Teaching and learning of electric charge with PIMCA model

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Abstract. Research on the physics learning of electric charge has been carried out using MR-SR (Multiple Representation and Semiotic Resources). The research aims to find out the outcomes of student learning using the PIMCA learning model (Presentation, Idea Mapping, Conceptualization, and Assessment formative) introduced and developed by Cosmas Poluakan. The research was conducted at the Department of Physics, Manado State University, with 22 pre-service teacher students as respondents using the One Group Pre-test-Post-test Design. The instruments used in the form of pre-test and post-test which have been tested and validated. The research implementation stage starts from the pre-test, and then the implementation of physics learning follows the 4 steps of the PIMCA model. The results of data processing and analysis obtained an average pre-test score is 18.88 and an average post-test score is 75.16. There was an increase in concept mastery. In the idea mapping stage only 2 concepts are correct to drafting concept mapping, 6 are correct from 10 concepts that were used as references. PIMCA MR-SR learning model is very effective in helping students find and understand the correct concepts of physics. The use of the PIMCA MR-SR as a new model in the teaching and learning process is very effective in learning physics, mathematics and science or in the STEM area.

1. Introduction
The interaction between the two charges in Coulomb's law is very abstract and complex and difficult to solve for students. Explanations that are equipped with pictures or graphics that match the electrical material will be easier to understand [1]. Multiple representations can help develop abstract and complex scientific knowledge [2]. The use of multiple representations can help solve problems to improve student learning outcomes [3-5]. Wu-Yuin Hwang suggested that multiple representation skills should be stimulated and applied to explanation and criticism in the problem-solving process [6]. The main function of multiple representations is as a complement, limiting interpretation and constructing understanding [7]. Semiotic resources can convey the meaning and relevant disciplines to assist students in solving problems and working with multiple representations [8,9]. Research conducted by Toliliu shows an increase in student learning outcomes by applying semiotic representations through graph lines in a Cartesian coordinate system [10].

Vygotsky's cognitive theory explains self-regulation in which the formation of knowledge is formed scientifically or occurs empirically. Then Vygotsky explained the formation of knowledge using mediation, namely the help of semiotic tools (semiotic resources). Vygotsky introduced the concept of Zone Proximal Development (ZPD) and Scaffolding. The concept of a zone proximal development (ZPD) by Vygotsky describes the improvement of a person's mental function using semiotic mediation tools, environment and adult or peer tutors [11]. Vygotsky distinguishes between actual development and potential development. Actual development is determined from if someone can solve a problem without
using mediation tools and without the help of adults or peers (the basic mental function a person has). To improve one's basic mental function, help from others (scaffolding) is needed. Potential development is determined when someone can solve problems by working together using mediation tools and help from adults or peers [12].

PIMCA (Presentation, Idea Mapping, Conceptualization, Assessment Formative) is a new learning model which is a development of the MOMBI model but emphasizes teaching and learning process based MR (Multiple Representation) – SR (Semiotic Resources) developed from Vygotsky's ZPD concept. The formative assessment process is similar to Vygotsky's concept regarding the zone of proximal development (ZPD), namely in the range of problems students are able to solve these problems with the help of other parties, in other words formative assessment, and teachers observe and understand the capabilities of learners during the learning process, such as when they are interact. The PIMCA learning model consists of 4 steps, namely; (1) presentation, namely the step in which learners gets initial information through the presentation of various forms of representation. This stage can be a combination of provocation steps and preconception of the MOMBI model. (2) idea mapping, which is the stage where learners construct concepts and build conceptual fabrics based on information received from various forms of representation. At this stage the concept map built by learners may not be mature. (3) conceptualization, which is the stage where learners receive information and are accompanied by instruction assistance from the teacher / lecturer who functions as a resource and / or facilitator and / or tutor, so that the scaffolding function can take place . At this stage, the immature idea mapping is corrected and constructed into the correct concept so that later misconceptions are not built. (4) Formative assessment, namely the steps to ensure that the concept of knowledge constructed by learners is correct. The formative assessment stage can serve as a scaffolding assessment. Formative assessments can be used as a basis for diagnostic [13].

Based on the above studies, research on the physics of electric charge using MR-SR (Multiple Representation and Semiotic Resources) has been conducted. The research reported aims to determine student learning outcomes using the PIMCA (Presentation, Idea Mapping, Conceptualization, and Assessment formative) learning model introduced and developed by Cosmas Poluakan. The PIMCA model as an alternative developed from Vygotsky's ZPD concept to improve problem-solving skills and improve student learning outcomes based on multiple representations (MR) and semiotic resources (SR).

2. Methods
The type of research used is experimental research because in this study it aims to determine learning outcomes after being given treatment using PIMCA (Presentation, Idea Mapping, Conceptualization, and Assessment formative) Conceptualization, and Assessment formative) Conceptualization, Assessment formative). This research was conducted at the beginning of the odd semester of the 2020/2021 school year in the Department of Physics Education, Manado State University, with 22 student teacher respondents using One Group Pretest-Posttest Design. In this study, there are two variables, namely the treatment variable and the response variable. The instrument used in the form of a test (pretest and posttest) used have been tested and validated. The research implementation stage starts from the pretest to determine the students' initial abilities, Furthermore, the implementation of learning follows 4 steps of PIMCA, namely presentation, idea mapping, conceptualization, formative assessment.

The first step of a PIMCA presentation is presenting videos, pictures and also conducting demonstrations related to the material. In the second step of PIMCA idea mapping, respondents were asked to write down the physical concepts they understood at the presentation stage. The third step, PIMCA conceptualization, provides information and is accompanied by instructions so that the scaffolding function can take place. At the end of this stage, respondents are asked to draw a concept map. The fourth step is the formative PIMCA assessment, the respondents are given practice questions then discussed together, then the posttest is carried out to determine the students' abilities after being given the treatment.
3. Results and discussion

PIMCA is a new learning model introduced and developed by Cosmas Poluakan from Vygotsky's cognitive theory about the formation of self-regulation knowledge and adult assistance or working with peers to improve problem-solving skills using the help of other parties using semiotic mediation tools, and interacting with each other by working. The same as adult or peer help. The results of using the PIMCA model on electrically charged material can improve MR-SR-based problem solving skills (Multiple Representations and Semiotic Resources). The effectiveness of the electric charge material through the PIMCA model can be seen from the application of a semiotic resources based test instrument. Improving student problem skills using the MR-SR-based PIMCA learning model can be seen from the histogram and table 1 below;

![Histogram of pretest and posttest scores](image1)

**Figure 1.** Score of pretest and posttests.

| Table 1. Paired samples test. |
|--------------------------------|
| Paired Differences            |
|                               | Mean | Std. Deviation | Std. Mean Error | 95% Confidence Interval of the Difference | t    | df | Sig. (2-tailed) |
|--------------------------------|------|----------------|-----------------|----------------------------------------|------|----|----------------|
| Pair 1 pretest - posttest      | -56.28136 | 24.97417       | 5.32451         | -67.35429 -45.20844                    | -10.570 | 21 | <0.000         |

Figure 1 shows the average pretest score of 18.88 and the posttest average score of 75.16. From the “Paired Samples Test” output table above, it is known that the use of the PIMCA model based on MR-SR has a tendency to increase learning outcomes with an average increase of 56.28. Sig score. (2-tailed) is 0.000 <0.05, then Ho is rejected and Ha is accepted. So it can be concluded that there is a significant difference between the average pretest and posttest scores. There is a significant influence in the use of the MR-SR-based PIMCA learning model in improving learning outcomes. Kurnaza reveals a lot of literature that supports the fact that the use of multiple representations provides efficient results [14]. Maria Opfermann et al. said that many abstract physics concepts can be understood much faster when visualized using multiple representations [15]. We also found an increase in students' mastery of concepts. The empirical experience of students shows that the mastery of the concept is not sufficient in the material of electric charge. It can be seen at the idea mapping stage that only 2 concepts are correct. After scaffolding was carried out at the conceptualization stage and then drafting the concept map, there were 6 correct concepts out of 10 concepts that were used as references. The graph line as one of the
semiotic resources approaches chosen in the test instrument. The use of line graphs can reduce student errors to increase the ability and understanding of the concept of vectors in describing the direction of electric and electric force lines [16]. Semiotic resources are considered as an appropriate first step in the investigation of the skills required when solving problems [17]. Using semiotic resources in learning physics can help learners to understand, solve and overcome problems with the help of multiple representations.

4. Conclusion
This study used PIMCA MR-SR learning model. Based on the results of research and discussion, it can be concluded that student learning outcomes have increased significantly in terms of the results of statistical analysis. There is an increase in student understanding of concepts in terms of mapping ideas and drafting concept maps. With the PIMCA MR-SR learning model, it is very effective in helping students find and understand the correct physics concepts. The use of the PIMCA learning model as a new learning model in teaching and learning by using multiple representations is very effective in the learning process of physics, science, mathematics and engineering or in the STEM area.

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