Attainment of students’ conception in magnetic fields by using of direct observation and symbolic language ability

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Abstract. This study focuses on description attainment of students’ conception in the magnetic field. The conception was based by using of direct observation and symbolic language ability. The method used is descriptive quantitative research. The subject of study was about 86 students from 3 senior high school at Purworejo. The learning process was done by guided inquiry model. During the learning, students were required to actively investigate the concept of a magnetic field around a straight wire electrical current. Data retrieval was performed using an instrument in the form of a multiple choice test reasoned and observation during the learning process. There was four indicator of direct observation ability and four indicators of symbolic language ability to grouping category of students conception. The results of average score showed that students conception about the magnitude more better than the direction of magnetic fields in view of symbolic language. From the observation, we found that students could draw the magnetic fields line not from a text book but their direct observation results. They used various way to get a good accuracy of observation results. Explicit recommendations are presented in the discussion section at the end of this paper.

1. Introduction

Scientific theories are characterized by the ability to predict and to observe of natural phenomena. The concept of magnetic field, used in a relation of electric current and magnetic phenomena, is a good example of these characteristics. In this paper, we look in detail at the conception of senior high schools students by using of direct observation and symbolic language ability. The conception encounter with the concept of magnetic field in the context of the relation electric current with magnetic phenomena.

The field concept is theoretically more challenging than the force concept. It also requires a change in the theoretical thinking of students. This change takes place when the surrounding space around the source is being described with a field—without having any other object with which to interact and thus exert a force so that the ‘action at a distance’ model is replaced with a model
describing the action with field source [1]. According to earlier studies, the students fail to described direction of magnetic field around a straight current carrying wire[2]. Another learning, on previous research by Thong & Gustone [3] which looked at the need to help students come to an understanding of both the nature of the construct "field" and the purpose physicists has in creating this construct.

Magnetic phenomena have been experienced by many students from a young age. As these students enter high school and encounter more abstract and mathematically structured magnetic field concepts. When learning process, usually teachers require students to use sophisticated ideas they are not familiar with, but the experiences in their daily lives are not often taken into account in formal education [3].

A growing body of research in physics education indicates that a majority of students have difficulty learning basic physical concepts in a course built around traditional lectures, textbook problems, and verification experiments [4], [5]. These studies indicate that for improved learning, students must engage actively in close interaction of students with their peers. And the laboratory can be an excellent environment [5][6]. The laboratory should help students to understand the role of direct observation in physics and to distinguish between inferences based on theory and the outcomes of experiments.

Physics consists of concepts, hypotheses, theories, and observations. All of them are connected. On laboratory experiments, it is often difficult to separate inferences based on theory from direct observations. Students should understand that experimental evidence is the basis of our knowledge of the laws of physics and that physics is not merely a collection of equations and textbook problems. Many students have no concrete experience with everyday phenomena. Whereas it is important to understand the relationship between observations and concepts in physics. The process of observing phenomena, analyzing data, and explaining observations can develop verbal and mathematical abilities. This is because the process provides an opportunity for students to connect concrete experiences with scientific theory.

In the classroom, objective interpretation raises different interpretations between the formation and meaning of symbols. The difference in symbolic language used in a single concept makes it difficult for students to understand the meaning and relationship between symbols. This difficulty relates to problems in semiotic processes [7]

2. Research Method
The study was conducted at about 86 students from 3 senior high school at Purworejo. The data were gathered by using a paper and pencil test and observation during learning.

In this research, we observe students' activities in doing the experiment. Steps of learning are:

a. Student doing the investigation in group
b. in the process of learning, we observe their direct observation ability
c. Student make a report from their investigation
d. The researcher assessed students' report based on the conception by using symbolic language ability. The range of score is between 1 and 10.

Guided by assessment and observation were using indicators in Table 1. It has been arranged based on some early studies [4], [7],[8].

Table 1. Categories of explanations given by students and corresponding typical answers

| Students’ Ability | Indicator |
|-------------------|-----------|
| Direct observation| describe objects according to observations |
|                    | select the information by the purpose of the investigation |

2
apply the principles of physics in the reported observations
use the scientific method to obtain the accuracy of the observations
Symbolic Language
use symbols appropriately
use mathematical rules to solve problems
read draw and mathematical signs of the magnetic field direction and electric current
understand the quantitative meaning of units and magnitudes of magnetic field equations

3. Results and Discussion

3.1 Paper and Pencil Test's Results

The test consists of eight problems (four problems about the direction of magnetic fields and four problems about the magnitude of magnetic fields). Students finished the test about 30 minutes. And then the results were analyzed in average score depend on a group of the problem), as seen in Table 2.

Table 2 Average score of Students’ conception of magnetic field around current electric wire

| Problems                        | Symbolic Language (Average score and Standart of Deviation, N=86) |
|---------------------------------|---------------------------------------------------------------|
|                                 | 1       | 2       | 3       | 4       |
| Direction of magnetic fields    | 5.83    | 6.01    | 6.06    | 6.20    |
|                                 | 1.31    | 1.16    | 1.28    |
| Magnitude of magnetic fields    | 6.36    | 6.35    | 6.46    |
|                                 | 1.71    | 1.20    | 1.12    |
|                                 | 6.65    | 1.03    |

From Table 2, we can see that students conception about the magnitude more better than the direction of magnetic fields in view of symbolic language. For example, in problem 1 (as seen in Figure 1), There were four sketches that describe the relation electric current with magnetic field surrounding. The student should select the direction of the magnetic field from 4 sketches and give their reason.

In symbolic language, they should read the figure of the magnetic field direction and electric current. After that, they should write the reason of their answer based on their observation. In this section, many students get failed to describe and explain the reason based on their observation.
As seen in Figure 2, they didn't explain about the direction of compass needle-like their observation. They said it because of right-hand rules. They should be written their analysis about the change of electric current direction with the deviation of a compass needle. In another problem, students were asked to give reasons on how to get the magnetic field value. Answers given by students tend to use verbal language. The use of symbols and mathematical signs is still very small.

In indicator using symbolic and mathematics rules to solve the problems, the average score was much better than two indicators before. Students can solve problems with proving in mathematics rules and using notation (as seen in Figure 3).

Some students have used the units correctly and know the relationship between units of magnetic field equations. Other students still confused with a unit of magnetic field. They said weber/meter² (Wb/m²) is different with tesla (T). From the previous study [9], also found that symbolic language ability was one of the abilities that needed in learning the magnetic concept. The direction of magnetic field is sometimes stated in a direction to paper view or observer. For example, into the paper or go away from the observer and out of paper or near observer. This state was confusing for the student when applicate to solve the problem.

### 3.2 Observation during learning process

Learning the concept of the magnetic field has been done with the inquiry through experimentation. Students are required to actively carry out an investigation in groups and conduct their investigation. Nevertheless, the teacher still provides guidance in making conclusions from the results of the investigation.

Observations were made by two observers. The process of focusing on observation is the ability of students to perform direct observation and symbolic language. There are two concepts that are investigated in this study is determining the direction and magnitude of the magnetic field. The first investigation is the magnitude of the magnetic field. Determination of magnitude is done using iron powder and plotting compass. Students made observations on the pattern of iron powder and compass needle deviations on the electric current changes strongly. The second investigation is the direction of magnetic field. Determination of the magnetic field direction is done using some plotting

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Figure 2. Example of the reason of students’ answer from problem number 1

| Reason 1 | Reason 2 |
|----------|----------|
| Using right-hand rules | Increasing electric current \( i \) makes \( B \) stronger. |
| The farther the distance \( a \), makes \( B \) smaller. | \( i \) direction influences on \( v \) direction |

Figure 3. Example of students’ answer in a view symbolic language ability

\[
\begin{align*}
\text{1.} & \quad f = \frac{N}{A} \\
\text{2.} & \quad B = \frac{\mu_0 I}{4\pi} \\
\text{3.} & \quad a = \frac{\mu_0 I}{4\pi} \text{ cm}
\end{align*}
\]
compass that is placed around the electric current carrying straight wire.

Some findings during observation are student can better understand the magnitude and direction of magnetic field. But they have difficulty in describing the deviation of a compass needle in paperwork. The first indicator of direct observation is described object based on observation. The pattern of iron powder indicates the magnitude of magnetic field. From the observation can be observed that if the closer to the wire hence the pattern of iron powder will be more tightly. To observe the relation of the magnetic field and electric current, the students vary the magnitude of electric current. And they draw any pattern changes that occur. The ability of selected information according to the purpose of the investigation is needed. The direction of the magnetic field is the same as the direction of the magnetic force line. The magnetic field magnitude is proportional to the magnetic force line density. The next activity was observed against deviations compass needle around the current-carrying wire. The problems encountered were students' difficulties in reading the compass. In the previous study, also found that pre-service teachers have difficulty interpreting the pattern and direction of the magnetic field with the direction of the compass needle deviation [2]. It was indicated that experiments illustrated how the learning path provides the students with a set of experiences and observations that allow them to explore experimentally the phenomenology of the magnetic field. [5].

In discussion session, found that some student couldn’t apply the principles of physics in the reported observations well. They didn't use principles of north and south in magnet when reading compass needle deviation. And at the beginning of observation, principles of flowing electric current still forgotten. Therefore, teacher guidance is necessary during learning. In the inquiry, the assistance provided by the teacher aims to train students in conducting the process of independent inquiry process [10].

4. Conclusion

The results from of the proposed learning illustrate the necessity to introduce a specific experiment. The aim was to allow students to explore magnet property of the object, and giving them a "practical" idea of the magnetic field through the simple observation done by the needle of the compass.

Experiments illustrated how the learning path provides the students with a set of experiences and observations that allow them to explore experimentally the phenomenology of the magnetic field around the electric current wire. Providing a first explanatory model based on an idea that even though it does not have the whole structuration required by the theory of direction of the magnetic field, it has its main conceptual cores, and even if the pupils use the magnetic field in a non-quantitative way, it has its main phenomenological characteristics.

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