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Comparison of Problem Solving Between the Use of Columb's Law and Gauss Law for the Determination of the Electric Field

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Abstract

Problems are an essential part of human life, and problem-solving strategies have been shown to improve students' critical thinking skills. This study aimed to describe students' understanding of Coulomb's law and Gauss's law through problem-solving tasks in determining electric fields. The research was conducted during the odd semester of 2021 at Tadulako University using a qualitative descriptive approach. Six students were selected as respondents based on the Respondent Selection Test (RST), representing three ability levels: moderate, low, and very low, with two students in each category. Data were collected using essay-based problem-solving tests consisting of five questions and supporting instruments. Data credibility was ensured through credibility testing, and the results were analyzed descriptively. The findings showed clear differences in students' problem-solving performance across the three ability levels. Most students were more familiar with applying Coulomb's law than Gauss's law when solving electric field problems. Students also experienced considerable difficulty determining the electric field produced by an infinitely long wire. The study concludes that while Coulomb's law is more commonly understood, Gauss's law serves as an effective alternative for determining electric fields, particularly in situations involving symmetrical charge distributions and homogeneous spatial geometries.

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Introduction

Problems are part of human life. Almost every day people are faced with problems that need to find a way out. Problems are often referred to as difficulties, obstacles, distractions, dissatisfaction or gaps (Sastri et al., 2019). One indicator of intellectual behavior is the ability to solve problems (problem solving). According to Ince (2019) the application of problem solving strategies can improve students' critical thinking skills. These results can be implemented in physics lessons such as electromagnetism, thermodynamics, optics, etc. Problem solving ability in determining the electric field can be known based on students' understanding of the concept (Mason & Sigh, 2016). The benefits of this research can be used as material for further research as well as information about problem solving descriptions in solving physics problems about Coulomb's law and Gauss's law.

Mason & Sigh, (2016) problem solving is involving students actively and providing feedback based on their needs, so that learning becomes meaningful, students must be actively involved in the learning process. In addition, it is important to consider the difficulties that play a role in building their previous knowledge, with adequate problem solving abilities that will make it easier for students to deal with work situations filled with various problems that must be solved (Sung, 2017) Therefore, it is very important for participants students know the determination of the electric field by using problem solving because it can stimulate the mindset of students in solving problems in the questions given. Coulomb's law is widely used in almost all branches of physics, not only in the fields of electromagnetism and electrodynamics, but also in quantum mechanics, cosmology, and thermodynamics. Studying the superposition of Coulomb's law, symmetry in Gauss's law can help students improve their understanding of calculus-based physics concepts (Jing. & Singh, 2018).

Belyaev, A.S. (2020) Gauss's law can be an alternative method of helping students understand wave theory and electromagnetic fields (EMT), Gauss' law is also an alternative to Coulomb's law. In this case Coulomb's law states the relationship between electric charge and electric field related to the effect of distance on the coulomb force, and the effect of the type of charge on the direction of the coulomb force, namely the greater the charge, the greater the value of the resulting coulomb force. The farther the distance between q1 and q2, the smaller the coulomb force value with the same

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magnitude of charge q1 and q2, and the same type of charge will repel, different types of charge will attract. Based on this description, this finding will be very important as an initial effort to find out the use of Coulumb's law and Gauss's law in determining the electric field, by describing how the relationship between determining the electric field uses the problem solving method.

Materials and Method

This research is a qualitative description research, namely the research aims to systematically describe the facts and characteristics of the object or subject studied.

This research was conducted at Tadulako University in odd semesters of 2021. The research subjects were students of FKIP Physics class of 2018 at Tadulako University. Respondents who were the source of qualitative data were 6 people with moderate ability 2 people, 2 people low and 2 people very low based on the results of the Respondent Selection Test (RST). From each ability level, 2 people were selected for the variation of the data which includes the possibility of occurring in the field.

Before analyzing problem-solving abilities in solving questions, of course, researchers look for respondents first. In this study, questions were used in the form of multiple choices representing three categories, namely moderate, low and very low categories to measure students' abilities according to the desired domain and according to their level of difficulty.

All students in one class were selected as research subjects. Then the questions were distributed in the form of multiple choices. After the process of giving the test is complete, the researcher checks the results of the test answers given. From the students who were given the multiple choice test, 6 people were selected with 2 students each with moderate, low and very low ability to be given essay questions again.

To select the six respondents, the following formula was used: To select the six respondents, the following formula was used: (Memon et al, 2020) To calculate the average value of students in the standard deviation, the following formula is used:

To calculate the average value of students in the standard deviation, the following formula is used:

The type of data used in this study is quantitative data in the form of test results for selecting respondents and then conducting respondent tests and the data is analyzed quantitatively.

The preparation stage is the initial stage before conducting research. At this stage the researcher carried out several stages, namely searching for literature related to the research topic, compiling a respondent selection test instrument (RST) for multiple choice questions, consulting the instrument made to the supervisor, compiling an essay test instrument to analyze student problem solving in determining the electric field using Coulomb's law and Gauss's law then consulting with supervisors, determining research locations and research subjects, arranging field survey permits, and making answer sheets according to the number of respondents

steps in the stages of conducting research namely Providing initial debriefing on the subject matter, aims and objectives of the research, explaining how to fill in the instrument and guiding respondents, as well as documenting the research, collecting answer sheets for the instrument respondent selection test, analyzing the results of the respondent selection test (RST), selecting 6 respondents with three variations of respondent selection test results, consisting of 1 male and 5 female then distributed 5 essay test questions to 6 selected respondents, collected essay test answer sheets, analyzed question and answer essay test results, conducted interviews with selected respondents and documented research.

Activities in the final stage include managing student ability test data in solving electric field determination questions, analyzing and discussing research findings, providing conclusions and making recommendations based on the results obtained from data processing, and preparing research reports (Bowen, 2019).

The research instrument was in the form of a test consisting of 30 multiple choice questions regarding the electric field material which was given to students in one class to select research respondents, then given a comparative test of the basic formula in the form of electric field description questions to measure higher problem solving abilities. in the cognitive aspect according to student perceptions.

The purpose of conducting interviews in this study was to reinforce respondents' statements on test answers or to strengthen in analyzing students' problem-solving abilities in determining electric charge.

The stages of qualitative data analysis are data reduction, data presentation, and conclusion and verification (Pane at al., 2018).

The data analysis used in this study was based on the answers given by students from the tests given. The research data analysis technique is the scoring of students' answers, the average score and the standard deviation (Manfaat et al., 2021).

Results and Discussion

The results of the respondent selection test obtained the highest score of 53.33 and the lowest value of 13.33 while the average value obtained from the results of the respondent selection test was 25 and the standard deviation was 9.81.

Respondents in the high category are respondents who are above 34.81. Determination of the high category value is obtained from the results of adding the average value to the standard deviation value (25 + 9.81). The low category of respondents is the value of respondents who are

below 15.19. The determination of the low category value is obtained from the result of subtracting the average value from the standard deviation value (25 - 9.81). Respondents in the moderate category are respondents who are between 15.19 – 34.81. The determination of respondents in the middle category is obtained from the lower limit value for the high category and the lower limit value is (Sudjana, 1996).

The results of this study were obtained from all the data while the researcher was carrying out the research process using supporting instruments that had gone through the process of credibility testing and data analysis techniques. The data is described based on the ability of the respondents who were selected in three categories, namely 2 students in the Moderate Category Respondents (RMC), 2 students in the Low Category Respondents (RLC), 2 students in the Very Low Category Respondents (RVLC) were given 5 number problem solving questions in the form essay.

(Susanto & Budhi, 2019) Discussion of research results which include descriptions of students' understanding of concepts through problem solving tests and interviews in thinking aloud. Sonmez & Sulak, (2018) the thinking aloud strategy can develop student understanding, the implementation of which is going well and has a positive effect on students' critical thinking skills (Anggraeni et al., 2019).

According to Arwanto et al. (2018), RKSR1 uses affirmative intuition, namely to understand problems using direct (self-efident) cognition. This means that cognition is received directly by individuals without the need for further checking and verification which is carried out only by making observations, in solving problems a thinking process is needed that is different from analytical and logical thinking. Furthermore, when connected with Kustos (2010), there is a feeling component, meaning that RVLC1 only uses feeling in solving problems.

For the discussion of question number four, RMC1 solved the problem using the Coulomb's law approach, according to him it was easier to use Coulomb's law than Gauss's law and there was no additional explanation about the reasons for choosing that answer Tiandho et al., (2020).

For question number two, RLC2 understands the problem through image analysis, so when answering the question using the Coulomb's law approach, but RLC2 is wrong to keep the negative source charge secret, RLC2 describes the direction of the field lines coming out, as shown below:

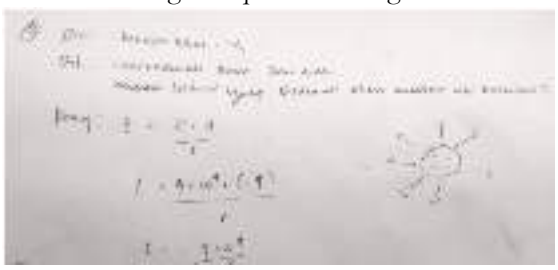


Figure 1 The answer to question number two using the Coulomb RLC2 law approach describes the direction of the field lines out

In addition, RLC2 directly from the Coulomb's law equation without explaining the use of vector units

For question number two, the test charge is negatively charged, so that it is the same as the charge charge so that the direction of the test charge is away from the source charge, related to the opinion of Hudoyo, (2001) mistakes in learning a previous concept will affect the understanding of the next concept because glasses are a structured lesson.

According to Karmila & Narius, (2019), the mistakes made by students can be classified into several forms of error, including: 1. Procedural errors, namely in using algorithms (work procedures), for example errors in performing arithmetic operations. 2. Errors in organizing data, for example errors in writing down what is known, what is asked of a problem. 3. Errors in sorting, grouping and presenting data. 4. Errors in the use of symbols, tables and graphs that contain information. 5. Errors in mathematical manipulation, characteristics in solving problems. 6. Errors in drawing conclusions. For example, mistakes in writing conclusions from the problems they have worked on.

For the discussion of question number four, RMC1 solved the problem using the Coulomb's law approach, according to him it was easier to use Coulomb's law than Gauss's law and there was no additional explanation about the reasons for choosing that answer (Dolocan & Dolocan, 2012).

For question number two, the test charge is negatively charged, so that it is the same as the charge charge so that the direction of the test charge is away from the source charge, related to the opinion of Herman Hudojo, mistakes in learning a previous concept will affect the understanding of the next concept because glasses are a structured lesson. According to Yuliani & Kartini (2020), the mistakes made by students can be classified into several forms of error, including: 1. Procedural errors, namely in using algorithms (work procedures), for example errors in performing arithmetic operations. 2. Errors in organizing data, for example errors in writing down what is known, what is asked of a problem. 3. Errors in sorting, grouping and presenting data.4. Errors in the use of symbols, tables and graphs that contain information. 5. Errors in mathematical

manipulation, characteristics in solving problems. 6. Errors in drawing conclusions. For example, mistakes in writing conclusions from the problems they have worked on. (Susanti, 2020) students still experience mastery of concepts and misconceptions in everyday life.

Conclusion

Based on the discussion of the research results, it can be concluded that students are very familiar with the use of Coulomb's law compared to the use of Gauss's law. difficulty determining the electric field in a wire of infinite length. Spontaneous answers resulting from a moment's thought in problem solving are a picture of students' way of thinking, in answering physics problem solving questions that are still identical, most students give answers that are in line with what they know, therefore if associated with (Reddy & Panacharoensawad, 2017) it can be said that problem solving plays an important role in solving physics problems.

The connection between Coulomb's law and Gauss's law is that Gauss's law is an alternative for determining electric fields other than point charges, besides that (Carvajal et al., 2022) Gauss's law can be determined under conditions that are homogeneous between the distribution of charges and the shape of space.

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