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INTERACTIVE DEMONSTRATION WITH MULTIPLE REPRESENTATION IN LEARNING OF MAGNETIC FIELD CONCEPTS

Abstract*. The aim of this research is identify the effectiveness of an interactive demonstration with multiple representation to increase students' understanding within the concept of magnetic field. The research sample of 62 students is obtained randomly from among students of senior high school using a random sampling technique. Normality test results indicated that participants were normally distributed. In the experimental class, the learning was conducted by using interactive demonstration with multiple representations, whereas the control classes undertook conventional learning. Result of the research shows that (1) Learning by interactive demonstration with multiple representations is more effective in increasing students' understanding the concept of magnetic field compared with the conventional learning; (2) using various way to representation help student to minimize their difficulties with cross product direction include the application of various right-hand rules, physics content issues, the orientation of the vectors, the symbols used, and the type of reasoning required. The learning model is discussed as an alternative in class lessons in order for training the students with various way to describe their answer in constructing their understanding in abstract concepts.*

Key words*: Interactive demonstration, multiple representation, magnetic field*

Introduction. Magnetic force's concept is a unique and challenge phenomenon in the natural world. Many studies have discussed students' conceptual difficulties in understanding a magnetic force [1]–[3]. Difficulties often found in students is how to determine the direction of magnetic force. These findings are in line with several other studies. There is the necessity of using the unfamiliar and abstract operation of the vector cross product [1]. In the initial stages of our study we observed that a significant number of students made a "sign error" when determining the direction of the magnetic force they recognized that the magnetic force was perpendicular to the velocity and magnetic field, but they chose the incorrect sign of the direction [4]. Incorrect sign of direction was also become provides a more detailed and holistic understanding of student difficulties with fields, poles, and cross products [2]. The way of learning the magnetic force's concept still to be a problem.

In physics learning, demonstrations are useful and importance of acquired information. We can get more information about laws, concepts, and constructs of physics. also we can analyses processes and phenomenon of nature. With demonstration, knowledge is well memorized and for a long time retains in memory. Interactive Demonstration is the manipulation performed by the teacher by using simple tools, then the teacher asks a question to investigate or predict a possible situation. Teacher demonstrations, develop and ask questions, elicits a response, asking for an explanation, and assist students in making conclusions based on evidence.

In learning, some representations can be used to make easier for students to understand unclear concepts. The use of multiple representations in learning can provide many contexts for learners to understand a concept [5]. In the Ainsworth (2006) study also stated that multiple- representation in learning is necessary to develop the concept and build students' scientific ability[6]. According to [7] the use of multiple representations when solving problems affect learners' performance in problem-solving and can be used as a way to solve abstract problems.

In this paper, we look in detail at the innovation of learning model with increasing students' conceptual understanding. We focused how to learn the magnetic concept and explore student difficulties with hand rules and their understanding in solving problems.

Experimental design

Research Design. In this study, the research design was using the randomized static group comparison design with experimental class and control class. The effectiveness of interactive demonstration with multiple representation was tested by using t-test with two tail. There are two types of data in this research that is quantitative and qualitative data. Quantitative data in the form of test results and observation of learning implementation while qualitative data in the form of student interviews.

Population and Sample. The population consisted of 128 senior high schools' students of Grade XII in Purworejo, Central Java, Indonesia. The sample was selected by using random cluster sampling. There were 62 students who divided into experimental class (with N= 32) and control class (with N=30). Students in the experimental class were treated with interactive demonstration with multiple representation learning, and those in control class have been addressed with conventional learning.

Data Analysis. This research approach using quantitative and descriptive method. Data collection was conducted through a single study. Quantitative analysis is used to prove the hypothesis of research by statistical analysis t-test sample related with two tail in this study. The statistics were calculated with the aid of SPSS v. 17.0 program. Students' activeness in learning was analyses by counting active and not active. Students' response to questions from interview data are also analyzed. Descriptive analysis was performed through transcription and categorization in order to identify the students' difficulties commonly occurring when facing multiple representation, especially in solving problems regarding the magnetic field concept.

Results and Discussion

Learning Activity. Steps of interactive demonstration with multiple representation can be seen in Table 1.

Table 1

Teacher and students' activities in each step of interactive demonstration with multiple representation

Steps	Teachers' Activities	Students' Activities
Observation	- Provide a case that raises students' curiosity - Guide students to identify problems from topics to build student representation	- Students give their opinions on cases given by teachers with enthusiasm - Students use various representation in describing their opinions
Manipulation	Guides the students to write their prediction with a representation of images and verbal	Students write the predictions that cause each with a representation of images and verbal
Generalization	- The teacher guides the students into small group discussions and improves the prediction if there is a mistake. - Each group presented the results of the discussion	Representing the results of experimental analysis in mathematical, image and verbal form
Verification	- The teacher asks students to compare the results of the demonstration with the predictions that students have made. - The teacher identifies alternative conceptions that arise	Make analyze and evaluate inquiry processes and their initial hypotheses in various forms of representation
Application	Teachers guide students to apply what has been summarized into the application of everyday tools	Make resume of application in everyday tools

In interactive demonstration, teacher use simple tools which can be made from used goods in the neighborhood. In Figure 1, sample of simple tools which used to explain the direction of magnetic force. It was made from recycle wood, magnet from speaker, zinc plate.

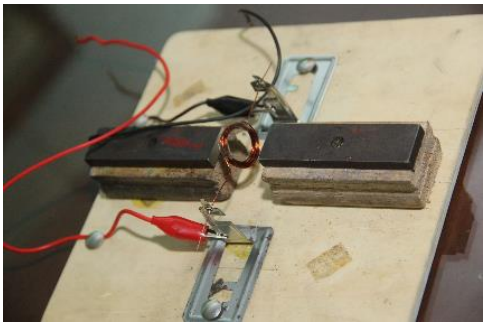


Figure 1. *Simple tools to demonstrate direction of magnetic field*

In first phase, observation, this simple tools are used to raises students' curiosity. When the cables are connected with power supply or batteries, the coil is round. Students give their opinion and can try to operate this simple tools with group. After observation, students write their prediction in picture and verbal representation. This phase was not usually for students. Sample of students' answer can be seen in Figure 2.

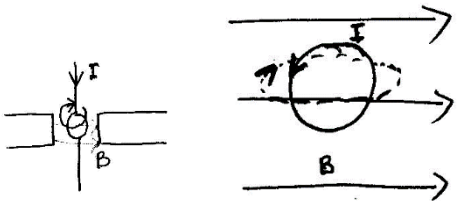
Picture representation	**Verbal representation**
	Arah arus (I) dan (B) menyebabkan kawat berputar. *Current direction (I) and (B) cause rotation of loop wire* Kawat berputar karena ada arus (I) yang berada di dalam pengaruh medan magnet (B) *Rotation of loop wire because of there is a current (I) in influence of magnetic field (B)*

Figure 2. *Sample of students' answer in Picture and Verbal Representation*

Next phase is generalization and verification. In these phase, students were enthusiastic during the observation and discussion activity. From observation showed 91% students were active and 9% were not.

Students response. Students response of interactive demonstration with multiple representation can be seen in Table 2.

Table 2

Students response of interactive demonstration with multiple representation in learning magnetic field

Statements	Percentage(%)			
	Strongly Agree	Agree	Slightly Disagree	Disagree
Learning phases is easier to done	81	19		
The simple tools make curiosity	96	4		
Interactive demonstration makes concepts understanding much better	91	9		
Multiple representation give easier way to explain the answer	78	12	10	

Most of the students gave positive responses. The application of that learning model was proven to be able to train process skills of students. They used their observation and various representation to get their conceptual understanding in magnetic field.

Post test results. Normality test results of post-test obtained statistical value of 0.133 with sig of 0.173, while the value of sig > 0.05 it can be said that both data were normally distributed. Test results of post-test difference between experiment and control class is presented in Table 3.

Table 3

Post-test difference between Experiment and control class in 2 meeting

Treatment class	**means**	**Std Deviation**	**t**	**Sig (2 tailed)**
Experiment 1	6.84	2.13	2.005	0.049
Control 1	5.90	1.57		
Experiment 2	8.97	2.21	6.023	0.000
Control 2	6.03	1.65		

In the first meeting showed t = 2.005 with sig 0.049. It can be concluded that there is a significant difference between the experimental class and the control class. At the second meeting showed t = 6.023 with sig 0.000, when

compared with t_{table} then the conclusion is there are significant difference between experiment class and control class. This suggests that in learning using interactive demonstration with multiple representation is effective to improve conceptual understanding in magnetic field.

Interview results. After completing the test then at the next meeting conducted interview. In the interview section, there was some finding. Right-hand rules were the predominant method for solving the direction of magnetic field problems. Every student explicitly used their prior physics knowledge to answer physics problems with right-hand rule that usually use. They said that known right hand rule from memorize that they found from their high school teacher. In deep interview we also found that when student have been accustomed with one model of right hand rule, it will be difficult to learn magnetic force with another model. And many students do not know what is the meaning of this rule. As the result, when confronted with problems, many students become confused in applying.

From the appearance of the right-hand rule in the late 1800s, it has changed and accumulated over the years, culminating in several that are used in most introductory physics courses [8]. In study of magnetism, right-hand rules became pronounced, where cross products are used to describe numerous phenomena, such as the force on a charge moving in a magnetic field. Since it is one of the most common way for finding the direction of a cross product, many researchers have speculated that poor performance on it [1], [9], [10]. Application of the right-hand rule that is not appropriate in solving physics problems and the cross product problems or the failure to use such a rule.

Although performance on basic vector concepts was better than that on vector multiplication, students seem to have an innate sense of their knowledge about vectors overall, as evidenced by the disconnect between experience and performance. In deep interview we found that on the questions about the direction of magnetic force, the most common incorrect response involved a sign error. The force would be perpendicular to the field and the velocity of the charge, but opposite the correct direction. This error, too, was dependent on the representation of the field. For those given a problem with magnetic poles, this sign error was at least partly due to reversing the direction of the magnetic field (from south to north instead of north to south). However, Scaife and Heckler (2010) found that these sign errors were not systematic, indicating that there are multiple sources for this incorrect response. Additionally, the same research suggests that students struggle with understanding cross products outside of any physics context, as well as in the context of magnetism and in other physics areas such as torque [3], [9], [11].

Conclusion. Learning by applying interactive demonstration with multiple representation has given authentic experience for teacher. This finding is in line with the finding [12] that the students' science process skills that will increase if they have the experience to perform or train these skills.

From interview results present compelling evidence that there are many factors influencing students' difficulties with magnetic field concepts. Some of these factors include the application of various right-hand rules, physics content issues, the orientation of the vectors, the symbols used, and the type of reasoning required. If we want our students to answer our test questions correctly, we can design problems that avoid these issues.

Based on the results of those study it can be concluded that the application of interactive demonstration with multiple representation was effective to be applied as learning model in increasing students to understand abstract concepts. Learning activity has changed the conception of determine magnetic field direction. The conclusion of this research based on Sun, *et.al* finding said that when learning model is effective to be applied, it indicates that it is suitable to students' learning styles and characteristics [13].

The application of interactive demonstration with multiple representation invoked Based on the research results, the researcher recommends for each physics teacher to apply interactive demonstration with multiple representation because it give precious experience to students to construct their own knowledge with various ways.

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ІНТЕРАКТИВНА ДЕМОНСТРАЦИЯ З РІЗНИМИ ЗОБРАЖЕННЯМИ ПРИ ВИВЧЕННІ ПОНЯТЬ ТЕОРІЇ МАГНІТНОГО ПОЛЯ

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Анотація. *Метою даного дослідження є підтвердження ефективності використання інтерактивної демонстрації з різними зображеннями для підвищення розуміння студентами понять теорії магнітного поля. Вибірка з 62 студентів вибирається випадковим чином з числа учнів старших класів. Результати тесту показали, що розподіл учасників є нормальним. В експериментальному класі навчання проводилося з використанням інтерактивної демонстрації з різними зображеннями, в той час як у контрольних класах навчання проводилося традиційно. Результат дослідження показує, що (1) навчання із використанням інтерактивних демонстрацій з з різними зображеннями є більш ефективним в плані підвищення у студентів розуміння понять теорії магнітного поля в порівнянні з традиційним навчанням; (2) використанням різних способів зображення допоможуть школяреві мінімізувати труднощі, повязані з векторним добутком та використанням правила буравчика, орієнтації векторів. Модель навчання розглядається в якості альтернативи на заняттях з метою навчання учнів формулювати їх відповіді різними способами при вивченні абстрактних понять.*

Ключові слова: *інтерактивна демонстрація, різні зображення; магнітне поле.*