selecting and using learning models. Selecting the right and appropriate learning model can increase the effectiveness of learning, especially in physics learning.

In essence, physics learning consists of three components, namely process, product, and scientific attitude. Physics as a process is a series of activities that discover concepts, principles, and laws about natural phenomena. Physics as a product is a collection of scientific knowledge that contains facts, concepts, principles, and laws of natural phenomena. Meanwhile, physics as a scientific attitude demonstrates the ability to develop student character. Knowledge about the nature of physics is important in planning physics learning. The physics learning process also emphasizes providing direct experiences to develop competencies so that students are able to understand the natural world scientifically (Rusliadi & Azhar, 2022:5).

Physics is an exact science that contains many theories and applications. Equations and formulas in physics are closely related to solving physics problems (Agustinasari & Sumarni, 2021:74). Improving student learning outcomes is one of the goals of current learning (Suhardinam et al., 2022:779). Through the problem-solving process, students are expected to be able to understand problems, plan solutions, implement plans, and review the process of solving physics problems. This problem-solving process helps students improve their cognitive learning outcomes in physics.

Based on data obtained from learning outcomes of grade XII students at Madrasah Aliyah (MA) Darul Hikmah in the previous semester, it can be said that the result wee low, with only 14% of students obtaining a score of 65. Based on the problems mentioned above, researchers used a learning model that can support students' ability to solve physics problems to enhance students' cognitive learning outcomes. One learning model that can be used is the Investigation Based Multiple Representation Learning Model Assisted by Virtual Simulation, abbreviated as the IBMR Learning Model. This learning model consists of five phases, namely orientation, investigation, multiple-representation, application, and evaluation.

Technology-based physics learning is expected to help enhance students' understanding through a direct learning process, so that there is an increase in students' cognitive learning outcomes. Therefore, one of the technological media that can be used in the science learning process today is virtual simulation, namely PhET simulation. The application of technology in this research is a visual simulation used in one of the phases of the IBMR learning model, namely the investigation phase. The use of technology in learning facilitates education (Astuti, 2021:105).

2 Research Methodology

This research used a quasi-experimental design with a post-test only control group. This research was conducted in the MA Darul Hikmah Pekanbaru, with the sample being students of experimental and conventional classes. The population of this research was 79 students from 4 classes, with class XII Engine 2 as the experimental class and class XII Medical 2 as the control class. Sampling of the experimental class and control class used simple random sampling techniques, which was done on the condition that the population was considered homogeneous (Sugiyono, 2023:127).

The experimental class was taught using the Investigation Based Multiple Representation Learning model assisted by virtual simulation, while the control class received a conventional learning model. The data were obtained from students' cognitive learning outcomes, and data collection provided a post-test question. Then, the data research was analyzed using descriptive analysis with Excel and inferential analysis with SPSS 26. The results of the descriptive analysis are categorized using the following criteria:

Table 1: Categories of Cognitive Learning Outcomes Standards.

Value Interval	Category
$85 \leq x \leq 100$	Very good
$75 \leq x < 85$	Good
$65 \leq x < 75$	Sufficient
$55 \leq x < 65$	Less
$0 \leq x < 55$	Very Less

(Hikmah et al., 2023:52).

Inferential analysis used an independent sample t-test to test the data hypothesis, with the hypothesis H_0 rejected if the significance value (p)<0.005 for indicating a difference in cognitive learning outcomes between the experimental classes using the Investigation Based Multiple Representation Learning model assisted by virtual simulation, and the control class received a conventional learning model (Sugiyono, 2023:208).

3 Results and Discussion

The Investigation Based Multiple Representation (IBMR) learning model is a modeling process supported by constructivism theory, in which students gain a deep understanding through the process of inquiry. The IBMR learning model has phases of orientation, investigation, multiple representations, application, and evaluation (Siswanto et al., 2018:2).

In the orientation phase, physical phenomena and the identification of relevant physical concepts are presented, followed by scientific investigation of the phenomena in the investigation phase. In the multiple representation phase, the results of the investigation are presented using various modes of representation. In the application phases, multiple representation is applied to solve physics problems, and in the evaluation phases, the process and results of problem solving are checked and follow-up provided (Siswanto, 2019:97). The following is a more detailed explanation of the stages in each phase of the IBMR learning model, namely:

Table 2: Phases of the IBMR Learning Model.

Phase	Phase Description	Teacher Activities
Phase 1: Orientation	Orienting students to phenomena and the use of multiple representations	• Presenting examples of physical phenomena • Guiding students in identifying the physical concepts presented • Ask students to present the identified physics concepts using multiple representations • Communicate learning objectives
Phase 2: Investigation	Design and conduct scientific investigations	• Inform students of investigation requirements • Guide investigations to test the assumed multiple representations

Phase 3: Multiple Representations	resenting physics concepts using multiple representations (verbal, images, etc.)	• Guiding students to analyze and present investigation results using multiple representations
Phase 4: Application	Applying multiple representations of physics concepts in physics problem solving	• Providing problems related to the concepts • Guiding students in problem solving using multiple representations
Phase 5: Evaluation	Evaluating presentation results	• Guiding and helping students to evaluate and reflect

Source: (Siswanto et al., 2016:128-129)

Advances in digital technology and information technology can provide alternative solutions for the world of education to use and apply various types of online learning media that can be accessed anywhere and anytime. The use of media as a learning tool makes it easier for teachers to deliver lesson material to students (Agustina et al., 2024:76). One technological innovation that can be used as a medium for physics learning is physics education and technology (phet) simulation (Ledjab et al., 2024:114). The application of technology in this research is visual simulation used in one of the phases of the IBMR learning model, namely the investigation phase (Siswanto, 2019:97).

Taxonomy in education for the classification of instructional objectives, which are grouped into three domains, namely: 1) the cognitive domain related to thinking skills; 2) the affective domain related to feelings, attitudes, emotions, and value systems; and 3) the psychomotor domain related to motor skills. The taxonomy model that can be used to help evaluate cognitive learning outcomes is Bloom's revised taxonomy, revised by Anderson and Kratwohl in 2010 (Oktaviana & Prihatin, 2018;82-83), as follows:

1. Remembering (C1) is long-term knowledge. The remembering category consists of the cognitive processes of recognizing and recalling.
2. Understanding (C2) is cognitive in transferability, and the category includes interpreting, exemplifying, classifying, summarizing, concluding, comparing, and explaining.
3. Applying (C3) involves the application of two cognitive processes, namely executing and implementing.
4. Analyzing (C4) involves the cognitive processes of attributing and determining relationships between parts and other structures.
5. Evaluate (C5) involves solving problems by making decisions after examining and critiquing.
6. Create (C6) involves formulating problems, planning hypotheses, and producing plans to solve the problems given.

3.1 Descriptive Analysis

The data analyzed using descriptive analysis in this research was the cognitive learning data of students in the experimental class and control class on the subject of direct current circuits. The experimental class was class XII Engine 2 with 17 samples, and the control class was class XII Medical 2 with 16 samples. The average post-test data for students' cognitive learning outcomes for each indicator can be seen in Table 3 below.

Table 3: Analysis of Students' Cognitive Learning Outcomes for Each Indicator

Cognitive Aspect	Experimental Class		Control Class	
	Average	Category	Average	Category
Remembering (C1)	98.52	Very Good	82.81	Very Good

Understanding (C2)	88.23	Very Good	54.16	Very Less
Applying (C3)	90.58	Very Good	62.50	Less
Analyzing (C4)	76.46	Good	75.00	Good
Evaluating (C5)	58.82	Very Less	14.58	Very Less
Creating (C6)	67.64	Less	15.62	Very Less
Total	**80.04**	**Good**	**50.78**	**Very Less**

Table 3 shows that the cognitive learning outcomes of students in the experimental class who applied the Investigation Based Multiple Representation learning model assisted by virtual simulation were better than those in the control class who applied conventional learning. Analysis of the experimental class shows that of the six cognitive aspects, the aspect of remembering achieved the highest score of 98.52, which is in the excellent category, while the aspect of evaluating was the lowest cognitive aspect with a score of 58.82. Meanwhile, in the control class, analysis of the six cognitive aspects shows that the remembering aspect achieved the highest score of 82.81 in the good category, and the evaluating aspect was the lowest cognitive aspect with a score of 14.58 in the very less category.

Based on the analysis of cognitive learning outcomes data for each cognitive aspect in the experimental class and control class, there were differences as shown in Table 4. Further details regarding the six aspects of cognitive learning outcomes are described as follows.

1. Remembering (C1)

The first cognitive aspect is remembering, where memory is used to receive information from the reading text and recall it (Fadhillah, 2021:1114). There are four questions on the cognitive aspect of remembering in this research, with a difficulty level of C1, in questions 1, 3, 8, and 15. Question 1 discusses the definition of electric current, question 3 discusses the definition of Ohm's Law, question 8 discusses the definition of Kirchhoff's First Law, and question 15 discusses the definition of Kirchhoff's Second Law. Although classified as easy questions, questions 3, 8, and 15 showed significant differences in average scores between the experimental class and the control class. This was due to external and internal factors that affected student learning, resulting in suboptimal learning outcomes. This is in line with research conducted by researchers (Samawa et al., 2018:25) who stated that there are internal and external factors affecting student learning outcomes.

Based on Table 3, the average cognitive learning outcome of students in the experimental class in the cognitive aspect of memory was categorized as very good with a score of 98.52, while the control class was categorized as good with a score of 82.81. It can be said that students in the experimental class can remember the learning material better than the control class, as evidenced by a score difference of 15.71, so it can be said that there is an effect of applying the Investigation Based Multiple Representation IBMR) learning model assisted by virtual simulation on electrical circuit material. This is in line with research conducted by (Utama et al., 2024:150) which states that science learning will be more meaningful when assisted by learning media so that students are motivated to learn and improve their learning outcomes.

2. Understanding (C2)

The second cognitive aspect is understanding at the C2 level of difficulty. There are three questions in the post-test that assess cognitive learning with an understanding aspect, namely questions 5, 13, and 16. Although the questions are only to recall the learning material that has been studied and are relatively easy, they are given answers and questions that are misleading. Question 5 discusses electrical resistance in accordance with Ohm's Law, and students are asked to understand the relationship between electrical resistance and Ohm's Law. Question 13 touches on series circuits, and students are asked to understand the characteristics of series circuits. Question 16 discusses the rules of Kirchhoff's Second Law, and students are expected to understand the rules that apply to Kirchhoff's Second Law. The results of the research show that there is a significant difference in the achievement of students in the experimental class and the control class, as evidenced in questions 5, 13, and 16, where the experimental class had an average score of 94.11 in question 5, which is in the excellent category, and 100.0 on question number 13, which was categorized as excellent, and on question number 16, which was categorized as fair. Meanwhile, in the control class, the average score for cognitive learning on question number 5 was 50.00, which was categorized as very less, on question number 13, it was 81.25, which was categorized as good, and on question number 16, it was 31.25, which was categorized as very less.

Based on Table 3, the cognitive learning outcomes of students in the understanding aspect in the experimental class were superior to those in the control class, namely 88.23 with a very good category compared to the control class average score of 54.16 with a less category. The difference in the average score between the experimental class and the control class was 34.07. This difference in average scores and categories proves the influence of the IBMR learning model on the experimental class. The reason students in the experimental class remembered more was because the IBMR learning model included investigative activities in the form of experiments with the help of virtual simulations, so that students remembered from the discoveries made during the investigative activities. This makes students' understanding of the concept more factual and concrete so that they can easily grasp the material being taught. This is in line with research by (Liputo & Purwaningsih, 2022:215) which states that the IBMR learning model helps students in physics modeling and concept understanding through representation skills that facilitate students' ability to solve physics problems.

3. Applying (C3)

The post-test questions on cognitive learning outcomes in the aspect of applying consisted of five questions, namely questions 2, 6, 9, 11, and 19. Question 2 discussed the application of electrical measuring instruments, and students were asked to apply the correct use of current and voltage measuring instruments in a circuit. Question number 6 asks students to calculate using the resistance equation to prove the relationship between wire length, and wire width to wire resistance. Question number 9 discusses Kirchhoff's First Law, and students are expected to be able to apply Kirchhoff's First Law. Question number 11 asks students to calculate voltage using Ohm's Law. Question number 19 discusses electrical energy, and students are expected to be able to apply the electrical energy formula.

Based on the results of the research on question number 2, there was a very significant difference, namely the average score in the experimental class reached 100 with a very good category, while in the control class it was 18.75 with a very less category. The average score of the experimental class was much higher because the learning model included a virtual simulation-assisted investigation phase, during which students automatically applied visual representations in virtual simulations while conducting their investigations. This is in line with research by (Arum et al., 2014:91), which states that visual representations can influence physics learning outcomes because visual representations in the form of images, graphics, and models can help students understand concepts optimally.

In question number 6, the difference between the experimental class and the control class was 37.5. This occurred because the learning motivation of students in the experimental class was superior due to the use of the IBMR learning model assisted by virtual simulations, which made students more enthusiastic about finding answers. In question number 9, although the control class outperformed the experimental class by a difference of 11.03, this was because the experimental class investigated Kirchoff's First Law in general terms in mixed circuits, did not investigate the form of the post-test questions, and evaluated questions with different forms, while the control class was given questions in the LKPD that were similar to the post-test questions. On questions 11 and 19, the average score in the experimental class was higher than that of the control class.

Based on Table 3, the average score of the experimental class in the application aspect reached 90.58 with a very good category, while the control class scored 62.50 with a less category. This shows that the cognitive learning outcomes of the experimental class were 28.08 higher. The difference in average scores and categories in the application aspect indicates that there is an influence of the IBMR learning model assisted by Phet virtual simulation because the learning process involves investigative activities aided by experimental media, thereby obtaining answers from the concepts studied in the book. The cognitive application aspect contains the application of laws, formulas, methods, ways, and principles in various physical and factual problems. With the investigation assisted by Phet virtual simulation in the learning process, students remember the material from real learning activities better. This is in line with the research conducted (Arifin et al., 2022:22), which states that the use of Phet allows students to discuss in groups, requiring them to provide input to other students so that students with less performance will be motivated to participate in learning activities.

4. Analyzing (C4)

Based on the analyzing indicator, students are said to have analyzing skills if they can analyze, solve problems, and break down problems into the correct parts. In this research, there were three questions for the cognitive aspect of analyzing, namely questions 4, 18, and 20. Question 4 discusses Ohm's Law calculations, and students are asked to find and analyze the correct answer. Question 18 discusses calculating electrical power, and students are first asked to analyze the electric current in the previous question and the voltage before they can calculate the electrical power. Question 20 discusses the advantages of electrical energy sources, and students are asked to analyze the correct answer.

Based on the results of the research, it can be seen that on question 4, the average score of the experimental class reached 100 with a category of very good and the control class reached 87.50 with a category of very good. Although they were in the same category, the experimental class was superior to the control class by a difference of 12.50. This was inseparable from the students' analytical abilities. On question number 18, the average score of the experimental class was 35.29, which was categorized as very less, while the control class achieved 43.75, which was also categorized as very less. Although the average score of the control class was higher, in the previous question, number 17, the control class students answered questions about the flowing current, and the average score on that question was low at 18.75, which was classified as very less. Therefore, it can be assessed that the students in the control class chose the answers to question number 18 without looking for the correct answers from the previous questions. On question number 20, the average score in the experimental class reached 94.11 and the control class achieved 93.75, which is in the excellent category.

Based on Table 3, the average cognitive learning outcome score for the experimental class in the analysis aspect was 76.46, which is categorized as good, while the control class achieved a score of 75.00, which is also categorized as good. The average scores for the experimental class and the control class are in the same category, namely good, and the average score for the experimental class is higher. Although the average score of the experimental class students was not much different from that of the control class students, with a difference of 1.46, these results show that learning with the IBMR learning model contributed significantly. This was because students were able to think critically in concluding their observations and also because the teacher was present to provide guidance when analyzing problems.

In the experimental class, it can be said that the learning outcomes were better because of the Investigation Based Multiple Representation learning activities. Students were able to form conceptual understanding, process information from investigative activities assisted by simulations, and connect it with various forms of representation, including image representations obtained from real investigations using Phet virtual simulations, mathematical representations, and verbal representations by answering questions in the worksheets. This is in line with research conducted by (Priyasmika, 2020:63), which states that multi-representation-based inquiry learning has a significant effect on learning outcomes.

5. Evaluating (C5)

There were three questions on the post-test assessing cognitive learning outcomes, namely questions 7, 10, and 12. Question 7 discussed Ohm's Law, asking students to evaluate five flashlights and rank them in order of strongest voltage. Question 10 discusses series and parallel circuits, asking students to evaluate three circuit configurations and analyze their current strength. Question 12 discusses mixed circuits, asking students to evaluate the total resistance, current strength, and voltage difference between two different points.

Based on the results of the research, it can be seen that in questions 10 and 12, there was a significant difference between the experimental class and the control class, namely 58.09 and 52.21. This is because the IBMR learning model in the experimental class included an evaluation phase where students were given questions discussing issues related to the post-test questions. Students in the experimental class were better at evaluating questions discussing the differences in electric current and voltage in electrical circuits with different resistances.

Based on the research results in Table 3, the average score of the experimental class in the evaluation aspect was 58.82, categorized as less, while the control class scored 14.58, categorized as very less. There is an average difference of 44.24 in this aspect, indicating that there is an effect of applying the IBMR learning model assisted by virtual simulation in the experimental class. This is because in the IBMR learning process, students can carry out investigative activities assisted by virtual simulation and also by the use of multi-representation carried out in the learning process while conducting investigations with virtual simulation and in the LKPD. At the end of IBMR learning, there is an evaluation phase so that the average score of the experimental class is higher than the average score of the control class. This shows that the experimental class is superior in evaluating electrical circuit problems because it conducts an investigation phase and an evaluation phase, while the control class only relies on books and worksheets without any direct investigation, making it difficult for students to evaluate other cases regarding current strength and voltage differences in direct current circuits.

This is in line with the results of research conducted by (Ningsih et al., 2023:293-295), which shows that the average score for the evaluation aspect in the experimental class was 74.07, while in the control class it was 54.63. This is because the use of effective Phet and worksheets can improve learning outcomes. However, Table 4.2 shows that both the experimental and control classes had difficulty answering questions, lacked understanding, misinterpreted questions, and skipped the formulation process in answering questions at a high order of thinking level (Nabilah et al., 2020:5).

6. Creating (C6)

There are two questions on the post-test for cognitive learning outcomes in the area of creating, namely questions 14 and 17. Question 14 discusses mixed circuits. Students are asked to create a parallel circuit, which is then connected in series, and then calculate the current flowing through each resistor in order to answer the question. Question number 17 discusses Kirchoff's Law in loop circuits, where students are asked to create the direction of current in the circuit according to Kirchoff's First Law.

Based on the results of the research, there was a significant difference in the average cognitive learning achievement scores between the experimental class and the control class in the aspect of creativity, namely in questions 14 and 17, where the experimental class obtained an average score of 76.47 in the good category and 58.82 in the less category, while in the control class, the average score was 12.50, categorized as very less, and 18.75, categorized as very less. The difference in the average score between the experimental class and the control class was 63.97 for question number 14 and 40.07 for question number 17. This very significant difference shows that there is a difference in cognitive learning outcomes between the experimental class, which applied the IBMR learning model assisted by virtual simulation, and the control class, which did not apply this learning model. This is also supported by the investigation and evaluation phases in the IBMR learning model. Through investigation, students can explore information and experiences directly, while through the evaluation phase, teachers can provide feedback on the extent of the success of the learning process that has been carried out. The provision of high-order thinking (C6) questions in the evaluation phase in the second and third meetings showed an increase in learning outcomes in the experimental class.

This is in line with research conducted by (Susanti., 2023:81-82) which states that through practical learning, students can answer high-order thinking questions tested in learning, thereby improving student learning outcomes. In her research, the average learning outcome score for the experimental class reached 80.1, which is considered high, while the control class scored 60.3, which is considered moderate. This is because in practical activities, students will try to analyze, evaluate, and even create.

3.2 Inferential Analysis

The results of inferential analysis in this research were obtained from normality tests using the Shapiro-Wilk test, Homogeneity tests using Levene's test, and data hypothesis tests using independent sample t-tests. All three tests were conducted using SPSS 26. The research data analyzed using inferential analysis were post-test data obtained after treatment. The post-test data were analyzed using normality and homogeneity tests to meet the prerequisites for hypothesis testing. Based on the result of the Spahiro-Wilk test, a significant result was obtained in the experimental class of 0.328 and a significant result in the control class of 0.066. With data normality testing at a 5% error rate, the results indicate that both class data are normally distributed (Sugiyono, 2022:302). Furthermore, the post-test data was tested for homogeneity using the Levene test, which obtained a significance result between the experimental class and the control class of 0.975 and it can be concluded that the variance of both classes is homogeneous. After fulfilling the prerequisite test, hypothesis testing can be carried out using the independent sample t-test.

Hypothesis testing was conducted to determine whether there was a difference in cognitive learning outcomes between the students who learned using the Investigation Based Multiple Representation (IBMR) learning model assisted by virtual simulation and students who learned using the conventional learning model. The independent sample t-test result was 0.000. based on the independent sample t-test requirement, if the significance value $(p)<0.005$, then Ho is rejected. The Significance value obtained from the t-test was 0.000, so H_o was rejected, and H_a was accepted.

Then results of inferential analysis shows that the hypothesis in this research is accepted, which means that there is a significant different between cognitive learning outcomes of students who apply the Investigation Based Multiple Representation learning model assisted by virtual simulation and the cognitive learning outcomes of students who do not apply the Investigation Based Multiple Representation learning model assisted by virtual simulation. Therefore, it can be interpreted that the application of the Investigation Based Multiple Representation learning model assisted by virtual simulation in direct current circuit material effectively improves the cognitive learning outcomes of students at MA Darul Hikmah Pekanbaru.

The results of this research are supported by research conducted (Setyarini et al., 2021: 46-52) which examined the improvement of physics problem-solving skills using the Investigation Based Multiple Representation learning model (IBMR). The average score for students' problem-solving skills was 77.24, indicating that the IBMR learning model can train problem-solving skills. The results of research by (Agustina et al., 2025:95) state that learning outcomes are influenced by problem-solving skills; students with high problem-solving skills are, on average, able to complete problems according to their stages, and this can certainly improve learning outcomes.

4 Conclusion

Based on the results of the research and discussion presented regarding students' cognitive learning outcomes through physics learning using Investigation Based Multiple Representation (IBMR) learning model assisted by virtual simulation in class XII MA Darul Hikmah Pekanbaru , the following conclusions can be drawn :

1. The cognitive learning outcomes of students who learned using the IBMR learning model assisted by virtual simulation on direct current circuit material were in the good category with an average score of 80,04.
2. The cognitive learning outcomes of students who learned using the IBMR learning model assisted by virtual simulation differed from the cognitive learning outcomes of students who learned using

the conventional learning model on the same material. This is reinforced by the cognitive learning outcomes of students who learn with the IBMR learning model assisted by virtual simulation which are in the good category with an average score of 80,04, while the cognitive learning outcomes of student who learn with the conventional learning model are in the very less category with an average score of 50,78. This is also supported by the result of the inferential test with a sig value <,005, which means that the research hypothesis is accepted and shows a significant difference.

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