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The Practicality and Effectiveness of Multiple Representations Based Teaching Material to Improve Student's Self-Efficacy and Ability of Physics Problem Solving

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Abstract: The objective of this research was to find out the practicality and effectiveness of multiple representation based teaching material to improve student's self-efficacy and ability of physics problem solving in static electricity material. This was a quasi-experiment research by using pretest-posttest control group design. Samples were taken by using purposive sampling. Samples were grade XII students in Public Senior High School 15 (SMAN 15) in Bandar Lampung, YP UNILA Senior High School in Bandar Lampung, and Public Senior High School 2 (SMAN 2) in Kalianda. Instruments used were observation sheets for teaching material implementation, students' response to teaching material, student's activity sheet, self-efficacy sheet, and problems for student's problem solving ability test. Data were analyzed by using descriptive analysis with percentage, N-gain analysis, and independent t-test. The research results showed that multiple representations based teaching material were: 1) practical to use in learning, and it was shown by (a) the average implementation of teaching materials in each learning activity, and (b) positive student's response in using teaching materials; 2) effective, and it was shown by (a) active category for student's activity during learning, and (b) significant differences of self-efficacy and problem solving ability.

Keywords: multiple representation, problem solving ability, self-efficacy.

1. Introduction

Education is a life time need. Each individual needs education forever and whenever. Education in Indonesia has a vital role in improving human resource to compete in 21 century, where an effective learning process is one of the ways to overcome these challenges [1] and this demands four matters to have; critical thinking skills, creativity, communication, and collaboration. In addition, teachers are also required to be skilled in guiding students in observing, trying, asking, analyzing, and communicating the findings. Physics is one of the natural sciences to describe natural phenomena systematically, and to explain those phenomena scientists use complicated mathematics as means to uncover those phenomena and use theories by using abstract symbols that are uneasy to understand. These make most students dislike physics subject in schools. That many physics problems especially abstract and complicated materials are difficult to solve because they involve complicated mathematics [2]. Therefore, in the initial stages of thinking what is needed is the correct understanding of concepts [3]. After understanding the correct concepts, students can build their knowledge comprehensively and can actively participate in the learning process [4]. Based on a preliminary research of senior high school students in Bandar Lampung, there 83% students experienced

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difficulties in learning static electricity material and 85% of students only used symbolic representations in forms of formulas in physics problem solving. Learning physics materials should need self-efficacy and the ability of the student to interpret various representation forms when solving physics problems. The representation interpretation ability is very required to implement various concepts in solving the problem correctly [5], [6]. The previous multiple representations research said that the application of physics learning using multiple representations had benefits in enhancing cognitive ability and problem solving of high school students at parabolic motion points [7], and the novelty of my research was to develop teaching materials based on multiple representations on electrical material to improve self efficacy and problem solving abilities.

The main target of static electricity material is to develop student's ability thinking upon static electricity comprehensively in macroscopic, microscopic, and symbolic scales. The student's problem solving ability shall be seen from the student's understanding of static electricity material that is indicated by a student's ability in transferring and connecting between phenomena, macroscopic, microscopic, and symbolic. Any inability to represent one of those three shall influence another, so that the student shall have difficulty in a more complex problem solving [8].Verbal explanation through text shall be easier to understand if it is complemented with visual of graphic of the related material. Each student has a different visual interpretation in science assessment [9]–[11]. One representation may be easily understood by some students, but other students may experience difficulties. Teaching materials with multiple representations will provide choices for all students in solving problems or learning new concepts [12]

Representation is something that represents, illustrate, or symbolizes an object and/or a process.Multiple Representations (MR) means to re-represent a concept with different formats, including verbal, pictures, graphics, and mathematics [13]. Multiple representations has three main functions, namely to obtain additional information or to support the existing cognition process and to mutually complementing, to limit interpretation that may happen, and to motivate students in building deeper understanding [14]. Multi representations used in interactive and conceptual learnings program have high effectiveness in cultivating conceptual understanding [15]. The use of MR in learning can improve student's concept understanding [16], [17] and metacognition ability [18], [19]. Other studies suggest that the use of analogy and representation in learning is more effective in improving student's conceptual understanding of static electricity and magnet materials [20].

Self-efficacy is self-confidence or self-believe. Ormrod [21] suggests that self-efficacy is an individual assessment of his ability to perform a particular behavior. A similar notion suggests that self efficacy expectancy is a person's judgment of his or her capability to perform the skills, actions, or persistence required for the given outcome [22]. There is a positive relationship between self-efficacy and problem solving ability [23],A student with a high self-efficacy shall be easier in delivering his mathematical notions, and he shall be involved more actively in problem solving and can explain some processes to obtain a final solution.A student with a low self-efficacy tends to be passive, and this indicates that self-efficacy influences characteristic, thinking pattern, and behaviour of a student [24].

The objectives of this research were to implement learning by using multiple representations based teaching material and to describe improvements of self-efficacy and physics problem solving ability of students to be seen from practicality and effectiveness of teaching material in static electricity learning. The problem statements of this research are as follows: (1) How did the practicality of multiple-representations-based teaching material in static electricity learning to improve self-efficacy and problem solving ability? (2) How did the effectiveness of multiple-representations-based teaching material in static electricity learning to improve self-efficacy and problem solving ability?

2. Methods

2.1. Research Design

This was quasi-experiment research by using a pretest-posttest control group. Data of practicality assessment result were indicated by qualitative data of observation results of teaching material implementation, while data of effectiveness assessment results were indicated by observation results

of student's activity, student's self-efficacy, and student's physics problem solving ability test given in the pre-test and post-test.

2.2.Research Sample

This research used purposive sampling where samples were selected based on locations and similar initial students' abilities. Research samples were 100 students and 3 senior high school teachers distributed in two schools in Bandar Lampung and one school in South Lampung, and data for analysis were collected by using questionnaires. One classroom was taken to use multiple representations based teaching material for testing the product.

2.3. Research Instrument

The instrument consisted of two observation sheets of teaching material implementation to find out the implementation level of teaching material in learning and student's response sheet toward the teaching materials. Data were collected by an 11 items questionnaire consisting of 8 items of questions feeling of 'joyful', 'joyful enough', 'plain', and 'dislike', and 3 items of questions concerning the student's opinion related to used teaching material. Before being used, the questionnaires had been validated by experts and stated to be valid. The effectiveness was measured by the self-efficacy sheet by Bandura [25], student's observation activity during learning by using multiple representations based on teaching material and problem solving ability test.

2.4. Data Analysis

Data of teaching material practicality was analysed descriptively. Teaching material practicality was seen from multiple representations based teaching material implementation in learning by using the REAL model [26], and the student's response toward the teaching material was analysed with the percentage technique. Teaching material implementation was determined by the estimating average score of each aspect in learning by using a Likert scale, and then by analysing the average score descriptively [27] (Table 1).

Table 1 Assessment Score Conversion of Practicality Grade Quality Statement

Achievement level	Qualification
81 – 100%	Very Good
61 – 80%	Good
41 – 60%	Fair
21 – 40%	Not Good
0 – 20%	Poor

In data analysis, the students' responses toward teaching materials in 'joyful' and 'joyful enough' categories belonged to positive responses, while 'plain' and 'dislike' categories belonged to negative responses.*T-test inferential statistical analysis* was used to obtain student's problem solving ability and *N-gain* average score analysis was used to find out effectiveness level of multiple representations based static electricity teaching material [28]. The N-gain interpretation criteria are presented in Table 2.

T-test *inferential statistical analysis* was used to find out the student's problem solving ability and N-gain score average analysis was used to find out the effectiveness level of multiple representations based static electricity teaching material [29]. The N-gain criteria are presented in table 2.

Table 2 *N-gain* Interpretation Criteria

Gain Score	Interpretation Criteria
$g > 0,7$	High
$0,3 < g \leq 0,7$	Moderate
$g \leq 0,3$	Low

3. Results and Discussion

Multiple representation-based teaching material practicality was measured by the teaching material implementation in learning and student's response toward teaching material. Teaching material implementation in learning included learning activities such as material explanation, problem solving, and self-reflection. The observation results of teaching material implementation are presented in Table 3.

Table 3 Multiple Representations Based Teaching Material Implementation Observation Result

Meeting	Observation Aspect	Observer		Average	Average of each meeting
		I	*II*		
I	Activity steps	87.00	72.00	79.50	85.23
	Social system	100.00	71.00	85.50	
	Principle of reaction	89.50	70.00	79.75	
	Supporting system	100.00	90.00	95.00	
	Instructional effect	90.00	82.75	86.38	
II	Activity steps	88.25	89.25	88.75	87.20
	Social system	89.00	80.00	84.50	
	Principle of reaction	95.00	80.00	87.50	
	Supporting system	100.00	81.00	90.50	
	Instructional effect	89.50	80.00	84.75	
III	Activity steps	87.50	92.50	90.00	89.50
	Social system	100.00	85.00	92.50	
	Principle of reaction	85.00	80.00	82.50	
	Supporting system	100.00	91.00	95.50	
	Instructional effect	90.00	84.00	87.00	
Average of Teaching Material Implementation					87.31

Table 3 shows teaching material implementation observation results from meeting I to meeting III with 87.31 average scores and it belongs to the high category. It indicates that used multiple representations based teaching material have good activity steps, social system, the principle of reaction, supporting system, and instructional effect. Learning activity by using multiple representations based teaching material with the REAL model provides an opportunity for students in understanding and recognizing the target concept by using the concept that the students have already had. Learning with multiple representations based teaching material lead students to implement verbal implementation, symbol/formula, and visual/pictorial to explain target concepts [30]

The social system in learning is seen from interactions between teachers and students, when teachers guide students to formulate target concept with analogy concept and target concept through multiple representations. Students are guided to implement the concept to solve problems. Students in problem solving are provided with helps in forms of solution examples similar to the problems that must be solved. In this step, students shall do self-reflection concerning self-drawback in explaining concepts and problem solving in static electricity teaching material. Students' responses toward multiple representations based teaching material with the REAL model are presented in Table 4.

Table 4 Students' Responses Toward Multiple Representations Based Teaching Material

Response	% of students
Positive	83.75
Negative	16.25

Table 4 shows that 83.75% of students respond positively to the multiple representations based teaching material. Most of the students (81.5%) suggest they are joyful to learn by using multiple representations based on teaching material. 79.75% of students' state by using multiple representations based teaching material is easier to understand abstract concepts because the developed teaching materials are complemented with an analogy of target concept that is similar to the concepts they have learned before. This finding supports another finding stating that analogies can improve understanding of concepts and overcome concept errors [31]. Students' learning activities by using multiple representations based teaching material seem to be more active, because students are involved in each activity phase from the target concept explaining phase until the self-reflection phase. The multiple representations based teaching material can improve student's learning activity and student's retention [32]. Effectiveness of multiple representations based teaching material in learning is measured through self-efficacy and problem solving ability. The questionnaire results of self-efficacy and problem solving ability are presented in table 5.

Table 5 Results of *N-Gain*self Efficacy and Problem Solving Ability of Student

Aspect	Name of school	*Pretest*	*Posttest*	*N-gain*	Criteria	P
Self-Efficacy	Public Senior High School 15 in Bandar Lampung	17,78	33,87	0,70	High	0,001*
	YP UNILA Senior High School in Bandar Lampung	18,30	36,63	0,84	High	
	Public Senior High School 2 in Kalianda	20,93	36,78	0,83	High	
Problem Solving Ability	Public Senior High School 15 in Bandar Lampung	29,14	78,78	0,70	High	0,001*
	YP UNILA Senior High School in Bandar Lampung	29,14	80,30	0,71	High	
	Public Senior High School 2 in Kalianda	29,71	80,28	0,71	High	

*$p < 0.05$, significantly different at trust level of 95%

Table 5 shows that N-gain score of self-efficacy belongs to high category, and this indicates that using multiple representations based teaching material in learning can improve student's self-efficacy. After learning by using multiple representations based teaching material, students become confidence and certain that what they are doing are correct. Table 5 also shows that N-gain score of physics problem solving belongs to high category. This indicates that using the multiple representations based teaching materialin learning can improve problem solving ability in static electricity material. Learning by using sources that are based on multiple representations provides students to use some representations that students have already mastered, so that the problems that previously seemed to be difficult shall be easier. Solving physics problem by using some representations shall not only rely on single form of representation. When using one form of representation the student's problem solving ability does not improve yet, other representation forms shall help students to solve the problems. Therefore, when student's problem solving improves, the student's self-efficacy shall also improve, and vice versa. This is in accordance with the notion that multiple representation can support the construction of deeper problem solving [33]. The similar research result suggest that multi representations learning is effective to improve student's concept understanding and to improve

teacher's insight about the student's understanding [34]. Training students to transform their acquired knowledge within and across various representational forms and to reflect on the scope and function of each level fosters their relational reasoning hence helps them develop conceptual knowledge and problem solving ability [35].

Using multiple representations based teaching material is also very helpful for students to create their self-confidence in physics problem solving by using various ways. This is in line with data in the field that a student has different intelligence with another. Some students are more significant in their verbal abilities, while other is more significant in their mathematics abilities, as well as significant in visual and graphic at some others. Displays of multiple representations based teaching material to explain static electricity the material have provided opportunities for students to understand the material according to their respective specific abilities.

Problem solving begins with displaying a model either verbally, pictorial, or formula then students analyse the problem, so it appears that the use of multiple representation is quite easily understood for students by learning to use teaching materials based on multiple representation models REAL [36], [37].

4. Conclusions

Multiple representations learning is effective for increasing students' understanding of concepts and teacher insight into student understanding. Pictures, graphs, diagrams display qualitative information and formulas, mathematical representations to display quantitative information so that students prefer and respond well to multiple representations because students more often apply qualitative representations such as pictures, graphs and diagrams to help themselves understand problem before they use equations to solve problems quantitative. Multiple representation is also very influential on students' self-efficacy. Students who have high self-efficacy will show their perseverance and ability in problem solving which are quite difficult compared to students who have low self-efficacy. So, the conclusions of this research are that the multiple representations based teaching material are: 1) practical to be seen from teaching material implementation result that is easy to implement by teachers in learning and positive student's response in using teaching materials; 2) effective to be seen from students' activities during learning that belong to active category, and from self-efficacy and problem solving ability that belong to high category.

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