Enhancing Conceptual Understanding and Critical Thinking Skills Pre-service of Physics Using Mechanics Multi Representation (MMR)

TI Hartini, S Liliasari, A Setiawan, T R Ramalis

Abstract: Physics learning based on multiple representations is to association dual or more representations as a method of learning progress that utilized to enhance pre-service teachers' responses after implementing multi representation-based mechanics lectures. In mechanics subject, pre-service physics teachers' have trouble and misconception on some concept such as; gravity and central force (GCF), dynamics system particle (DSP), rigid object rotation (ROR), three-dimensional rigid object rotation (TROR). This study aims to find out that using multiple representations (MR) can enhance conceptual understanding and critical thinking skills (CTS) skills for physics teacher candidates. MR-based modules content and pre-service teachers' worksheets (PTW) with the CTS was utilized to enhance conceptual understanding. Descriptive quantitative and qualitative research methods are carried out to get an evident description of the implementation of MMR to improve conceptual understanding and critical thinking skills. The results found that the level of understanding of MR-based concepts increased for an average N-gain of 0.44% while for the implementation of CTS an average value of 44.9% with quite good criteria. The pre-service teachers' responses to learning of multi-representation-based mechanics are positive. This research is the first study to map a mechanics conceptual understanding and mechanics critical thinking skills based on multiple representations. The results of this research found new discoveries, that all pre-service teachers' have the ability to understand concepts MR-based and using PTW MR-based can enhance the critical thinking skills of pre-service teachers.

Index Terms: multi representation, mechanics, conceptual understanding, critical thinking skills, pre-service teacher

1 INTRODUCTION

Mechanics lectures are connections among pre-service teacher's and lecturers or other education possessions about abstract concepts, natural phenomena, and phenomena in mechanics. Mechanics lectures cover many concepts and principles which generally identical abstract. This abstract concept makes pre-service teachers' frequently find problems and misconceptions in learning mechanics. Problems and misconceptions that are mostly faced by most pre-service teachers' in understanding numerous concepts and principles of mechanics, because they are compulsory to be able to interpret the conceptual understanding of mechanics correctly and not cause meaning misperception. Pre-service teachers'' ability to identify and interpret physics concepts is clearly an important requirement to make more multifaceted discovery or for solving physics problems related to these concepts [13]. The initial study shown by our at one of universities in Jakarta using form of a instruments trial to pre-service teachers', as well as an analysis of the trial test results in a mechanics concept for gravity and central force, data analysis result and discussion of concept mastery central force on pre-service teachers' in semester 3 found that concept mastery average pre-service teachers' based on multiple depictions reached the good category, though there were still low pointers of achievement.

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Furthermore, from five indicators aspects of conceptual understanding on central force concept showed that the highest pre-service teachers'' conceptual understanding is in the classifying indicator with a percentage of 86.65%, while the lowest pre-service teachers'' conceptual understanding lies in the comparing indicator that is equivalent I to 66.55%, so mechanics learning on the concept of central force through multiple representations-based learning methods are effectively practical to other theme mechanics material for physics learning pre-service teachers' in semester 3. Based on conclusions from the results of study, we suggest that the application of learning a central force material based on multiple representations can be used as an alternative knowledge method to other concept and it is expected that other investigators can deliver a more varied approach to learning mechanics based on multiple representations [5]. The relationship between multi-representation and conceptual understanding concepts by Suhandi and Wibowo [12] stated, "... multi representations are one method that is fairly actual to be used in order to implant physics conceptual understanding between pre-service teachers'". The physics concepts utilized in this research are gravity mechanics and central force, particle system dynamics, rigid body rotations and three-dimensional rigid body motion [3]. Multiple representations also affect critical thinking skills. Satria [11] state that "... Pre-service teachers' critical thinking skills after the operation of inquiry-oriented worksheets can enhance critical thinking skills from an average of 10% to 74.6% on Virgin Coconut Oil (VCO)". Another researcher who studied the same question stated that "The results of the advanced sequencer tests presented that the rise in CBC, MR skill, and mastery of concepts was higher in the experimental group than control group. The implementation of PFSdAb-MR in the experimental group can enhance the CTS (N-gain = 60.3% in the medium category. Pre-service teachers' and lecturers respond very well to PFSdAb-MR and their implementation physics teacher"[2]. The results of many researches can prove as empirical facts

that the use of multiple representations in science learning can help pre-service teacher's better to understand the science concept, help pre-service teacher's to solve difficulties and encourage pre-service teacher's to pose difficulties [1], [4], [6], [8], [9], [10]. The thinking skill at a higher level includes thinking critically skill, and this is the skill to think rationally and reflectively based on what is believed or done [7]. Based on the explanation above, the problematic of the research is how mechanics multi-representation (MMR) can enhance pre-service teachers' conceptual understanding and critical thinking skills (CTS) on gravity and central force (GCF), dynamics system particle (DPS), rigid object rotation (ROR), three-dimensional rigid object rotation (TROR). Therefore, the researcher designed to find out how to enhance pre-service teachers' conceptual understanding and pre-service teachers' critical thinking skills, after getting physics learning using multi representations on a pre-service teacher.

2 METHODOLOGY

This research utilizes descriptive quantitative and qualitative research methods. The researcher uses this method to get a clear description of MR implementation to improve conceptual understanding and critical thinking skills (CTS), using the design of score assessment in MR-based modules as an achievement of conceptual understanding and assessment using MR-based PTW. In this study, pre-service teachers were given a pretest before implementation. Then pre-service teachers are given implementation using MR-based content modules and answer PTW to enhance critical thinking skills for a certain period of time. After learning is done, a post-test is conducted to know the level of skill conceptual understanding and critical thinking skills. This research was showed at one of the universities in Jakarta, with a sample of 31 pre-service teachers. The sampling technique used is purposive sampling technique. This technique is used on the basis that pre-service teachers' have educated basic physics concepts. MR-based concept instruments and pre-service teacher worksheet (PTW) implementation using CTS by analysis percentage and achievement category as well as instruments for pre-service teachers' responses about the learning using multiple representations. The data analysis technique used by calculating the score of the pre-test and post-test results, then calculated using the N-gain equivalent tion. N-gain defines an improvement in pre-service teachers' learning outcomes between before and after treatment is given. Meanwhile, pre-service teachers'' replies were measured by means of a multi-representation Likert scale.

3 RESULTS AND DISCUSSION

3.1 Enhancement of conceptual understanding

The data results of enhancing pre-service teachers' conceptual understanding MR-based can be seen from the N-Gain generated from pre-service teachers' pretest and posttest scores. The calculation results can be shown in Fig 1 as follows:

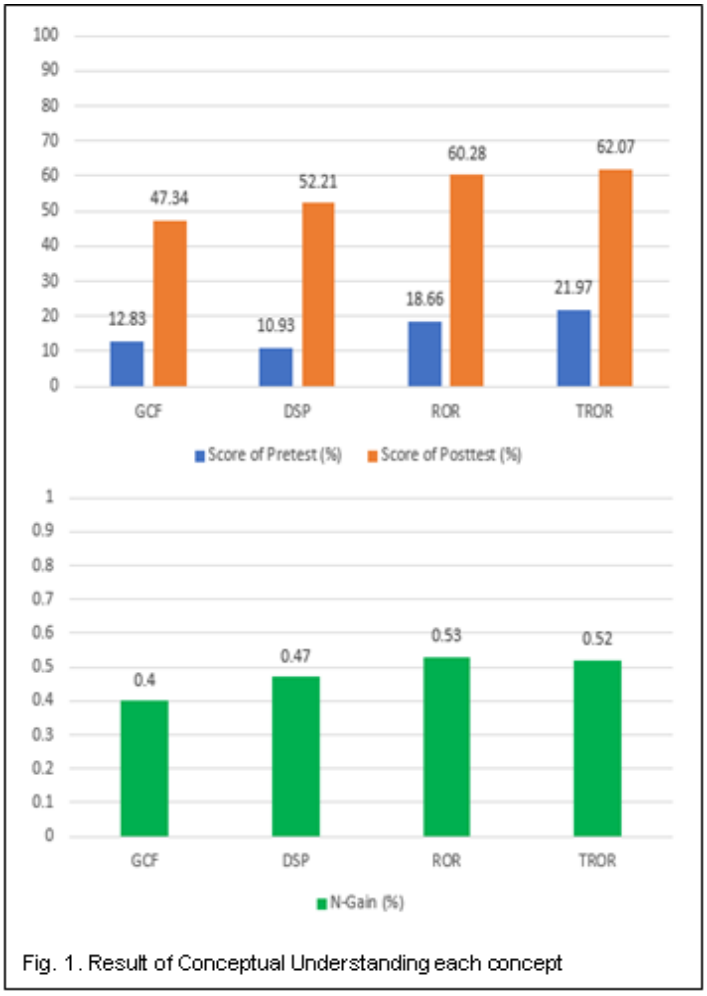


Fig. 1. Result of Conceptual Understanding each concept

Graph 1 showed that there is an enhancement in conceptual understanding after given MR-based lectures on pre-test and post-test. Gravity and Central Force (GCF) concept has enhancement equivalent l to 34,51% with 0,4 N-Gain, Dynamics System Particle (DSP) concept has enhancement equivalent l to 41,28 with 0,47 N-Gain, Rigid Object Rotation (RBT) concept has enhancement equivalent to 41,62 with 0,53 N-Gain, and three-dimensional rigid object rotation (TRBT) concept has enhancement equivalent l to 40,10 with 0,52 N-Gain. From those concepts that has been taught, RBT has the highest N-Gain while GCF has the lowest N-Gain. The growth in N-Gain value means that there is an influence after being given lectures based on MR. The level of pre-service teachers' conceptual understanding MR-based was in medium criteria.

3.2 Enhancement of Critical Thinking Skills

Data on the results of enhancing pre-service teachers'' critical thinking skills can be seen from the percentage value created from the typical pre-service teachers' score. The calculation results can be shown in Table 1 as follows:

TABLE 1
RESULT OF CONCEPTUAL UNDERSTANDING EACH CONCEPT

Responden	Score			
	GGF	DSP	ROR	TROR
R1	92	70	75	70
R2	83	80	80	75
R3	62	55	75	70
R4	80	50	68	75
R5	66	65	75	80
R6	68	65	70	75
R7	69	70	78	75
R8	63	85	85	80
R9	100	100	90	80
R10	88	50	85	70
R11	88	60	86	90
R12	88	70	67	65
R13	72	50	60	66
R14	79	50	65	67
R15	100	95	70	80
R16	78	50	65	60
R17	60	50	70	65
R18	100	90	78	76
R19	65	80	75	70
R20	65	70	75	75
R21	94	100	90	95
R22	72	55	65	60
R23	88	60	70	75
R24	69	75	70	78
R25	72	50	65	68
R26	59	64	60	66
R27	81	70	75	70
R28	66	55	65	70
R29	66	60	75	70
R30	85	70	67	77
R31	66	58	65	75

Table 1 can be depicted as in Fig 2 below as follows:

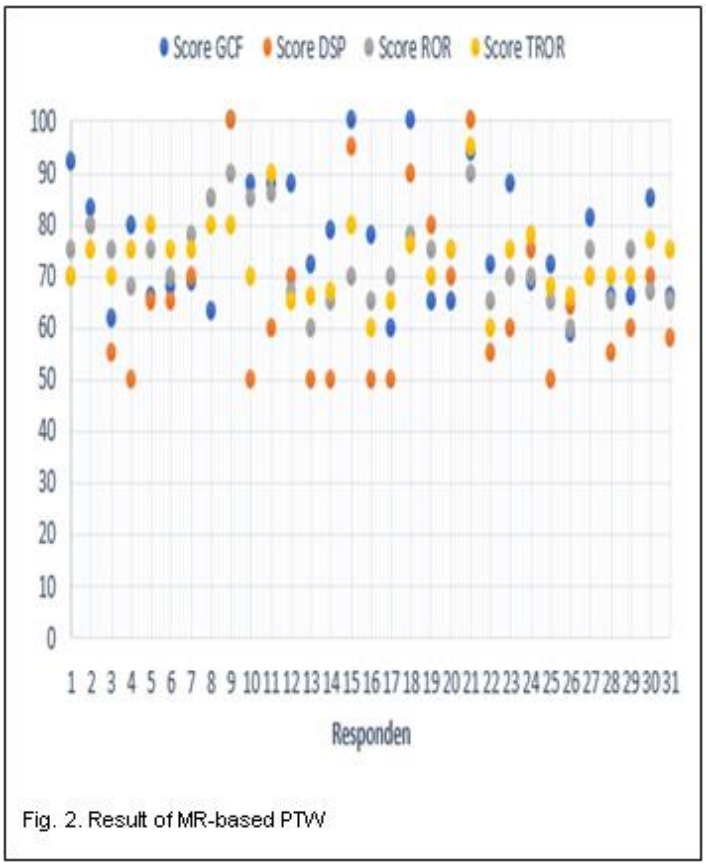
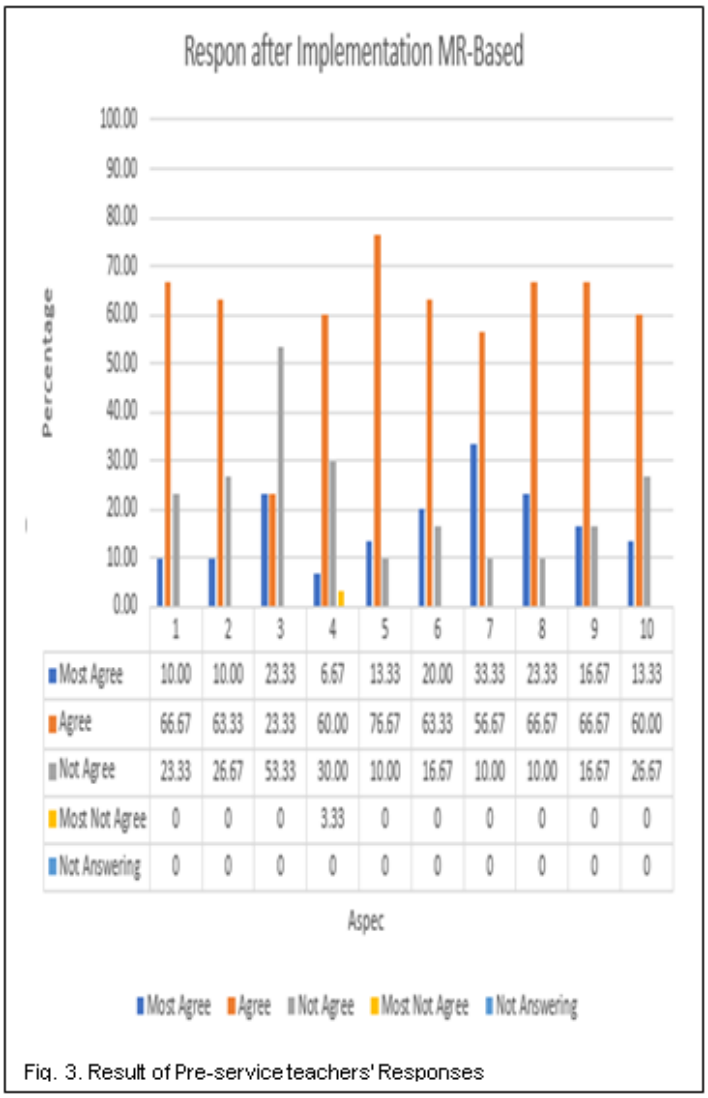


Fig. 2. Result of MR-based PTW

Table 1 and Graph 2 showed that there is an enhancement in pre-service teachers' critical thinking skills in answering using MR-based PTW. A percentage value advances the capability of CTS means that there is an effect of increasing the CTS. Pre-service teacher's Critical Thinking Skills have an enhancement from four concepts that have been taught. Graph 2 shows that all the pre-service teacher after post-test gets an enhancement above score 49. From 31 respondents, 16 pre-service teachers have a score between 59-72 with a percentage of 51,61% which is in a medium category while 15 pre-service teachers have a score between 73-100 with a percentage of 48,39% which is in the advanced category. We obtained a large capacity for the implementation of CTS on MR-based PTW with an average value of 44.9% on quite good criteria.

3.3 Response Pre-service Teacher

Pre-service teachers' responses after implementing multi-representation-based mechanics lectures were positive. Pre-service teachers are very happy and interested in lecturing mechanics using multiple representations. Data analysis results of pre-service teachers' responses to the MR-based mechanics' lecture process can be shown in Fig 3.



	1	2	3	4	5	6	7	8	9	10
Most Agree	10.00	10.00	23.33	6.67	13.33	20.00	33.33	23.33	16.67	13.33
Agree	66.67	63.33	23.33	60.00	76.67	63.33	56.67	66.67	66.67	60.00
Not Agree	23.33	26.67	53.33	30.00	10.00	16.67	10.00	10.00	16.67	26.67
Most Not Agree	0	0	0	3.33	0	0	0	0	0	0
Not Answering	0	0	0	0	0	0	0	0	0	0

Fig. 3. Result of Pre-service teachers' Responses

Fig 3 shows that 66,7% in the first aspect, pre-service teachers agree (S) with the concept is interested to learn. The second aspect is about learning sources and media with majority pre-service teachers agree of 66,7%. The third aspect gets 53,3% agree that media learning is not interested to learn by pre-service teachers. The fourth aspect is about understanding the concept and get 60% of agree. The fifth aspect gets 76,7% about 3D media useful to learn. The sixth aspect gets 63,3 agree that should be there is a PTW every lecture. 56,7% of pre-service teachers agree from the seventh aspect that very helpful using software and media learning. 66,7% of pre-service teachers agree from eight aspects that it can be trained to their critical thinking skills. The ninth aspect gets 66,7% agree that this learning makes them arouse curiosity. The last aspect (tenth) is about use language that is easily understood by students and gets 60% of agreement. Pre-service teacher responses are overall is in good. They accepted Mechanics Multi Representation (MMR) as positive learning

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4 CONCLUSION

After implementing the mechanics' lectures, student conceptual understanding of MR-based expressions that the majority of students have difficulties and misconception can be overawed with the instruments provided in the form of MR-based content modules and student worksheets using PTW have enhanced conceptual understanding with average categories and critical thinking skills with categories pretty good. Students' responses after MR-based mechanics lectures can improve general conceptual understanding and critical thinking skills (CTS) are positive.

5 ACKNOWLEDGMENT

We would like to thank all the pre-service teachers who have participated in lectures. We also thanks to UIN Jakarta for providing the opportunity to conduct this research. On this occasion, we would like to express appreciation and gratitude to BUDI-DN and LPDP as sponsors and all parties who have a large impact on the success and completion of this research. We realizes that this article is far from perfect, therefore constructive criticism and suggestions are expected. Hopefully this research will be useful for other researchers.

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Submission date: 15-Mar-2024 02:39PM (UTC+0700)
Submission ID: 2321023598
File name: conceptual_understanding_of_electricity_using_-_Tri_Hartini.pdf (699.64K)
Word count: 2535
Character count: 14175

Enhancing students' conceptual understanding of electricity using learning media-based augmented reality

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Abstract. Some contents of physics provide abstract concepts (e.g. electricity) so they are demanding to be visualized and students are challenging to understand. However, the recent development in technology namely augmented reality can be used as a learning media to depict the some abstract concepts in physics. This study aimed to examine the implementation of learning media-based augmented reality that was developed in electricity topics to enhance students' conceptual understanding. The research method used in this study was pre-experiment with one group pretest-posttest design. The participant of this study was 30 students in the first year of one public vocational high school in Garut. Students' conceptual understanding was snapped using an instrument test (26 item questions) developed in multiple choices. In addition, average gain and normalized gain were used to analyze the enhancing of students' conceptual understanding. The result of this study portrayed that improvement of conceptual understanding was in medium category. This case was illustrated by average gain (29.0) and normalized gain (0.56). According to result findings of this study can be inferred that learning media-based augmented reality developed in electricity topics could enhance students' conceptual understanding.

1. Introduction

Physics is one branch of science that underlies the development of advanced technology and the concept of living in harmony with nature. The rapid development of information technology and communication today is triggered by the findings in the field of material physics through the discovery of electronic devices capable of loading a lot of information with very small size. Various magnetic and electronic material-based technology products that we usually encounter in everyday life such as computers, the internet, lasers, GPS (Global Positioning System), fiber optic broadband networks, and etc. They are real technology products from basic physical research activities in the last 50 years. The spectacular leap rate in modern information and communication technology is inseparable from the incessant research in

the field of Material Physics. In other words, technology is a driving force in the changing behavior of people from industrial societies into knowledge and information-based societies.

In the world of education, the development of information technology was felt to have a positive impact because with the development of information technology, the world of education began to show significant changes. Many things are perceived differently and changed compared with the way that developed earlier. The development of ICTs allows the creation of various multimedia in learning that can facilitate and generate students' motivation in learning the concept of physics.

Physical material itself is composed by concrete and abstract concepts. Abstract physical materials such as electrical, magnetic and modern physics are difficult to visualize, causing students to have difficulty in studying abstract physical concepts. This is what makes students think that physics becomes difficult and boring. Therefore, to be able to develop students' understanding of the concept of physics learning, especially on the concepts of physics that are abstracts needs the help of information technology. Information technology in education is applied in the form of multimedia software (software), which provides facilities to students to learn a material.

One of the learning media that is seen help and facilitate to facilitate students in studying abstract physical materials is Augmented reality. Augmented Reality is an effort to combine the real and virtual worlds created through the computer so that the boundary between the two is very thin. In simple terms Augmented Reality can be defined as a real environment with added virtual objects. Several previous studies have examined how augmented reality applications developed in various forms such as in the form of games, the application of augmented reality learning in the form of games can increase student learning interest [1], besides making augmented reality in view of its marker can divided into two marker forms in image based and location based [2], several studies have also attempted to implement augmented reality in the form of books [3, 4] and besides the view of hardware used augmented reality can use desktop or mobile [5].

In addition, several studies have also tried to apply augmented reality application to classroom learning. Some studies show that the application of augmented reality in learning can have a positive impact in learning such as improving students' concept understanding after applying virtual lab augmented reality on the subject of kinetic gas theory [6] Application of AR technology can improve laboratory capability and student attitude toward physics [7], can improve learning motivation in computer learning [8] and can facilitate in studying abstract concepts [9]. some studies have also tried to compare the effects of augmented reality in comparison with other technologies. augmented reality is more effective than applying web based application learning, especially in improving learning effectiveness and flow student experience [10], augmented reality also improves student learning outcomes in comparison with 2D simulation media [11] and if compared to interactive simulation technology (IS), technology AR technology can overcome the affective aspects of learning (SSI) [12] in addition to comparing with several research technologies also compare augmented reality with traditional learning when compared with traditional learning was augmented reality is more effective in improving students 'learning outcomes and students' learning motivation on the subject of optics [13], further improving student learning outcomes on vector concepts [14] and mobile augmented reality. The appeal of traditional learning [15].

2. Method

The method used in this research was pre experiment method with one-group pretest posttest design. In this design, pre-test was first administered to the subjects, followed by a treatment of using learning media-based augmented reality.Then,post-test was administered to measure the effect of learning media-based augmented reality on students' conceptual understanding improvement on electricity.

The population of participant in this research are all students of the first year of 2017-2018 academic programmes in one public vocational high school consisting of four classes. From the population, researchers took sample for the study. Sampling was carried out by purposive sampling technique that is sample determination technique with certain consideration.The sampel of this research was 30 students consisting of 27 female students and 3 male students ranging in age from 15 to 16 years who

participate in this study. The location of the research was conducted in one public vocational high school located in the city of Garut. Students' conceptual understanding is identified using instrument multiple choices test (20 item questions) on the concept of electricity. The improvement of students' conceptual understanding determines with the N-gain score <g> from Hake [16]. The pretest and posttest data were tested statistically using the students test (t-test) using Microsoft Excel and SPSS Program 16.

3. Result and discussion

To see the effect of augmented reality learning media on students 'conceptual understanding, it is done by pre-test and post-test with the aim to see students' early ability, student's final ability and improvement. The initial ability is obtained from the pre-test administered before treatment while the final ability is obtained through the post-test given after the treatment. Increased understanding of student concepts is obtained by calculating the normalized gain. The statistics of students' conceptual understanding before (pre-test), after (post-test), and N-gain can be seen in table 1.

Table 1. Descriptive statistical data of students' conceptual understanding score in electricity.

Statistics	Value		N-Gain
	Pretest	Posttest	
Average	49.50	78.50	0.56
Variance	84.53	36.94	
At lest	31.00	65.00	
Maximum	65.00	92.00	
Standar deviation	9.19	6.08	
Median	50.00	77.00	

Table 1 shows that there is a difference between pretest to posttest results and the value of N-gain indicates how much influence using learning media-based augmented reality on Students' conceptual understanding improvement on electricity topic. The average improvement score (gain) of students' conceptual understanding was 29.0 there is an increase from 49.50 to 78.50. Based on the calculation the average score <g> of students' conceptual understanding is 0.56 which is categorized as medium.

The normality of the data were checked as the consideration to choose the appropriate statistic method. The normality results are shown in the Table 2. Table 2 shows the result of normality test using spss. there are two types of calculation which are Kolmogorov-Smirnov and Saphiro-Wilk. The first type is used if there are a lot of data (>50), while the second one used for the small size data. As sees from Table 2, the score distribution of pretest dan posttest displays a normal distribution (sig.>0.05).

Table 2. The result of normality test of students' conceptual understanding score in electricity.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pretest	.121	30	.200	.959	30	.286
Posttest	.140	30	.135	.967	30	.457

Table 3. The result of student test (t-test) and Levene test of students' conceptual understanding score in electricity.

	Levene's Test		t-test				
	F	Sig.	T	df	Sig. (2-tailed)	Mean	Std.
Equal variances assumed	6.691	.012	14.41	58	.000	29.0	2.01
Equal variances not assumed			14.41	50.28	.000	29.0	2.01

Table 3 above shows the significant effect of media based augmented reality on students' conceptual understanding. As seen from Table 3, the different between mean score of pretest and posttest is significant (sig.(2-tailed)<0.05). This statistical test shows that augmented reality learning media can improve the understanding of physics concepts of students, especially abstract physics concepts such as electrical concepts. this is caused because augmented reality is a technology that combines the real world and the virtual world [17]. So the concept of abstract physics in the real world can be visualized into the virtual world.

4. Conclusion

Based on the data obtained then the gain average is 29.00. while N-Gain data showed an increase of 0.56. From the data can be concluded that the application of learning media Augmented reality on the learning of physics can improve the understanding of physics concepts of students on the subject of electrical language.

Acknowledgments

The authors would like to thank to the organizer of BUDI-DN and LPDP which has provided financial support to the author so that we can finish this article. Acknowledgments also are conveyed to all parties who assist in the collection of research data.

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