Developing mastery of electricity and magnetic concept for pre-service physics teacher

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Abstract. The mastery of concept of electricity and magnetic is ability to understand the concepts of electricity and magnetic both in theory and practice. The concept of electricity and magnetic is an important concept for students in dealing with real problems in daily life. The development of ICT in learning provides many opportunities for educators to integrate electricity and magnetic concepts in learning. The purpose research is to develop mastery of the concept electricity and magnetism pre-service physics teacher by using ICT. Utilization ICT in learning can helps students to understand abstract concepts and increase student interest in learning. The method used in this study is an experimental research design with pre-test-post-test control group design. The participants in this study were the students of physics education at a private university in the city of Palembang. The research sample is the students in 3rd semester of physics education programs. The sampling technique used is purposive sampling. The instrument used was a concept mastery test consisting of 45 multiple-choice questions. The results showed that the mastery of the concept of magnetic electricity for students who received ICT-based learning was significantly greater than the mastery of the concepts of students who got traditional learning.

1. Introduction

Electricity and magnetism are important concepts of physics that are abstract and difficult [1,2]. Although the concept of electricity and magnetism is widely used in daily life, teachers still have difficulty giving examples of its application in learning activities [3–5]. The difficulties encountered by students in understanding the concepts of electricity and magnetism are due to numerous calculations, formulas and principles used [6,7].

The development of physics concepts learning technology aims to help students achieve their learning goals by helping them learn difficult physical concepts. Factors that have made the concepts of physics difficult include abstract phenomena, the use of certain mathematics, and relationships between concepts [8]. The use of ICT allows the presentation of abstract phenomena to be more concrete, the availability of mathematical materials supports for learning certain concepts and the presentation of concept maps to illustrate the link between a concept and other concepts, which are strategies to help students understand electrical concepts. The application of ICT in learning of magnetic electricity also increases the interaction between students and teachers or systems by observing changes in distance from the magnitude of the electric force, which in itself increases the curiosity of the students.
The use of ICT has changed the learning process that was previously teacher-centred to student-centred. By using ICT, enrich learning resources so as to provide maximum learning services, even without face to face [9]. In addition, the use of ICT for learning offers teachers the opportunity to implement a variety of learning strategies, models, or approaches to increase students’ interest in learning. By using ICT, students are confronted with interesting phenomena in the form of text, images, or videos. The combination of text colours, or images, phenomena, can help students remember the concepts being studied.

The use of ICT also allows teachers to provide feedback on student assignments easily, quickly and accurately. The task or student's assignment can be assessed directly by the system so that it does not become a burden for the teacher. Archiving assignments or student work is easier because it does not need a location to store it.

The development of student’s concept mastery of electricity and magnetics is a complex task of education. The most substantial concepts of students in electricity and magnetics is the ability required to solve problem[10]. The advantageous framework for the development of such indicator mastery concept electricity and magnetics can be formed by the use of the ICT [11]. Such a framework should be: a mastering concept focused on enlargement centred, student-centred, assessment, computer support to encourage the expansion of students’ mastery concept and reduction of an extra-heavy assignment for a teacher [12].

Some researches on the concept of electricity and magnetics prove that, still found students confused and misconception [13,14]. Based on the description above, the purpose of this study is to develop mastery of the concept of magnetic electricity students using ICT. Development of remembering concepts through activities defining or giving examples of the criteria of a concept, understanding students' concepts through learning magnetic electricity through graphic drawing activities, setting up training exercises mathematical application for certain concepts and confronting students with complex problems to determine other unknown variables. This kind of learning can very well done using ICT so that it can develop students' mastery of concepts. Thus the problem in this study is 1) How to develop mastery of students’ concepts for pre-service physics teachers using ICT, and What is the impact of ICT on mastery of concept for pre-service physics teachers?

2. Methods
The research methods used research and development used DDD-E model. The DDD-E model consists of step that: 1) Decide : Analysis of curriculum, characteristics, and needs of students; 2) Design: determine learning outcomes, planning learning systems using ICT, and evaluating ICT-based learning systems; 3) Develop : preparation of learning materials, and development of ICT for learning; 4) Evaluation: the validation of the results of the development of learning tools is seen in terms of material and in terms of technology, limited testing, and implementation in learning [15,16].

The quasi-experimental method is used in this research to collect and obtain data. The researcher uses this experimental research to test the effect of ICT on mastering the concept of students. In this method, the research focused on an experimental group of 7th-grade pre-service physics teacher which are girl class and boy class. Pre-test and post-test design provides a measure of certain attributes or characteristics that are evaluated for participants in an experiment before receiving a treatment. The post-test can be used to evaluate participant in experiment after a treatment. The experiment design is shown in Table 1.

| Group   | Pre-test | Treatment | Post-test |
|---------|----------|-----------|-----------|
| Experiment | O1       | x         | O2        |
| Control  | O1       | y         | O2        |

Table 1. Experiment design.
The location of this research is taken at one of the private universities in Palembang. The sample is taken from semester of the 7th. There are 50 pre-service teacher students who participated in the research. A sampling is selected by a reasoned sampling technique according to [17]. In this research is the concept of electricity and magnetism topic. The type of instrument used in this research is an objective test. The objective test aims to describe the cognitive abilities of students in mastering the concept of electricity and magnetism.

The objective test consists of two sections which are pre-test and post-test. Multiple choice questions consist of cognitive domain C1 (memorization), C2 (comprehension), C3 (application), and C4 (analysis) [18]. The objective test consists of forty-five questions that are judged by experts. The test was then distributed to students in semester 7 as a limited test. The next step after conducting a limited test to 7th-grade students is the analysis of this objective test using ANATES to measure the validity, reliability, level of difficulty, discriminating power, and distractor.

3. Result and discussion

3.1. Result

The pre-test, post-test, and normalized results data gain mastery of electricity and magnetism concepts for pre-service physics teachers using ICT compare the knowledge acquired with conventional learning. Figure 1 shows the pre-employment teacher-physics concept diagram-by-percentage comparison for the experimental group and the control group with the average score obtained in the pre-test, post-test and standardized tests.

![Figure 1](image-url)  
**Figure 1.** Comparison of the average of pre-test, post-test, and normalized gain score: mastering the pre-service physics teacher concept.

The pre-test was conducted at the beginning of the learning to investigate students’ prior knowledge. A pre-test with the same question was given to both experiment and control groups. The statistic results show that the normality test data are 0.65 for the group of experiments and 0.30 for the control groups.

The concept of electric force is a basic concept for studying magnetic electricity. In general, the concept of electric force begins with the phenomenon of electricity caused by electrically charged objects. Examples of electrically charged objects are palette sticks rubbed with hair. This phenomenon is illustrated by the attraction of the sheets of paper brought close to the bar.

The results of the mastery concept test at each cognitive level are analysed to determine the increase in the mastery concepts of the experimental and control group at each cognitive level. The results of the mean mastery concept test for each cognitive level for experimental and control groups are presented in Table 1.
Table 2. Improvement of master’s concept of the pre-service physics teacher based on cognitive levels.

| Group   | C1 | C2 | C3 | C4 |
|---------|----|----|----|----|
| Experiment | 0.66 | 0.68 | 0.58 | 0.66 |
| Control | 0.55 | 0.68 | 0.64 | 0.68 |

Table 2 shows the N-gain mastery concepts pre-service physics teachers based on cognitive levels. Overall, the N-gain for each cognitive level of mastery concept of electricity and magnetism experiment class was higher than that of the control class, except at the cognitive level C3, the N-gain of the control group was higher than the experimental group. These results indicate that the use of ICT is better in developing mastery of the concepts of pre-service physics teachers. The results of the mean difference <g> test of the two groups using parametric statistical test, the Mann Whitney test is shown in Table 3.

Table 3. ANOVA mastery concept for experimental and control groups.

| Group   | N | <g> | Sig. | Decision |
|---------|---|-----|------|----------|
| Experiment | 35 | 0.68 | 0.000 | The mean normalized gain by the mastery concept of the two groups differ significantly |
| Control | 15 | 0.30 |       |          |

Table 3 shows the results of statistical tests using the Mann Whitney test between the experimental class and the control class. The hypothesis test indicates that there are significant differences in N-gain for the experiment and control groups. To obtain the magnitude of the impact of using ICTs to improve mastery of concepts, it is calculated using the effect size formula. The results of an analysis effect size for experimental and control groups are shown in Table 4.

Table 4. The effect size of ICT implementation in learning.

| Group        | \( M_E \) | \( M_K \) | \( SD_E \) | \( SD_K \) | D  | Criteria |
|--------------|----------|----------|------------|------------|----|----------|
| Experiment - Control | 51.24   | 23.11    | 15.85      | 9.72       | 1.92 | Strong   |

Table 3 shows the effect size of ICT implementation in the experimental class toward the control class. Effect size is used to determine the effect of ICTs in mastering the concept of magnetic literacy for physics teacher candidates. The effect of ICTs on improving the mastery of concepts for students is better than conventional learning shows that the presentation of abstract concepts through animated videos and simulations effectively increases students' mastery of concepts. Illustration of phenomena through pictures aims to motivate the exploration of information related to the phenomenon presented, so that learning makes more sense for students.

3.2. Discussion

In the learning activity of electric force between two large charged particles, the electric force is formulated by Coulomb, as indicated in the equation (1).

\[
F_{12} = k \frac{q_1 q_2}{r^2}
\]

Equation (1) shows that the electric force is inversely proportional to the distance between two charges, so that the greater the distance between the charges, the smaller the force generated. The learning strategies used to improve student’s understanding include training them to draw up charts of force versus the distance between charges. The student success in understanding force vs. distance graphs is influenced by the determination of the given r value. Value \( F_{12} \approx \frac{1}{r^2} \) so that the value r selected is 1, 2, 4, 8, etc., so that it is easy to divide 1 by students and that the value obtained is rounded. The use of
ICTs to show the changes of force using r is easier and more accurate than the use of real tools, which allows students to better master concepts.

Understanding the concept of the relationship between electric force and distance increases students' ability to transform graphic representations into verbal forms. Or conversely, students can transform the representation of the form of a table into a verbal form. In addition, students are also able to interpret graphical representations to determine the magnitude of the force at a particular point represented in Cartesian coordinates. The ability to move from one performance to another is an indication that students understand the concept.

The change value of two charges is proportional to the electric force caused so that the larger the charge, the greater the electric force. To help students draw a graph of the relationship between force and charge, the distance between charges is fixed. Thus equation (1) become (2).

\[ F_{12} = kq^2 \]  

with

\[ K = \frac{k}{r^2} \text{ is constant} \]  

Equation (2) shows that the graph of the relationship between force and charge is quadratic or parabolic with the minimum point on q = 0. The graph of the relationship between force and magnitude of the charge, is shown in Figure 2. By plotting a graph of the relationship between the electric force and the charge, the student can determine the magnitude of the force exerted by the point charge. The amount of charge that creates an electric force can be related to the magnitude of the magnetic force or the electric force caused by another charge, which enriches the concept to training students' analytical skills.

Development of students' ability to apply concepts such as the application of equation (1) is to solve electrical force problems in several ways. The application of equation (1) is effective if the direction of the force caused by each charge is sketched out of a free body. If only the application of equation (1) is applied without taking into account the direction of the lines of force, the students will be clueless in finding the resulting style, whether the forces are reinforcing or weakening. It is a learning weakness if students are underlined only by memorizing mathematical formulas without participating in qualitative descriptive activities.

![Figure 2. Graph of the relationship between electric force and charge.](image-url)
understanding. The average pre-test score in the experiment group is 35 students, while in the control group, it is 15 students. These results indicate that ICTs can be used to develop mastery concept of electricity and magnetism pre-service physics teacher [19,20]. Development of students’ mastery of concept teachers using ICTs at every level of knowledge, as shown in Table. 2

Development of the ability to remember the prospective physics teacher students using ICT occurs in the process of practicing questions with easy categories. The practice questions are presented to motivate student teacher candidates to learn and apply definitions or symbols to solve problems. Motivation of learning encourages prospective teacher students to look for various facts or concepts so that students themselves are trained to find concepts as a solution to the problems presented. In addition, students also actively apply symbols to the concepts of electricity and magnetism so that they are easier to remember and understand.

Developing of remembering ability pre-service physics teacher using ICT occurs in the process problem solving for questions with easy categories. The practice to solve problem are presented to motivate student teacher candidates to learn and apply definitions of concept or symbols to solve problems. Learning motivation encourages pre-service physics teacher to look for various facts or concepts [21] so that students are trained to find concepts as a solution to the problems presented. In addition, students also actively apply symbols to the concepts of electricity and magnetism so that they are easier to remember and understand [22].

4. Conclusion
The development of concept mastery of magnetic electricity of physics teacher candidates can be measured using ICT based on DDD-E mode. A significant influence of the ICT use on the mastery of pre-service physics teacher was observed.

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