Pattern of mathematic representation ability in magnetic electricity problem

R R H Hau1,2,*, P Marwoto1 and N M D Putra1

1 Program of Physics Education, Graduate Program, The StateUniversity of Semarang, Jl. Kelud Utara III, Semarang City 50237
2 Program of Physics Education, University of Nusa Nipa, Maumere 86111

*Corresponding author : hrambu@yahoo.co.id

Abstract. The mathematic representation ability in solving magnetic electricity problem gives information about the way students understand magnetic electricity. Students have varied mathematic representation pattern ability in solving magnetic electricity problem. This study aims to determine the pattern of students’ mathematic representation ability in solving magnet electrical problems. The research method used is qualitative. The subject of this study is the fourth semester students of UNNES Physics Education Study Program. The data collection is done by giving a description test that refers to the test of mathematical representation ability and interview about field line topic and Gauss law. The result of data analysis of student's mathematic representation ability in solving magnet electric problem is categorized into high, medium and low category. The ability of mathematical representations in the high category tends to use a pattern of making known and asked symbols, writing equations, using quantities of physics, substituting quantities into equations, performing calculations and final answers. The ability of mathematical representation in the medium category tends to use several patterns of writing the known symbols, writing equations, using quantities of physics, substituting quantities into equations, performing calculations and final answers. The ability of mathematical representations in the low category tends to use several patterns of making known symbols, writing equations, substituting quantities into equations, performing calculations and final answer.

1. Introduction

Electrical magnetic topics have abstract, difficult and complex characteristics. The results of [1] and [2] research showed students difficulties in understanding magnetic electricity topic. Further research conducted [3] states that the concept of electricity and magnetism is a difficult concept. It is also stated [4] that the concept of electricity and magnetism in physics is complicated. Based on the observation on the field, students have difficulty in solving the problem in the magnetic electricity course. The questions in magnetic electrical courses are identical to mathematical solutions. Most students write it immediately without considering the context. This situation may cause the students find it difficult to solve magnetic electricity problems. One of the factors causing this is the lack of ability of mathematical representation, as an example, students used to memorize the physics formulas in the form of mathematical equations but they do not understand the meaning of it so it makes students find it difficult to do the calculations. The initial phase of the problem solving of physics relating to the use of external representations [5]. The process of qualitative thinking in solving quantitative problems is part of the mathematical representation ability. The mathematical representation is the symbolization and modelling of physics concepts and the relation contained in a particular configuration, construction, or particular problem situation displayed by students in symbolic form as an effort to gain clarity of meaning, to show their understanding, or to find a solution of the problems. This is in accordance with the results of research [6] states that students tend to use mathematical representation than other representations. The scope of the ability of mathematical representations is in the form of numerical and symbols used in mathematical equations, and symbols of a label such as F for style and others. Symbols are also used to denote units such as kilometres (km), kilograms (kg) and others [7].
[8] states that the sign = (equal to) in physics has more meaning than just meaning "equilibrium" as in algebra. This study aims to find the specific patterns of mathematical representation ability in solving magnetic electrical problems.

2. Methods
This research uses qualitative research method of grounded theory design. The subject of this research is the fourth semester students of Physics Education Study Program of Semarang State University (UNNES). Techniques of data collection are written test, in which student is given test of 4 description questions about ability of representation of mathematics, and interview test on field line topic and law of Gauss. Students' answers were analyzed to determine the pattern of mathematical representation ability in solving magnetic electrical problems.

3. Result and Discussion
Results of students’ work are analyzed based on rubric of scoring ability of mathematical representation. The result score of students' mathematical representation ability is categorized into three categories that is high, medium and low and the result for interview for each category are coded R11 for high category, R8 for medium category and R9 for low category as respondent. Based on the result of respondents’ description in each category, the pattern of mathematical representation ability in solving magnetic electrical problem is found.

3.1. Pattern of ability of high category mathematical representation in solving magnetic electrical problem
The pattern of high category mathematical representation ability in solving magnetic electrical problems is shown in Figure 1.

![Figure 1. Higher Mathematical Representation Ability Coverage Pattern in Electrical Magnetic Problem Solving.](image)

The pattern of ability of high category mathematical representation is shown in Figure 1 based on the result of the test of mathematical representation ability. It indicates that the answer given is based on a previously acquired understanding. Therefore, it can be concluded that students with higher category of mathematical representation tend to use the pattern by making known and asked symbols, writing equations, using quantities of physics, substituting quantities into equations, performing calculations and final answers. There is a difference in the writing of the charge symbols covered by
the integral form of Gaussian law. Likewise, they do not write vector signs on nabla symbol in conservative field equations.

R11 wrote it based on a previously acquired understanding that results in a habit. The process of decomposition of the Gaussian equation of this integral form, the students do not pay attention to the vector sign. This is because the students had not understood the purpose of deciphering the vector sign in this equation. It is seen from the student's answer "Yes because e and de are all parallel, with cos 90 equal to zero then e at any point on the surface of Gauss same as this". The process of solving the problem of mathematical representation skills of R11 used excellent mathematical knowledge. This can be seen from the result of the students' work in solving the math problems during the interview and (mean) and the average score of the study result of the Mathematics Basic subjects in the high category get the value of 87 (high). Physics teaching has been using mathematical approach. This is in line with the opinion [9] which states that the lecturers spend too much time on math problems. This condition traps students to the habit of memorizing physics formulas rather than understanding the physical meaning of physical concepts in representational form. It is found in a student answer in solving the problem number 3 on the following interview excerpt,

   "answer number 3 is all right, how do you solve it?"

   R11: "It's like an example I've given and I'm pretty sure it's a way of resolving it"

This can cause the students find it difficult in solving problems in accordance with the understanding of the concept. To solve the problems of physics requires logic, literal and creative thinking [10]. The possibility of science literacy in the science category as a body of knowledge is still low. It can be seen from the understanding of curl in the spherical coordinate system, the students find it difficult to write the formula on the answer of number 4 [11]. This is due to the students' knowledge of memorizing the physics formula, as it is said [12], the skilled students saw problem solving as a process, while the less skilled students thought that problem solving is recalling task.

3.2. Pattern of ability of medium category mathematical representation in solving magnetic electrical problem

The pattern of ability of medium category mathematical representation in solving magnetic electric problem is shown in Figure 2.

![Mathematical Representation Ability Pattern Category Medium in Electrical Magnet Problem Solving](image)

The pattern of mediocre mathematical representation capabilities shown in Figure 2 is based on the results of the mathematical representation work test based on the previously acquired understanding. Students with medium category mathematical representation tend to use several patterns of writing down known symbols, writing equations, using quantities of physics, substituting quantities into
In the writing of embedded charge symbols, ephsilon and electric field vector signs on the integral form Gaussian legal equations. Likewise, respondents did not write vector signs on nabla on conservative and electric field and Gauss extention on the integral Gaussian law equation. R8 was confused to write it down and becomes a habit that causes students find it difficult in understanding the use of a symbol. The symbol written covered is written "Qc" and the zero ephsilon symbol is written "\( \varepsilon_0 \)". It is contained in the book *Introduction to Electrodynamics* [13] and *electromagnetic books* [14]. In general the writing of the correct vector sign is to write the variable with italics, bold and give arrows on the variable. For example the electric field vector signing “\( \mathbf{E} \)”. During the process of decomposition of Gaussian equations in integral form, the students did not pay attention to the vector sign. This is because students had not fully understood the concept of Gauss law. Similarly to the results of the study [15] finding the question of vectors in the physical context is more difficult to represent. The process of solving 3 questions in a test of mathematical representation ability R8 were confused in determining the integral boundaries in a volume which was based on the results of student work in solving math problems at the time of interview can be quite good and also the average value of the study results for the category of subjects in Basic Mathematics obtained a value of 79 (medium). This means that students have difficulty with mathematics on physics issues. Descriptive results also reveal that the majority of students believe that mathematics and physics are interrelated with each other in terms of content [16]. In accordance with what was found by [17] that there are constraints faced by students when applying calculus to field problems. The results of the study for the medium category in the Mathematics Physics course 1 get a score of 70 (medium) and Mathematical Physics 2 get a value of 72 (being). Therefore it requires a deeper understanding in solving magnetic electrical problems.

3.3. Pattern of ability of low category mathematical representation in solving magnetic electrical problem

![Mathematical Representation Ability Pattern Category Lowin Electrical Magnet Problem Solving](image)

The pattern of ability of the low category mathematical representation in solving magnetic electrical problems is shown in Figure 3. The mathematical representation ability pattern of the low category shown in Figure 3 is based on the results of the mathematical representation ability test which showed the previously acquired understanding. Thus, students with low categories of mathematical representation tend to use several patterns of making known symbols, writing equations, substituting quantities into equations, performing calculations and final answers. There are some differences in writing the covered symbols and not writing vector marks on the extension of Gauss on the integral form of Gaussian law equations. Likewise not writing vector signs on nabla for conservative field
equations. R9 had confusion to write it down and forget that cause student find it difficult in understanding the use of a symbol. This can be seen from the answers of students on the following interview excerpt.

P : “why is q formula like that?” And why on the equation you write, q, symbol is written lowercase, and da is this how to write it?
R9: “that is what i confused mba, I still find it difficult to understand and q, the content covered, is written like this. The de must have vector signs, forget mba, I was in a rush when I wrote that”
P : ”ok well, so this is your answer” next will you write symbol like this “
R9: ”yes mba, I was in a rush. It should be written as a vector symbol with arrow marks showing the value and direction"

The covered symbols writing is written "Qc" and the symbol of Gauss is written "da". in accordance with the book Introduction to Electrodynamics [13] and in the electromagnetic book [14]. It is similar as, writing the correct vector sign is to write the variable with italics, bold and give the arrow above the variable. For example the electric field vector signing "\(\mathbf{E}\)". The process of decomposition of integral form Gaussian equations, the student did not pay attention to the vector sign, it is similar to R11 and R8. In line with the results of the study [18], students' understanding of vectors is still low. Students look for quantity of Gauss area with wrong formula. R9 did not look for quantity of cylindrical coordinate system for the ball, some answers did not substitute quantities on equations, did not perform calculations and no final answer. This is because students had difficulties in applying mathematics to physics but their mathematical knowledge is good enough as it can be seen from the result of mathematics work at the interview time and the average value of the results of the study in the low category for Basic Mathematics courses had a score of 76 (medium). Similarly, the average value of Mathematics Physics subject 1 g ot 65 (low) and Mathematics Physics 2 got 66 (medium). Another thing found understanding about curl in spherical coordinate system, students have trouble writing the formula on answer about number 4.

Therefore, cognitive role is very necessary in the pattern of mathematical representation skills related to mathematical knowledge into the physics problem that shows the understanding of the concept in solving physics problems. [19] found that cognitive role is very important to be used in mathematical representation in physics. Similarly, found [20] students experience obstacles in representing the understanding of the concept. The difficulty of representation increases because of the lack of students' ability to connect physics knowledge with mathematics. Students have difficulties because of misuse of the principles and concepts of Physics. The format of representation raised in physics includes a mathematical representation that includes symbols of an object, mathematical formulas and operations. [14] found an obstacle facing students when applying calculus to field problems.

4. Conclusion

Based on the results of research and discussion, it can be concluded that the pattern of mathematical representation ability in solving the problems in the high category, medium category and low category varied in solving the physics problem in magnetic electrical lecture. Higher category tend to use patterns that make symbols known and asked, write equations, use quantities physics, substitute quantities into equations, perform calculations and final answers. The medium category tend to use several patterns by writing down known symbols, writing equations, using quantities of physics, substituting quantities into equations, performing calculations and final answers. The low category tend to use several patterns of making known symbols, writing equations, substituting quantities into equations, performing calculations and final answers.

References
[1] Demirci N and Cirkinoğlu A 2004 J Turkish sci educ 1 51
[2] Narjaikaew P, Emarat N, Soankwan C and Cowie B 2006 Year-1 Thai University Students’ Conceptions of Electricity and Magnetism(Physics Educational Network of Thailand (PENThai) and The Centre for science and Technology Education Research (CSTER))
[3] Dega BG, Kriek J and Mogese TF 2013 J Res Sci Teach 50 677
[4] Nousiainen M and Koponen IT 2017 Eur J Sci Math Educ 5 74
[5] Mansyur J 2015 Int Educ Stud 8 1
[6] Kusumawati I, Marwoto P and Linuwih S 2015 AIP Conf Proceeding 1677 040017
[7] Gilbert J K 2010 Asia-Pasific forum sci learn teach 11 1
[8] Xiaoyu W 2011 Phys Teach 49 405
[9] Lindenfeld P 2002 Am J Phys 70 12
[10] Hedge B and Meera BN 2012 Phys Educ res 8 1
[11] Rusilowati A, Kurniawati L, Nugroho SE and Widiyatmoko A 2016 Int J Environ Sci Educ 11 5718
[12] Harper K A 2006 Phys Teach 44 250
[13] Griffiths D J 1999 Introduction to Electrodynamics (New Jersey : Prentice Hall, Englewood Cliffs)
[14] Wiyanto 2008 Elektromagnetika (Yogyakarta : Graha ilmu)
[15] Kapucu S, Özcal M F and Simsek M 2016 Evaluating High School Students' Conceptions of the Relationship between Mathematics and Physics: Development of a Questionnaire. Sci Educ Int 27 253
[16] Zavala G and Barniol P 2013 AIP Conf Proceeding 1289 341
[17] Cui L, Sanjay N, Rebello, Fletcher PR and Bennett AG 2006 Proceeding sof the NARST 2006 Annu Meet (San Fransisco)
[18] Barniol P and Zavala G 2014 Phys Rev ST Phys Educ Res
[19] Tweney D R 2009 Top Cogn Sci 1 758
[20] Nguyen DH, Gire E and Rebello N S 2010 Facilitating Students’ Problem Solving across Multiple Representations in Introductory Mechanics (Department of Physics, 116 Cardwell Hall, Kansas State University, Manhattan, KS 66506-2601)