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CONTENTS

THE INFLUENCE OF EXTRINSIC LEARNING MOTIVATION TOWARD PHYSICS LEARNING OUTCOMES OF THE TENTH GRADERS OF JAYAPURA MUHAMMADIYAH SHS DURING THE COVID-19 PANDEMIC

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ABSTRACT

This study aimed to determine the relationship and influence of extrinsic learning motivation on student learning outcomes. This type of research was ex post facto research. The data collection technique in this study was non-test. The data collection instrument used was a questionnaire. The data obtained were then analyzed using the SPSS 16 program. The research was conducted at SMA Muhammadiyah Jayapura in the academic year 2020/2021. The population numbered 61 students of class X. The sample of the study was class X1 with a sample size of 30 students based on a random sampling technique. The analysis technique used was the product-moment correlation technique. Research results and data processing showed *Asymp* Sig. (2-tailed) = 0.000 < 0.05, meaning that there was a relationship between extrinsic learning motivation and student learning outcomes. Pearson correlation value = 0.934 was interpreted to have a very strong relationship. The value of R Square = 0.872 means that the influence of extrinsic learning motivation on learning outcomes is 87.2%. Sig value. = 0.000 < 0.05, meaning that there was an influence of extrinsic learning motivation on student learning outcomes.

INTISARI

Penelitian ini bertujuan untuk mengetahui hubungan dan pengaruh motivasi belajar ekstrinsik terhadap hasil belajar peserta didik. Jenis penelitian ini adalah penelitian ex post facto. Teknik pengumpulan data pada penelitian ini adalah non-tes. Instrumen pengumpulan data yang digunakan adalah angket. Data yang diperoleh kemudian dianalisis menggunakan program SPSS 16. Penelitian dilaksanakan di SMA Muhammadiyah Jayapura tahun ajaran 2020/2021. Populasi berjumlah 61 peserta didik kelas X. Sampel penelitian adalah kelas X1 dengan jumlah sampel 30 peserta didik berdasarkan *random sampling technique*. Teknik analisis yang digunakan adalah teknik kolerasi *product moment*. Hasil Penelitian dan pengolahan data Nilai *Asymp. Sig.(2-tailed)* = 0,000 < 0,05,

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artinya terdapat hubungan antara motivasi belajar ekstrinsik terhadap hasil belajar peserta didik. Nilai *pearson Correlation* = 0,934 diinterpretasikan memiliki hubungan yang sangat kuat. Nilai *R Square* = 0,872 artinya pengaruh antara motivasi belajar ekstrinsik terhadap hasil belajar sebesar 87,2%. Nilai *Sig*. = 0,000 < 0,05, artinya terdapat pengaruh motivasi belajar ekstrinsik terhadap hasil belajar peserta didik.

I. Introduction

Science and technology development and globalization grow quickly and enormously. The competition in the educational field increases due to the 4.0 industry [1]. One of the ways to participate in this competition is by improving the educational quality, such as improving the curriculum, the human resource, facility, and infrastructure [2]. Teachers, parents, and the community should support these improvements to improve educational quality. The discussion of educational quality cannot be separated from teaching-learning activity in educational institutions [3].

The teaching-learning activities at schools are the most fundamental activities [4]. It means the success of the educational objective achievement depends on how learners undergo the learning process. An individual introduction toward the result or progress is important. It allows the individual to struggle in improving his learning outcome. Thus, he will obtain the optimum learning outcome because the learners are motivated to improve learning outcomes [5].

Many factors influence the learning outcome improvements. One of them is learning motivation [6]. The learning quality improvement requires many efforts to do. One of them is learning motivation improvement [7]. Learners will be successful if they have the motivation to learn. It makes learners motivated and it directs their behaviors and attitudes in learning [8]. Motivation is the influential factor of learning outcomes. Learning motivation is a tendency of a learner to learn. It is encouraged by the intention to obtain excellent learning outcomes [9]. Learning motivation encourages the learning spirits of learners. Lack of learning motivation discourages learning motivation. It influences the learning outcomes of learners. Learning motivation is categorized into intrinsic and extrinsic motivations [10]. Intrinsic motivation covers learning situations, learning needs, and learning objectives of the learners. Extrinsic motivation occurs due to external factors of the learning situation. The learning process outcomes take forms into numbers and scores based on the cognitive, psychomotor, and affective assessments [8]. The features of high-motivated learning learners include the determination to work on the tasks, encounter difficulties, and show interest in solving problems. These learners do the tasks autonomously but they easily get bored with regular tasks. They could defend their arguments and have strong beliefs. They also like to solve problems [7].

Learning motivation deals with the ideals or aspirations of the learners [11]. Learning motivation is important for learners. It allows them to understand the learning objectives [6], [12]. Besides that, an excellent learning situation makes learners encouraged and able to solve the tasks excellently [13]. However, if the learners are not feeling well, they will lose their spirits to learn. Educators should notice when learners need motivation. Thus, the learning activity could last joyfully, communicatively, and interestingly without any anxiety. These situations could improve the learning creativity and activity [14]. The motivated learners will follow the learning joyfully. It also goes for the teachers. Motivated learners could complete their learning tasks and apply the learned materials.

Thus, teachers should encourage their learning motivations. It is important to reach the maximum learning outcomes [15]. Therefore, a teacher must assume his learners will struggle to accept the given learning materials [16]. The learners' learning motivation is useful to improve their learning outcomes in certain lessons [17]. With high learning motivation, learners could understand, master, and store what they learned in a long term [18]. Learners could also respect what they learned so that they find the materials useful for their daily lives in the community. Learners with high-learning motivation will obtain higher learning outcomes [19]. Learners could do various efforts to improve their learning success. Thus, they could reach excellent success as expected. Besides that, motivation also keeps the learning process of the learners running smoothly.

Based on the preliminary observation, the extrinsic learning motivation of the tenth graders of Muhammadiyah SHS Jayapura was low. The reviews about the summative, formative, midterm, and final term tests showed under-average results. Therefore, this research aimed to find out the correlation and the influence of extrinsic learning motivation toward the learning outcomes of the learners.

II. Research Method

This research type is an ex-post-facto. The independent variables of this research had existed and influenced the observation toward the dependent variables in research [20]. The researchers chose this research type because they wanted to find the influence of the dependent variables on the dependent variable. The researchers conducted this research to find out the influence of extrinsic learning motivation on the learners' learning outcomes. This research has a two-variable paradigm. It consists of the independent and dependent variables. The independent variables were the extrinsic learning motivation, symbolized by X. On the other hand, the dependent variable was the learning outcome, symbolized by Y.

The researchers conducted the research in three stages. They were the preparation, execution, and finalization stages. The preparation stage consisted of a field study. The study observed the school to determine the research problem. The next activities were - defining and formulating the problems, conducting a literature

study, tracking relevant journal articles in terms of the research variables, and formulating the research hypotheses. Then, the researchers designed the research, determined the population and the sample, conducted the research instrumentation activity, determined the data collection technique, and analyzed the data. The execution stage consisted of questionnaire distribution for the learners via an online learning medium. In the finalization stage, the researchers processed the data statistically, discussed the results, and concluded the results [21].

The population of this research consisted of the tenth graders of Muhammadiyah SHS Jayapura from two learning groups. They were the X1 and X2 with total numbers of 61 individuals. The selected sample was from the X1 learning group or class of the school. It consisted of 30 individuals. The researchers used a random sampling technique to determine the sample. This research used a questionnaire to measure the extrinsic learning motivation influence toward the physics learning outcomes of the learners via online media. The respondents answered by checking the list (√)) on the given columns. The questionnaire had 28 question items. The scores of the answers used the Likert scale as shown in Table 1.

Table 1. The rubric of the extrinsic motivation questionnaire

Indicators	Numbers	Total
The authority expectations	1, 2, 4, 5, 6,13, 15, 17,	8
The expectation received by the peers	3,7, 12,16, 25,26	6
The motivation of the domination	9,18,20,21,24,27,28	7
Feeling afraid to fail	8, 10, 11,14, 19,22,23	7

This research used the questionnaire to data collect the variable X data, consisting of 28 item questions. The researchers grouped the answers or the responses from each item into 4 answer levels based on the Liker scale (see Table 2).

Table 2. The Likert scale

Answers	Scores
SA = Strongly Agree	4
A = Agree	3
D = Disagree	2
SD = Strongly Disagree	1

This research determined the normality distribution of the data by using the data normality test assisted with SPSS version 16. The guideline to make the decision was - if the value of Asymp sig (2-tailed) was lower than 0.05, the data distribution was not normal. However, if the value of Asymp sig (2-tailed) was higher than 0.005, the data distribution was normal.

The stages to examine the simple correlation analysis by using SPSS version 16 were: testing the significance to find out the existence of a significant correlation

between the variables. The test used the two-tailed test. The correlative coefficients are in Table 3.

Table 3. The correlative coefficient criteria

r-value	criteria
0,00 until 0,29	A very weak correlation
0,30 until 0,49	A weak correlation
0,50 until 0,69	An average correlation
0,70 until 0,79	A strong correlation
0,80 until 1,00	A very strong correlation

The applied regression-test type was the simple regression test to predict both independent and dependent variables. The applied linearity test was to find out the linear correlation between the variables. It meant each change in a variable would be entailed by a proportional change of the other variable.

III. The Results and Discussion

The normality test result of the data showed the indicator of authority expectation influenced the learning outcomes with a significant score of 0.899. The indicator of the expectation received by the peers influenced the learning outcomes with a significance of 0.762. The indicator of the domination motivation influenced the learning outcomes with a significance of 0.948. The indicator of feeling afraid to fail influenced the learning outcomes with a significance of 0.763. All significance values of the indicators were higher than 0.05. Thus, each indicator had a normal distribution. Then, the researchers conducted the data normality test. Overall, the data of extrinsic motivation and learning outcomes had correlations with significances of 0.830 and 0.245. It showed that the normality test of the learning motivation obtained a sig score of 0.830 higher than 0.05. On the other hand, the learning outcome had a sig score of 0.245 higher than 0.05. It showed the data had a normal distribution.

The correlative analysis had a function to determine the confidence between the variables: X or learning motivation and Y or learning outcome. Table 4 shows the correlation analysis.

Table 4. The correlation analysis of X toward Y

Independent Variable	Sig. (2-tailed)	Pearson Correlation
Learning motivation	0,000 < 0,05	0.934
Remarks	It has the correlation	A strong correlation
Dependent variable = learning outcome KD = r^2 x 100% = 0,934x 100% = 93,4%		

The determinant coefficient is 93.4%. This value shows the contribution of variable X toward Y. On the other hand, the coefficient value of the X and Y correlation is 0.934. The correlation value between 0.80 - 1.00 indicates the strong

correlation between learning motivation and learning outcome. The processed data result showed a significant value of 0.000. Thus, H_0 is denied (sig < 0.05). It meant there was no significance between learning motivation toward learning outcomes.

The obtained data from the regression analysis are in Table 5.

Table 5. The regression analysis result of the influence of X toward Y

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error			
(Constant)	56,147	1,889		29,867	.000
Learning motivation	.291	.021	.934	13,802	.000
Dependent variable = learning outcome					
R = 0,934					
R Squre = 0,872 = 0,872 x 100% = 87,2% (The determining coefficient)					

Based on the calculation, the value of a is 56.147. It is a Constanta that means X = 0. It meant learning motivation influenced the learning outcomes. T value of b is 0.291. It meant the learning motivation improvement influenced the learning outcome with a correlative coefficient of 0.291. The regression equation is Y = 56.147 + 0.291 (X). The value of determining coefficient is 0.872 or it is equal to 87.2%. The value meant the learning motivation (X) influenced the learning outcome with a percentage of 87.2%. On the other hand, the percentage of 12.8% showed other unexamined factors influenced the model.

Based on the data processing results, the researchers obtained a significant value of 0.000. This value is lesser than 0.005. Thus, H_0 is denied and H_a is accepted. It meant there was a correlation between the extrinsic learning motivation toward the learners' learning outcomes. Based on the correlative analysis results, the researchers obtained a correlative coefficient of 0.934. It indicated that extrinsic learning motivation (X) had a strong correlation with the learning outcome (Y). This strong correlation level was in line with the previous research. It showed that extrinsic learning motivation influenced significantly the learners' learning outcomes [22], [23]. Rimbarizki (2017) also supported that motivation influenced the learners' learning behaviors. It encouraged them to improve their eagerness and determination for learning. Motivation has an important role to encourage and making learners feeling joyful while learning. Learning motivation could energize the learners to follow the learning process. Thus, learners could obtain better learning outcomes [8]. The physics learning outcomes of the learners were excellent although the learning was in an online manner during this COVID-19 pandemic [24]–[26]. The physics teacher carried out the physics lesson with the Zoom meeting application. The teacher had explained the materials about lights and optics, temperature and heat, dynamic electricity, and electromagnetic wave. The learning outcomes were excellent because of the strong extrinsic learning motivation.

The analysis results of the extrinsic motivation indicators showed each indicator had a significant correlation with the learning outcomes. Based on the data, the researchers concluded that the extrinsic learning motivation of the learners was excellent. The data processing results obtained a positive regression equation. It indicated that extrinsic learning motivation (X) had a positive correlation toward the learning outcomes (Y). It showed that higher extrinsic learning motivation led to higher learning outcomes. This result was in line with the previous research. It showed that extrinsic learning motivation influenced significantly the learners' learning outcomes [27], [28]. If learners have higher learning motivation, their learning outcomes are also higher [6].

This result supported the research of Fitriyani *et al.* (2020). They explained the positive and significant correlations between learning motivation toward the learning outcomes of the learners [9]. Research by Yuliana *et al.* (2019) showed that learning motivation had a positive and significant correlation toward the learning outcome improvement [10]. For this reason, teachers must establish the learners' learning motivation to achieve the maximum learning outcomes [29], [30]. The teaching-learning process will last effectively if the learners have learning motivation. Teachers have to struggle maximally to establish learning motivation. It is important because learning motivation is the key to success in achieving better learning outcomes. Teachers should establish this learning motivation for learners gradually [31].

The normality data test and the percentage analysis of the four-extrinsic learning motivation showed: the scales of strongly agree with a percentage of 34%, agree with 62%, disagree with 4%, and strongly disagree with 0%. The second indicator showed the scales of strongly agree with 33%, agree with 55%, disagree with 11%, and strongly disagree with 1%. The third indicator showed the scales of strongly agree with 34%, agree with 59%, disagree with 7%, and strongly disagree with 0%. The fourth indicator showed the scales of strongly agree with 45%, agree with 53%, disagree with 1%, and strongly disagree with 0%. Based on the data analysis of the four indicators, the researchers found the extrinsic learning motivation of the learners was excellent. Therefore, it could be concluded the extrinsic learning motivation positively and significantly influenced the learning outcomes.

IV. Conclusion

This research found the correlation between learning motivation toward learning outcome with a significant value of $0.000 < 0.05$. The correlation obtained a correlative coefficient value of 0.934. It indicated there was a strong correlation between learning motivation toward learning outcomes. Learning motivation influenced the learners' learning outcomes proven by a significant value of $0.000 < 0.05$. The simple regression equation of this research is $Y = 56.147 + 0.291$ (X). The learning motivation influenced the learning outcomes with a percentage of 87.2%. Thus, the remaining percentage, 12.8%, indicated other unexamined influential

factors. Therefore, there is a need for further studies about the improvement and disimprovement of learning motivation toward learning outcomes on other aspects.

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THE IMPLEMENTATION OF SCIENTIFIC APPROACH FOR COOPERATIVE LEARNING MODEL TYPED INSIDE OUTSIDE CIRCLE (IOC) TOWARD THE SCIENCE LEARNING OUTCOMES OF THE SEVENTH GRADERS OF LAWANG PUBLIC ISLAMIC JHS MANDAHILING

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ABSTRACT

The science learning outcomes of grade VIII students at MTsN Lawang Mandahiling are still low. Students physics's learning outcomes are low because teachers still dominate physics learning, and the intensity of student involvement when learning is a little. This study aims to determine how to apply a scientific approach to the Inside-Outside Circle cooperative learning model for students' physics learning outcomes. This type of research is quasi-experimental research, with the research design used is posttest only control group design. Sampling used random sampling, resulting in two sample classes, namely class VIII.2 as the experimental and VIII.3 as the control class. The data collection used a test of student learning outcomes on knowledge competencies in a multiple-choice test of 20 items. The competency data of students' attitudes and skills used observation sheets which were analyzed qualitatively descriptive. The results of the final tests conducted in the study showed that the physics learning outcomes of students in the experimental class were better than the control class. The average final score of students for knowledge competence in the experimental class and control class, respectively, was 78.00 and 66.00. For attitudinal competence, the average scores obtained by the experimental class and control class were 68.98 and 65.34, respectively. For the competency skills, the average scores obtained by the experimental class and control class are 74.22 and 68.25, respectively. Hypothesis testing is done by using a t-test. From the calculation on knowledge competency, the result of t_{count} = 3.07 while t_{table} = 1.684; on attitude competence, the price of tcount = 2.29; on skills competency, the t_{count} = 4.26; while t_{table} = 1.684 while t table = 1.684 at the real level α = 0.05. It means that $t_{count} > t_{table}$ so that H_0 is rejected and H_1 is accepted. It can be concluded that the students' physics learning outcomes in applying the synthetic approach to the Inside-Outside Circle cooperative learning model are better than the physics learning outcomes of students who do not use the Inside-Outside Circle

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cooperative learning model in solar system subject matter in grade VIII MTsN Lawang Mandahiling.

INTISARI

Hasil belajar IPA siswa kelas VIII di MTsN Lawang Mandahilin**g** masih tergolong rendah. Rendahnya hasil belajar fisika siswa disebabkan karena pembelajaran fisika masih didominasi oleh guru dan intensitas keterlibatan siswa pada saat belajar sedikit. Penelitian ini bertujuan untuk mengetahui langkah-langkah pendekatan saintifik pada model pembelajaran kooperatif tipe Inside Outside Circle terhadap hasil belajar fisika siswa. Jenis penelitian ini adalah penelitian eksperimen semu, dengan rancangan penelitian yang digunakan adalah posttest only control group design. Pengambilan sampel menggunakan random sampling yang menghasilkan dua kelas sample yaitu kelas VIII.2 sebagai kelas eksperimen dan VIII.3 sebagai kelas kontrol. Pengumpulan data menggunakan teknik tes dan non-tes. Tes hasil belajar siswa pada kompetensi pengetahuan menggunakan tes pilihan ganda sebanyak 20 butir soal. Teknik non tes untuk memperoleh data kompetensi sikap dan keterampilan siswa menggunakan lembar observasi yang dianalisis secara deskriptif kualitatif. Uji hipotesis dilakukan dengan uji-t. Hasil tes akhir yang dilakukan pada penelitian menunjukkan bahwa hasil belajar fisika siswa pada kelas eksperimen lebih baik daripada kelas kontrol. Rata-rata nilai akhir siswa untuk kompetensi pengetahuan pada kelas eksperimen dan kelas kontrol masing-masing yaitu 78,00 dan 66,00. Nilai rata-rata pada kompetensi sikap yang diperoleh kelas eksperimen dan kelas kontrol masing-masing yaitu 68,98 dan 65,34. Sedangkan kompetensi keterampilan pada kelas eksperimen dan kelas kontrol diperoleh nilai rata-rata masing-masing 74,22 dan 68,25. Dari perhitungan pada kompetensi pengetahuan diperoleh harga t_{hitung} = 3,07 sedangkan t_{tabel} = 1,684; pada kompetensi sikap diperoleh harga t_{hitung} =2,29; pada kompetensi keterampilan diperoleh harga t_{hitung} = 4,26; sedangkan t_{tabel} =1,684 sedangkan t_{tabel} =1,684 pada taraf nyata α = 0,05. Berarti $t_{hitung} > t_{tabel}$ sehingga H_0 ditolak dan H_1 diterima, maka dapat disimpulkan bahwa hasil belajar fisika siswa pada penerapan pendekatan sintifik pada model pembelajaran kooperatif tipe Inside Outside Circle lebih baik daripada hasil belajar fisika siswa yang tidak menggunakan model pembelajaran kooperatif tipe Inside Outside Circle materi sistem tata surya di kelas VIII MTsN Lawang Mandahiling

I. Introduction

Education is an important part of human life. The Regulation Number 20 the Year 2003 about the National Education System, Article 1, Item 1 states that education

is a conscious and planned effort to realize learning situation and process for students actively by developing their potencies to have spiritual power, self-control, personality, intelligence, valuable characteristics, and needed skill by society, nation, and the country [1]. Then, the Ministerial Regulation Attachment of the Education and Cultural Minister of the Republic of Indonesia, Number 66 the Year 2013 about the educational assessment standard, Article 3, emphasizes that "the National Education has the function to develop skills and establish the dignified characters and civilization [2]. It is for the sake of realizing the brilliant national generation and developing their potentials to be a faithful human toward their God, the Almighty, to have excellent characters, proper health, science, reliability, creativity, autonomy, and to be democratic and responsible citizens. Education should consider some aspects, such as physics and mental, individualization, social, science, attitude, skill, concentric interaction, horizontal interaction, and vertical interaction toward their God [3].

The government, represented by the Education and Cultural Minister applied the 2013 curriculum as the educational curriculum to realize the national education objective. The 2013 curriculum requires both direct and indirect learning. Direct learning deals with science, thinking, and skill development to process the knowledge while having direct interaction with the learning resource. On the other hand, indirect learning in situated daily learning causes accompaniment impacts. The learning demanded by the curriculum requires a scientific approach or scientific process-based approach. It is mandatory of the curriculum. The approach is a learning experience organization with logical order. It starts by observing, inquiring, collecting information, reasoning or associating, and communicating. They promoted scientific approach with both direct or indirect learning model becomes the principle to apply various learning models and strategies based on the demanded core competence to achieve [4].

The scientific approach is relevant to all lessons especially physics that requires innovative stages to provide an attraction for the learners. Teachers have the task to make physics lessons interesting and enjoyed by learners. They also must carry out their roles as facilitators, managers, and learning consultants for the learners. Wina Sanjaya (2008, p. 95) explains that in this current era, the teacher's role shifts from the only learning resource to the instruction manager. Thus, both teachers and learners are learning and studying [5]. Therefore, teachers need various facilities and must create a conducive learning atmosphere so that the learning process could last effectively and efficiently.

The learning process will run properly if the teachers are wise to determine the relevant applied approach based on the materials to teach. One of the approaches is the scientific approach. The Education and Cultural Minister provides the specific concept that the scientific approach for learning includes observing, inquiring,

reasoning, attempting or creating, and presenting or communicating. Teachers should use appropriate learning models to encourage learners to participate in the scientific approach. It is by applying the cooperative learning model. A cooperative learning model is a learning model with a small-group system or categorization system. It should cover four to six participants with various academic, sex, racial, and tribal backgrounds.

The cooperative learning model could also encourage learners to understand complex concepts and to facilitate learners developing their cooperation and train their critical thinking skills. Thus, learners will understand the materials better. The most important part of this cooperative learning is to improve the learners' learning activity, learners' positive attitudes, learning motivation, self-confidence, and happiness to study at school, and compassion to the classroom peers. One of the cooperative learning models is the Inside-Outside Circle model. It requires the learners to work in groups of large and small groups. The group consists of 12 to 14 participants. It has the purpose to strengthen individual and group relationships. This model also needs excellent communication skills and an excellent group process. Besides the appropriate model selection, the ways of the learners' learning activities also influence their learning achievement. Learners with high learning activities can quickly act out to improve their learning achievement. However, learners with low learning activities tend to be lazy.

The interview results with the school physics teacher informed that learners had difficulties expressing ideas, notions, and opinions in the learning process. They also had low motivation to learn physics. They preferred accepting all materials from the teachers to completing the given problems related to the lesson. They argued that the problems were difficult for them. This learning atmosphere causes lower learning achievements. The observation informed the researchers that the learners, 123 individuals, obtained low physics midterm test scores in the academic year 2016/2017 with an average score of 65.07. More than 50% of learners did not pass the test because the scores were low and under the minimum mastery standard, 75.

The learning process requires teachers to apply new learning models to improve the spirit and learning atmosphere. By applying scientific learning with the Inside-Outside Circle model, learners are expected to achieve better learning outcomes. Thus, they will learn more seriously. This model is suitable because it allows researchers to obtain various information at the same time. The model also allows researchers to pair the learners, elicit more ideas, provide more tasks, and monitor the learners. The material for this research was the solar system. It was selected because it was suitable for the applied model and did not require any calculation. Thus, it made the researchers interested to reveal the implementation of a scientific approach for cooperative learning model typed Inside Outside Circle (Ioc) toward the Science learning outcomes of the seventh graders of Lawang Public Islamic JHS Mandahiling.

II. Research Method

This research is a quasi-experimental research with a posttest-only control group design. It involved the seventh graders of Lawang Public Islamic JHS Mandahiling. The applied sampling technique was the random sampling technique. It resulted in two groups, the experimental group from the VIII-2 learning group and the control group from the VIII-3 learning group. The Inside-Outside Circle (IOC) was applied for the experimental group while the conventional treatment was for the control group. Each learning group consisted of 24 learners with relatively equal skills.

The independent variable was the learning with Inside-Outside Circle type learning. The controlled variables were the teachers, time allotments, and the given materials for both groups. The primary data from the research consisted of the physics learning outcomes from both groups.

The applied research instruments were the competence-achievement test and observation sheet. The test covered the cognitive field while the observation was important to find out the learners' attitudes and skills. The researchers adjusted the learning materials with the 2013 curriculum. They also consulted the materials with the teachers and the supervisors. Before conducting the test, the researcher validated the test-instrument items. The validation involved the VIII-1 learning groups as a test-instrument validation sample. This validation test had the purpose to examine the validity and reliability of the research instrument. When the instrument did not meet the validity and reliability criteria, the researcher had to revise the instrument.

The analysis of the test results was done by determining the difficulty index, distinguishing power, test reliability, and question classification. The question item difficulty index analysis found seven difficult questions, twenty moderate difficulty questions, and six easy questions. The analysis result found the distinguishing power consisted of 9 excellent questions, 11 average questions, 3 unfit questions, and 10 inaccurate questions. The validity test found a reliability score of 0.61, categorized as high reliability. After calculating the difficulty index, the discrimination power, and test reliability, the researchers determined the question item selections. They also classified the questions into ready-to-use or removed questions. Based on the test item analysis, twenty question items were ready to use.

The obtained data supported the authentic assessment system. It covered cognitive, affective, and psychomotor aspects. The techniques of analysis and learning outcome data process were the final scores of the learners. The learning outcomes on the competencies were from the learners' test results. The final test results were analyzed in terms of their normalities, homogeneity, and hypotheses. The learners' skills were measured with the observational sheet. It consisted of five aspects: honesty, discipline, responsibility, politeness, and activeness. On the other hand, the assessed skills were from the observation results of the produced products by the learners while learning. It consisted of tidiness, cleanliness, creativity, and accuracy.

The affective and psychomotor learning outcomes were analyzed by finding out the mean score percentages. Then, they were converted into quality scores.

III. Results and Discussion

The Research Results

The selected physics material was the solar system. This research used a lesson plan, trial run question, observation sheet of affective competence, observation sheet of psychomotor competence, and final test questions. The researchers carried out the research on Wednesdays and Saturdays, from April 22 until May 6, 2017, at Lawang Public Islamic JHS Mandahiling.

The physics learning outcomes of cognitive competence were based on the final test. Forty-eight learners joined the test. They were from both experimental and control groups. Each of them consisted of 24 learners. The final test consisted of twenty multiple-choice items. The time duration to work on the questions was 80 minutes. The average scores of both groups were 78 and 66 consecutively. The highest score for both groups was 90. The lowest scores from both groups were 65 and 50. The average score, the highest score, and the lowest score of both groups are in Table 1.

Table 1. the average score, the lowest score, and the highest score of the sample class

No	Group	Scores Average	Scores Highest	Lowest
1	Experiment	78	90	65
2	Control	66	90	50

The physics learning outcomes of the affective competence were based on the observation sheet. The researchers observed three times, started from the first meeting until the third meeting. On the other hand, in the fourth meeting, the researcher did not take the data because learners took the final test. The final scores of the affective competence of each learner were based on the sum of the obtained scores from the first, second, and third meetings. Then, the researcher calculated the average score. The researchers converted the final scores into quality scores. Table 2 shows the scores of each indicator.

Table 2. the average score of affective competence indicator

Number	Group	The average score of each affective indicator aspect				
		Honesty	Discipline	Responsibility	Politeness	Activeness
1	Experiment	75.26	65.6	76.5	71.1	60.4
2	Control	66.87	67.23	70.83	70.5	54.3

Based on the affective competence analysis results of the experimental group, no learners obtained the A value. Twenty-three learners obtained a B value (95.8%). Only one learner obtained the C value (4.2%). No learners obtained the values of D and E. On the other hand, eighteen learners of the control group obtained a B score (75%). Six learners obtained a C score (25%). None learners obtained A, D, nor E scores. The data were proven by the average score of affective competence from both groups with $\bar{x}$. The effective average score of the experimental group was 68.98 while the control group was 65.34. Table 3 shows the average scores.

Table 3. The physics learning outcome average scores of the learners on affective competence

Group	The average score ($\bar{x}$)
Experiment	68.98
Control	65.34

The researchers obtained the average scores of physics learning outcomes based on the psychomotor competence of each aspect from the observation as shown in Table 4 The analysis results were converted into quality scores.

Table 4. The average score of each psychomotor competence indicator

Group	The average score of each indicator on psychomotor competence			
	Tidiness	Cleanliness	Creativeness	Accuracy
Experiment	75	83.3	72.92	67.71
Control	69.8	71.9	66.7	65.63

Four learners of the experimental group obtained the A score (16.7%). Six learners obtained a B score (83.3%). None learners obtained C, D, nor E scores. All control group learners obtained the B score (100%). None learners obtained A, D, nor E scores. The data were proven by the average score of psychomotor competence from both groups with $\bar{x}$. The average score of experimental group competence was 74.22 while the control group was 68.25. Table 5 shows the average scores.

Table 5. The physics learning outcome average scores of the learners on psychomotor competence

Group	The average score ($\bar{x}$)
Experiment	74.22
Control	68.25

The researchers analyzed the data with a normality test by checking the sample normality. The normality test results of each competence, cognition, affection, and psychomotor, indicated that the skills were normally distributed. Then, the researchers tested the homogeneity with F-test. It had the purpose to determine both sample homogeneities. The homogeneity test showed the f-counts were 0.54, 0.58, and 1.05.

The research compared the f-count with the f-table. It showed the data sample had normal distribution and homogeneous variance. variansi yang homogen.

Then, the researcher could promote a hypothetic test with a t-test. The test was done for each competence. The calculation results with the t-test obtained a tcount of cognitive aspect score 3.07 with the ttable score of 1.684. The value of tcount of affective competence was 2.29 with ttable = 1.684. The value of tcount of psychomotor competence was 4.26 with ttable= 1.684 under the significance of 0.05. It meant the tcount > ttable thus Ho was denied but Ha was accepted. Therefore, the physics learning outcome of the learners taught with IOC were better than those taught by the conventional model. The hypothetic test analysis of each competence could be seen in Tables 6, 7, and 8.

Table 6. The hypothetic test of cognitive competence

Group	$\bar{x}$	N	s^2	t_{hitung}	**Remarks**
Experiment	78	24	62.542	3.07	**Accepting the hypothesis**
Control	66	24	115.958		

Table 7. the hypothetic test of each affective competence

Group	$\bar{x}$	N	s^2	t_{hitung}	**Remarks**
Experiment	68.89	24	22.190	2.29	**Accepting the hypothesis**
Control	65.35	24	38.23		

Table 8. The hypothetic test of the psychomotor competence

Group	$\bar{x}$	N	s^2	t_{hitung}	**Remarks**
Experiment	74.22	24	23.80	4.26	**Accepting the hypothesis**
Control	68.25	24	22.5375		

Discussion

The physics learning outcomes of the cognitive competence

Based on the final test data, the learners' learning outcomes of the experimental group's cognitive competence were better than the control group. The highest, lowest, and average scores of the experimental group were higher than the control group. The highest experimental group's score was 90 with the lowest score of 65 and an average score of 78. The highest control group's score was 90 with the lowest score of 50 and an average score of 66.00

The highest score of both groups was 90. However, based on the frequency of the scores, the experimental group had four learners achieving the score while the control group only had a learner achieving the score.

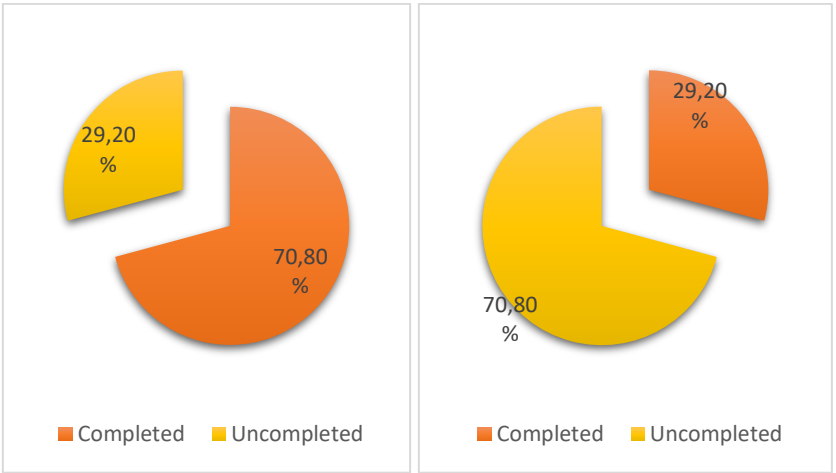

Figure 1. The physics learning outcome completion percentage on cognitive competence a) experimental group, b) control group

The figure shows the comparison of both groups' scores. The experimental group's completion percentage was 70.80%. The remaining percentage, 29.20%, indicated the uncompleted percentage. The control group had the contrast completion percentage from the experimental group. The control group's completion percentage was 29.20 %. The remaining percentage, 70.80%, indicated the uncompleted percentage. Some factors influenced both groups' completions. One of them was the Inside-Outside Circle-typed cooperative model. This model did not rely on the teachers but it allowed learners to find information from various resources and learning outcomes from other learners.

The applied cooperative model grouped the learners to learn. Grouping them to learn became the trick to give them the freedom to argue and share opinions. The learners argued that this method made them easier to learn. Kunandar (2007, p. 303) found that teaching with smaller groups allowed learners to cooperate and maximize their learning conditions to achieve the learning objectives [6]. Typical individuals learn more when they are interacting with their larger size of classmates. This situation leads to higher achievement compared to when the learners are learning alone.

The Inside-Outside Circle typed cooperative learning encouraged proper interaction among students and toward the teacher. Hartup (cited in Desmita, 2009. p. 224) explains the influential interaction deals with the psychological development of learners [7]. It refers to the interaction among learners that have a similar function as parents because learners of the same age could provide tranquility when their friends are feeling anxious. This excellent communication establishment among learners in a

group and toward their teachers would make them enjoy the learning. Then, once the learners felt joyful and happy with a certain material, they would improve their learning outcomes.

Besides that, the Inside-Outside Circle typed cooperative learning model could make learners understood the learned materials. The learners would get the chance to answer the teacher's questions. Thus, learners would be motivated to learn even before they started it. Then, the applied learning model could make learners active during the learning and prevent any monotonous learning.

The physics learning outcomes of affective competence

The affective competence deals with the values of an individual [5]. This research observed the affective competence, such as honesty, discipline, responsibility, politeness, and activeness. These aspects were assessed during the learning process. Each learner had to be active while joining the learning in each meeting. The teacher motivated the learners to cooperate in groups. Based on the data analysis, the average score of each affective competence indicator aspect showed changes. Table 2 eases the readers to understand the situation.

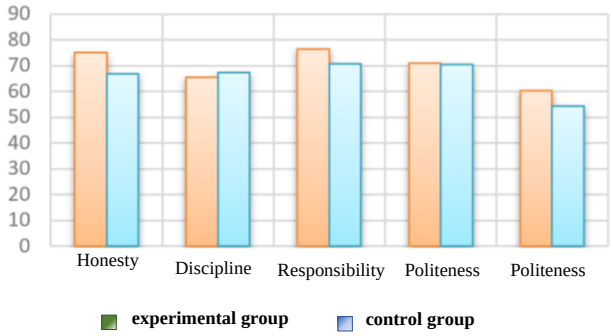

Figure 2. the average score of affective competence

Table 2 and Figure 2 show the average score of both groups' aspect changes. The changes were not very different, between 0.4% until 5.3%. However, the experimental group was better than the control group. Based on the observation, some factors influenced the affective competence differences, such as

Honesty: This aspect dealt with how learners could practice their honesty and integrate the aspect into a personal value system. In this aspect, the average score of the experimental group was 75.26 while the control group with 66.87. The average difference in this aspect was caused by the incapability of the learners. They could not express their argument based on what they thought.

Discipline: This aspect dealt with how learners could be discipline during the learning process. In this aspect, the experimental group obtained an average score of 65.6 while the control group was 67.23. These average differences were caused by

some learners in the control group who could not be discipline while learning, such as being punctual, obedient toward the lesson regulation, etc.

Responsibility: This aspect dealt with how learners respected a notion and could take responsibility for the notion. In this aspect, the experimental group obtained an average score of 76.5 while the control group was 70.83. The average scores of both groups were not very significant because some learners had carried out the instruction from the teachers. However, there were still some learners that did not do the tasks and carry out their responsibilities.

Politeness: This aspect dealt with how learners could respect each other. The obtained average score of 71.1 while the control group was 70.5. The average score differences were caused by some learners could not respect their friends' arguments or speeches.

Activeness: This aspect dealt with how the participants and their participation in the group and learning activities. In this aspect, the experimental group obtained an average score of 60.4 while the control group was 54.3. The average score differences were caused by some learners did not express their arguments although their arguments were correct.

The average scores of the whole physics learning outcomes in this affective competence showed that the experimental group had a higher score than the control group. The average score of the experimental group was 69.76 while the control group was 65.44. The physics learning outcomes of affective competence taught by IOC were higher than learning outcomes taught without IOC.

The physics learning outcomes on psychomotor competence

The physics learning outcomes on psychomotor competence were the continuity of the learners' physics learning outcomes on cognitive and affective competencies. The psychomotor competence consisted of muscular and neural behaviors. It was the learners' learning outcome in the forms of performance and trial activities [8].

The physics learning outcomes on psychomotor competence were from the learners' created products within a certain period. In this research, the products were made from simple props, such as solar system property. It was made from the surrounding materials. During the production, the teacher grouped the learners to work on it. The assessed activities were tidiness, cleanliness, creativity, and accuracy to create products.

Based on the psychomotor competence analysis results, the average score of the experimental group was higher than the control group. Some factors influenced the higher psychomotor competence scores. They were: First, the learners made the prop tidily and clean so the products were excellent.

Second, the learners exposed their creativity so the props were attractive. The learners cooperated while creating the products so they could finish the products in

time. The obtained psychomotor average skills from both groups were not significantly different. The experimental group obtained an average score of 74.22 while the control group was 68.25. The physics learning outcomes in this psychomotor competence showed that the experimental group had an excellent score than the control group.

IV. Conclusion

This research concluded that the scientific approach implementation with the Inside-Outside Circle typed cooperative learning toward the physics learning outcomes of the learners were higher than those without the proposed model. The evidence was the physics learning outcome average score of Lawang Public Islamic JHS learners in Mandahiling. The cognitive competence score of the experimental group was 78 while the control group was 66. The affective average score of the experimental group was 68.89 while the control group was 65.35. The psychomotor competence average score of the experimental group was 74.22 while the control group was 68.25.

Thus, with this Inside-Outside Circle typed cooperative learning model, the seventh graders of the school were more active to learn. This research recommends further research to apply the IOC learning model by considering some supporting factors that influenced the model learning success.

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THE DEVELOPMENT OF FOUR-TIER DIAGNOSTIC TEST INSTRUMENT TO IDENTIFY THE LEARNERS' MISCONCEPTION ON CIRCULAR MOTIONS

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ABSTRACT

Teachers must be aware of the learners' difficulties while understanding a concept. They should also improve the learners so the learners could master the concepts excellently. The misconception diagnostic test may become the alternative to reveal the misconception causes or factors. This research is a development study with a 4D development model. It aims to develop the diagnostic test instrument in the form of a four-tier test to identify the learners' misconceptions about circular motion. The developed test consisted of forty multiple-choice questions. The researchers involved five experts to validate the content. The result was the instrument's reliability obtained an average percentage of 86.34%. The empirical test results found 40 test items were valid with the excellent distinguishing category. The question reliability formula was using Kuder Richardson with a score of 0.785, categorized high. The developed test was in the form of multiple-choice to identify the learners' misconceptions. The test could be the assessment alternative to evaluate physics learning.

INTISARI

Guru perlu mengetahui kesulitan siswa dalam memahami suatu konsep dan melakukan perbaikan, sehingga siswa dapat menguasai konsep dengan baik. Tes diagnostik miskonsepsi dapat menjadi alternatif untuk mengungkap penyebab atau faktor miskonsepsi pada siswa. Penelitian ini merupakan studi pengembangan dengan menggunakan model pengembangan 4D dengan tujuan mengembangkan instrumen tes diagnostik dengan bentuk Tes Empat Tingkat (*four-tier test*) untuk mengidentifikasi miskonsepsi siswa pada materi Gerak Melingkar. Instrumen tes diagnostik *four-tier test* yang dikembangkan terdiri dari 40 pertanyaan pilihan ganda. Hasil validasi konten oleh lima ahli menyatakan bahwa instrumen ini sangat layak dengan persentase rata-rata 86,34%. Hasil uji coba empiris menunjukkan sebanyak 40 item tes diagnostik

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memiliki kriteria valid, dengan tingkat kesulitan dan daya beda soal dalam kategori baik. Reliabilitas pertanyaan dianalisis menggunakan rumus Kuder Richardson sebesar 0,785 dan termasuk kategori tinggi. Instrumen *Four-tier test* yang dikembangkan dalam bentuk pilihan ganda ini dapat digunakan untuk mengidentifikasi miskonsepsi siswa dan juga dapat digunakan sebagai alternatif asesmen dalam melakukan evaluasi pada pembelajaran fisika.

I. Introduction

Teachers must be aware of the learners' learning problems so that teachers can take the appropriate solutions. One of the most frequently observed problems is a misconception. It usually deals with an incorrect explanation about a relevant physics concept that is agreed by scientists. This misconception is observable during the daily life experience while the learners are interacting with their environment [1]. This experience leads to an inner-theory establishment that may be incorrect. If the constructed intuition of learning is incorrect, it will be difficult to correct it because it consistently allows the incorrect concept to be the basis for the learner [2]. Therefore, physics learning should emphasize understanding rather than memory [3].

The physics learning process should not only present new ideas but change the previous ideas of the learners. Thus, they could receive an understanding of facts, concepts, principles, laws, and theories with scientific reasoning. At the new learning stage, learners have already had the background knowledge from their daily experience and obtained information from their surroundings [4]. The knowledge may change or remain still as the accepted learning process. Learning physics still has problems with misconceptions of the learners. Thus, it requires further identification to determine the learners' conceptual understanding levels. This matter requires further review and it is not merely a test of learning achievement. A test should be able to analyze the learners' misconceptions [5].

The observation results at Arrahmaniyah SHS, on 34 learners, proved 30 learners thought that the physics lesson was the most difficult lesson. This problem to understand physics concepts made them not interested in a physics lesson. The percentage of 88% of learners of the school was not interested in a physics lesson. They did not pay attention or even did not listen to the teacher's explanation while learning physics. They did not want to autonomously learn before the class began. They did not learn the given materials after the class. These matters made them did not understand the physics concepts and led to misconceptions. The observation results proved that the most difficult physics misconception was the circular motion concept. The previous studies showed similar findings. They found learners with circular motion misconception [6]–[8].

One of the ways to detect misconceptions is the diagnostic test [5]. It is a test to check the strength and the weakness of the learners while learning a concept. Thus, the result could be used as the basis to follow [9]. The diagnostic test implementation at the beginning and the ending of learning could facilitate teachers to ensure the weaknesses and the strength of the learners. It is also useful to detect misconceptions of the learned materials [4]. An excellent diagnostic test provides accurate descriptions of the learners' misconceptions based on the information of their incorrectness. The excellent diagnostic question items should not only inform whether the learners understand certain material parts. The items should be able to reveal how the learners think while answering the questions even the incorrect answers [4].

The multiple-choice diagnostic test has various forms, such as one-tier, two-tier, three-tier, and four-tier multiple-choice tests. The four-tier diagnostic test is the development of the three-tier diagnostic multiple-choice test [10], [11]. The development deals with the increased confidence level of the learners while selecting the answers or reasons. The first tier contains multiple-choice options with three decoys and one key answer to select. The second tier contains the confidence level of the learners while selecting the answers. The third tier covers the reasons for answering the questions. The test has three reason selections and one opened-reason selection. The four-tier is the confidence level or degree for the learners to select the reason. This four-tier diagnostic test was differently developed within the intervals of one to six based on the study of [12].

The developed test would be useful for the teachers to (1) identify the confidence level of the answers and the selected reasons of the learners. Therefore, teachers could elicit more conceptual understanding strength from the learners; (2) diagnose the learners' misconceptions comprehensively; (3) determine the material parts that require more emphasis; (4) plan the better learning to avoid learners' misconceptions [9], [13].

The occurring misconceptions should be overcome because it hinders the learners to understand the concepts scientifically [14]. This research aims to develop the four-tier diagnostic test about the learners' misconceptions and to determine the reliability of the instrument to identify the learners' circular motion misconceptions. It also aims to test the developed test to identify the misconception.

II. Research Methodology

This research and development developed the four-tier diagnostic test to find out learners' misconceptions on circular motion. The R&D model was 4D with stages from defining, designing, developing, and disseminating. This research limited the instrument development only at the developing stage exactly in the limited-scale product test. The applied instruments were observation sheets, the four-tier test diagnostic instrument sheet, and the four-tier test validation sheet.

The applied data analysis stages were analyzing the validity, reliability, difficulty, distinguishing power, questionnaire analysis, learners' misconception analysis, and the four-tier diagnostic test result interpretation. The validity test involved two expert lecturers. The reliability test used the KR-20 formula. The learners' misconception analysis used Caleon & Subramanian's equation [12].

$$CDQ = \frac{(CFC - CFW)}{S} \quad (1)$$

The equation tells that CFC is the average of learners' confidence levels that answer correctly. CFW refers to the confidence average score level of learners that incorrectly answer. Then, S is the standard of deviation of the confidence level. The result interpretation grouped the learners into learners with clear, unclear, and misconception understanding. The high confidence level was when learners selected the scale-4 option (confident), scale-5 option (strongly confident), or scale-6 option (extremely confident). The low confidence level was when learners selected the scale-1 option (guessing), scale-2 option (feeling very not sure), or scale-3 option (feeling not sure).

III. Results and Discussion

The Defining Stage

The developed test was to overcome the encountered difficulties while having interviews or tests [15], [16]. Based on observation and the data collection, the researchers developed the diagnostic test instrument to identify the learners' misconceptions. The developed test was a four-tier test misconception diagnostic test. The defining stage required the researchers to identify the developed instrument and paid attention to some characteristics. They were 1) the investigated lesson, physics for X grade; 2) the developed test form, the four-tier test; 3) the tested question items, 40 question items; and 4) the applied materials in the test development about circular motion.

The Designing Stage

The researchers developed the instrument by (1) determining the materials, (2) creating diagnostic test question rubrics, and (3) writing the questions in the four-tier-test form, starting from the questions, answer option, the confidence level of the answers, reason, and confidence level of the reasons.

The four-tier test instrument framework is shown in Table 1.

Table 1. The four-tier test instrument framework

The developed *four-tier test* instrument framework	
1. Questions A. Option B. Option C. Option D. Option	3. Reasons toward the selected answers A. Option B. Option C. Option D. Option
2. The confidence level of the selected answer A. Confident B. Not confident	4. The confidence level of the selected answer A. Confident B. Not confident

The Developing Stage

The developed instrument consists of four-tier. They were questions, answers, confidence levels of the answers, reasons, and confidence levesl of the reasons. The developed questions were 40 items under the circular motion sub-topic. The instrument had to be validated by the experts before being used. The experts validated forty question items. The validating stage aimed to determine the validity of the developed question items before being used.

A test with high validity could reveal valid learning outcomes. Therefore, the experts of assessment and circular motion were very important for the validation stage [17]. Astutik (2018) [5] involved experts to validate the developed diagnostic test. Five experts validated the developed question items based on three assessment aspects: material, construct, and language aspects. The arrangement of the instrument assessment component was based on the validation sheet rubric. Each question item is given Y and T options. The Y option revealed when the question items were relevant to the indicators and obtained a score of 1. On the other hand, the T option showed when there was no relevance with the indicators and obtained a score of 0. The assessment result of each question item on each indicator was added. Then, the validity would be determined. After being validated, the researchers screened the questions based on the validation categories. For questions with excellent categories, they did not need further revisions and could be used. The experts' judgments are shown in Table 2.

Table 2. The experts' judgment

Experts	The content aspect (%)	The construction aspect (%)	The language aspect (%)	Average (%)
A	90	85	90	88,33
B	90	82	87	86,33
C	88	84	85	85,67
D	90	80	87	85,67
E	87	82	88	85,67
Criteria	**Very reliable**	**Reliable**	**Reliable**	**Very reliable**

Table 2 shows the final results of the test instrument validation. The average of three aspects was "very reliable". Thus, the instrument could be used.

The trial test involved thirty individuals of the X Science learning group. The learners worked on the test then the results were analyzed. The trial results were analyzed to find out the empirical validity of the developed question items. From the analysis results, forty questions had high until very high validity levels. The question items also had the average distinguishing power and the difficulty levels were normally distributed, from the easy until difficult levels. The researchers used the Kuler Richardson formula to analyze the question item reliability. The result was 0.785, categorized high. The confidence level increase of each answer and reason could measure the cognitive level difference of the learners. It would ease the detection of misconceptions. [18] found that it was difficult to differentiate the learners that did not know the concepts and those who had misconceptions. The four-tier diagnostic test could determine the learners' strength in mastering the concept via self-confidence levels while answering [19], [20].

The development stage had the purpose to improve the quality of this four-tier test by considering the answer possibilities that learners could easily guess. It was by creating the assessment indicators in the form of answer combinations to categorize. Second, it was describing the four-tier test questions to be more comprehensive and varied so that learners would obtain new insight. Third, providing an answer sheet so that learners could provide answers that were not only provided. This research provided the question examples to explain how the test could coordinate the learners to guess. The process to reveal the learners' misconceptions required a specific four-tier diagnostic test than the typical multiple-choice. Multiple choice had limitations because it could not differ the correct answers due to the correct reasons and correct answers with incorrect reasons [12], [15], [21].

IV. Conclusion

This research concluded that the developed test could measure the learners' misconceptions. The instrument was also reliable and valid to use based on the empirical findings. The developed test had high validity results. It also had excellent distinguishing power and proportional difficulties. The question reliability obtained

a score of 0.785, categorized high. From the explanation, the four-tier test was suitable to identify the learners' misconceptions on circular motion. Besides that, the four-tier test could be an alternative to conduct a physics learning evaluation.

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PjBL-BASED BLENDED LEARNING IMPLEMENTATION ON ENERGY TOPIC TO IMPROVE THE PROBLEM-SOLVING SKILL

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ABSTRACT

Blended learning is a new strategy or way in the learning process. Besides face-to-face learning, the learning process should also be carried out in an online manner. Online learning could facilitate teachers and learners to learn anywhere and anytime. It is an appropriate learning strategy and supported by a learning model that could integrate various science disciplines, such as science, technology, engineering, and mathematics. This research aims to describe the improvement of problem-solving skills on energy via blended learning-based PjBL STEM. Each syntax of the learning consists of five-stage. They are problem solving, focus the problem, describe the problem in physics description, plan a solution, execute the plan, and evaluate the solution. This research applied an experimental research design with pre-experimental (one group pretest-posttest design). The sample consisted of thirty-five Al-Azhar Islamic SHS 3 Bandar Lampung at X Science 1. The instrument was a problem-solving skill test in the form of an essay. The test results were analyzed with paired sample t-test. Based on the promoted research, the N-gain of experimental group learning outcome was 0.43, categorized moderate. The paired sample t-test hypothesis result obtained the Asymp. Sig (2-tailed) ≤0,05 is 0,00. It showed the improvement of problem-solving skills using the blended-learning-based PjBL STEM model.

INTISARI

Blended learning is a new strategy or way in the learning process. Besides face-to-face learning, the learning process should also be carried out in an online manner. Online learning could facilitate teachers and learners to learn anywhere and anytime. It is an appropriate learning strategy and supported by a learning model that could integrate various science disciplines, such as *science*, *technology*, *engineering*, and *mathematics.* This research aims to describe the improvement of *problem-solving* skills on energy via *blended learning*-based PjBL STEM. Each syntax of the learning consists of five-stage. They are *problem solving*, *focus the problem*, *describe the problem in physics description*, *plan a solution*, *execute the plan*, *and evaluate the solution.* This research

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applied an experimental research design with *pre-experimental* (*one group pretest-posttest design*). The sample consisted of thirty-five Al-Azhar Islamic SHS 3 Bandar Lampung at X Science 1. The instrument was a *problem-solving skill* test in the form of an essay. The test results were analyzed with *paired sample t-test.* Based on the promoted research, the *N-gain* of experimental group learning outcome was 0.43, categorized moderate. The *paired sample t-test* hypothesis result obtained the *Asymp. Sig* (*2-tailed*) ≤0,05 is 0,00. It showed the improvement of *problem-solving* skills using *the blended-learning*-based *PjBL STEM* model.

I. Introduction

The 2013 curriculum is perceived relevant with the 21st-century development in which the learners are demanded to have problem-solving skills. The problem-solving process requires an accurate approach to reach 21st-century reliability.

According to Matlin (1989), cited in [1], an individual requires problem-solving to reach his objectives. However, the objective has not been reached. Heller & Heller (2010) found some indicators of problem-solving [2]. They focus on the problem, describe the problem in physics description, plan a solution, execute the plan, and evaluate the solution.

The innovation in learning implementation could be realized in STEM education [3]. Trianto (2014) defines STEM (Science, Technology, Engineering, and Mathematics) as the scientific discipline that is inter-connected [4]. STEM learning provides opportunities for learners to solve problems. It also provides the freedom to design the solution so they will easily remember and master the technology.

However, in a learning activity, the problem-solving skill of learners was low because the learning process frequently had misunderstandings while learning physics [5]. Learners assume that physics is difficult material because it has many concepts [6].

The interview with the physics teachers of the school proved that physics learning on energy topics was merely transferring knowledge. Thus, the problem-solving skill was low. One of the efforts to improve the problem-solving skill was providing them conceptual meaning for the learners to learn and connect with daily life problems [7].

Therefore, learners need to make a simple project from the easily found materials in daily life. The project can be creating a mini solar water heater as the practice to apply physics concepts about energy. The energy topic is applicable in STEM-based learning.

One of the teachers' roles in the learning process is to select the applicable learning approach for their classes [8]. Learning approaches and models that can be integrated with physics-based on the education objectives, using daily life problems, is the learning-based PjBL STEM model [9]. PjBL STEM is a model in the learning

process via project activity [8]. PjBL STEM could improve the learners' interest, create more meaningful learning, and train learners to be problem-solvers in real life [10].

This research aims to find out the influence of blended learning-based PjBL STEM on the learners' problem-solving skill improvements on energy topics. The use of blended learning was due to the COVID-19 pandemic outbreak. Therefore, blended learning was a new way for the learning process.

II. Research Methodology

This research used a quasi-experimental method. The applied research design was pre-experimental (one group pretest-posttest design). This design provides a pretest before the treatment. Then, the research must analyze the results [11].

The research population covered all X science students of Al-Azhar 3 Bandar Lambung. They were distributed into five classes: X Science 1 until X Science 5. The sampling technique was simple random sampling. The sampling technique required the researchers to provide equal opportunities for the population to be selected as a sample. The result was a sample class, the X Science 1. It consisted of 35 learners.

The problem-solving of the learners was measured based on the worksheet outcomes and pretest-posttest answers of learners. The instruments were syllabus, lesson plan, STEM-based worksheet, and interview instrument of need analysis. The interview consisted of the guided interview guideline and the problem-solving intention test instruments. The test consisted of seven essay questions.

The researchers analyzed the obtained data with IBM SPSS Statistics software version 20.0. The normality test was to determine whether the data were normally distributed or not. The hypothesis test was paired sample t-test to determine the existence of problem-solving skill gain of the learners. The N-gain was to check the pretest and posttest score differences of the experimented group.

III. Results and Discussion

The frequent occurring mistakes were sub-scripts on the permeability quantity of vacuum space, such as its writing style that should have been written with the digit 'zero' instead of "o'" The prefix of the foreign term "non" should not have been separated with the following word. The results showed the improvement of the learners' problem-solving skills that were analyzed with N-Gain. The N-Gain data is in Table 1.

Tabel 1. The N-Gain average of problem-solving skills

Score achievements	Experimental group
The highest gain	0,75
The lowest gain	0,10
The gain average	0,43
The score increase average	43%
Category	Moderate

Table 1 shows that the experimental group's N-gain is categorized as moderate. Then, the data normality test was used to find out whether the data were normally distributed or not. The normality test could be seen in Table 2.

Tabel 2. The normality result of the problem-solving skill N-Gain

Groups	Kolmogorov Smirnov Sig.	
	Pretest	***Posttest***
Experimental group	0,428	0,657

The table shows the significant value of the experimental group's N-gain is normally distributed with Asymp. Sig (2-tailed) higher than 0,05. The test results show that the problem-solving skill scores of the class are normally distributed. The result met the requirement to conduct paired sample t-test.

The normality data test shows the N-gain of the experimental group is normally distributed. Therefore, the research used paired sample t-test hypothesis test. The results of the hypothesis test are in Table 3.

Table 3. The Learning Outcome Hypothesis Test Results

	Sig. (2-tailed)
pretest-posttest	.000

The table shows the Asymp Sig (2-tailed) ≤0,05. Therefore, H0 is denied but H1 is accepted. It meant the experimental group had the N-gain average differences.

The results were the problem-solving skill achievements based on the indicators of the worksheet assessment (Figure 1).

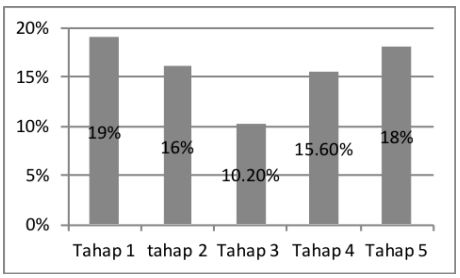

Figure 1. The problem-solving skill achievement for each indicator was based on the worksheet assessment.

Figure 1 shows the highest problem-solving skill indicator achievement for each group was in the first stage (the focus of the problem). The second stage, describing the problem in physics description, reached a percentage of 16%. The third stage, planning the solution, reached a percentage of 10.20%. The fourth stage, executing the plan, reached a percentage of 15.60%. Then, the fifth stage, evaluating the solution, reached a percentage of 18%.

Besides that, the quantitative data showed the differences between pretest and posttest scores of the experimental group. It proved there was an increase due to the applied learning with a score of 25.8. The data are in Table 4.

Table 4. Quantitative data of the learning outcomes

Statistics parameter	Pretest	Posttest
The sample number (N)	35	35
The highest score	59,4	88
The lowest score	21,4	33,2
The maximum score	100	100
The average score	41,3	67,1

Table 4 shows the experimental group's problem-solving skill average before and after the intervention. It shows a significant improvement.

The improvement was caused by the problem-solving skill training of the learners due to the STEM-based PjBL model implementation [12]. The paired sample t-test was accepted H_1 with a significant score $< 0{,}05$of 0.000. It meant there was an improvement of the skill taught by blended learning-based PjBL STEM. From the result, the learners' problem-solving skills had improvements although the N-Gain average was 0.43, categorized moderate.

In this research, the researchers adopted all research stages from the beginning until the evaluation of the PjBL STEM model [13]. This research was carried out for the even-semester learners in the academic year 2020/2021. Here are some explanations about the research model. They are

Reflection, This stage brought learners to the problem context of real-life or real structure [14]. In this research, the researchers researched an online manner via WhatsApp group. The trained problem-solving skills are: focusing on the problem means stimulating learners to pay attention, review, think about problems, and analyze the problems to solve [15].The skills can be observed in the worksheet answers shown in Figure 2.

After observing the phenomena and watching the presented videos, answer these questions:

1. What physics concept do you know?
   The energy conservation law. The given phenomenon is the sunlight energy conservation into heat.
2. Is there any energy conservation? If you think so, please explain!
   It is. The solar water heater has a sunlight catcher. The caught energy is conserved into heat.
3. What can you argue about the solar water heater as one of the developed technological uses to obtain water with higher temperatures?
   The solar water heater is a developed technology that uses solar energy. Thus, it is environmentally friendly.
4. Can you tell the sunlight energy uses as the material to create a solar water heater?
   The sunlight is caught by the screener. It is a collector that collects the heat. The screen is painted black to catch the high-temperature lights. The sunlight energy is conserved into heat and this heat energy is used to heat the water inside the collector.

Figure 2. The learners' answers on the worksheets

Research, Learners collected the relevant information based on the products. In this research, the researchers researched an online manner via WhatsApp group. Together with their teams, they sought the information to obtain the most relevant concept that would be used. They did it by using the Internet. By researching, the learners were trained properly via problem-solving skills with describing the problems in physics description indicators. The skills can be observed in the worksheet answers shown in Figure 3.

Based on the physics video, the most relevant matter of the video was the sunlight energy conversion into heat.
The device mechanism is to use the solar panel installed on the roof to receive the direct sunlight heat. It functions to collect the heat for heating the water.
The water heating process consists of a component called a cylinder. It stores the heated water to be flown via pipe installation.

Figure 3. The learners' answers on the worksheets

The figure shows learners could interpret and describe the problems based on information related to the problems [16].

Discovery, This stage mediated the research and the recognized information in arranging the products. Thus, learners could cooperate. In this research, the researchers researched an online manner via WhatsApp group. The trained problem-solving skills are: Planning a solution. The learners designed the problem-solution that they described previously. Here are the solution designs or sketches about the mini solar water heater (Figure 4).

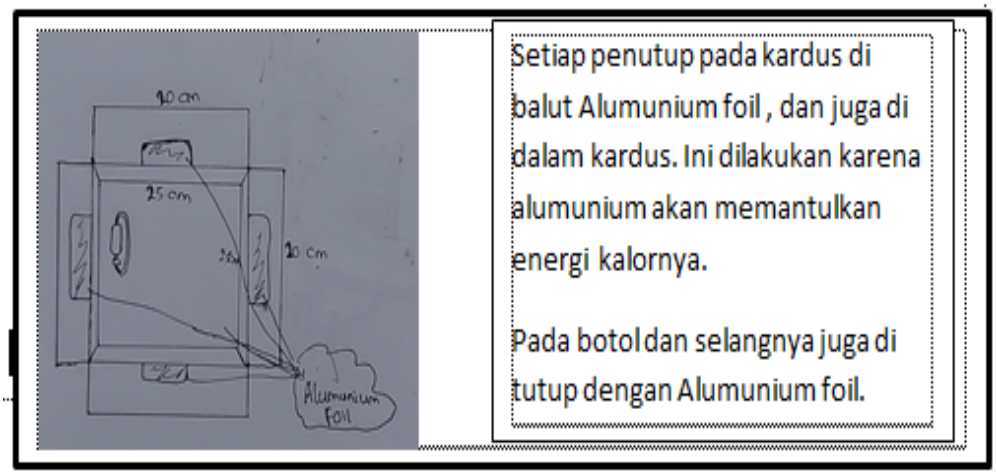

Figure 4. The learners' sketches about the mini solar water heater.

The figure shows learners planned the solution of the described problems previously by designing the product. According to Caporo et al (2013:29), it was in line with the *STEM PjBL* characteristics that emphasized the designing process [10]. This process is a systematic approach that develops solutions to the problems.

Application This stage aimed to create and test the product or solution to solve problems by using the obtained results to revise the solution. This research stage required the researchers to do it offline at school. Here is one of the learners' activities while constructing and examining the trial of a mini solar water heater (Figure 5).

Figure 5. The activities and the learners' learning products

The learning activities in Figure 5 integrate some science disciplines. They were science, technology, engineering, and mathematics. Dewi, Kaniawati, & Suwarna (2018) found that the science discipline integration could train the problem-solving with the indicator of Executing the plan [7]. The learners were trained to use the already made design, to determine the tools and materials, to measure mathematically for each product part correctly, and to examine the product based on the obtained concept.

Communication. This stage was the final stage. It dealt with communicating the products for the classroom environment. This stage was done via Zoom online. The learners' di d an evaluation in the form of conclusion. They also compared their results with the other groups' results with different answers or findings. With this activity, learners would collaborate and be active in sharing and communicating the solution excellently [17]. The attitudes were the actualization of problem-solving indicators exactly about evaluating the solution.

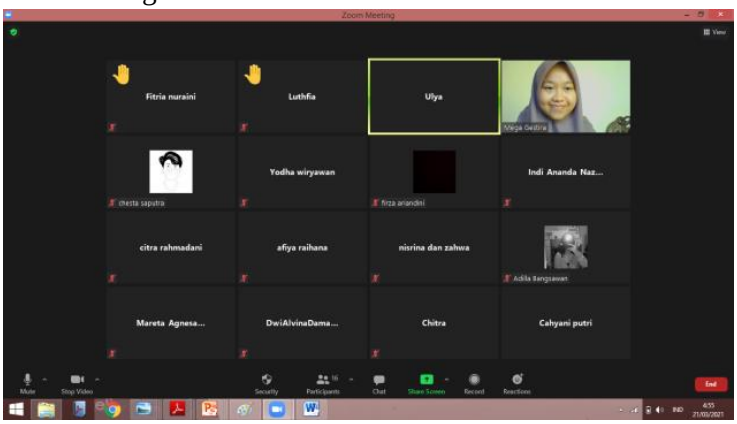

Figure 6. The presentation of the applied experiment

IV. Conclusion

Based on the research result and discussion, the applied blended learning-based STEM PjBL could improve the learners' problem-solving skills on energy topics. The applied model for learning physics is important especially the psychomotor aspect (CC 4). Thus, the teachers and learners would be easy to determine the product and test it The blended learning strategy for learning physics can be the learning alternative because it can be done in a face-to-face manner or electronically anywhere and anytime. The product trial proved the research had limitations. The rainy weather became a hindrance for this project. Thus, this research recommends a second plan to ensure the product trial runs.

Acknowledgment

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VIRTUAL LABORATORY: USING ELECTRONIC WORKBENCH AS ALTERNATIVE LEARNING PHYSICS IN COVID-19 MASS PANDEMIC

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ABSTRACT

The purpose of this research is to describe the use of assisted virtual laboratories of Electronic Workbench (EWB) in physics experiments learning. The method in this study used (1) calibration of the results of experiments with theory and (2) analysis of user responses to EWB in practicum activities. The study concluded that: 1) EWB is easy to use for practical learning, 2) capacitive reactance values obtained from calculations and observations following the theory (close to the same), 3) the time needed for one-time trial data retrieval until the analysis phase in this practicum activity is 10 minutes means that the experiment with EWB is very efficient. Based on the results obtained indicate that EWB is feasible to use as an alternative to physics learning in the mass pandemic COVID-19.

INTISARI

Tujuan penelitian ini adalah mendeskripsikan penggunaan laboratorium virtual berbantukan Electronic Workbench (EWB) dalam pembelajaran praktikum fisika. Metode yang digunakan (1) kaliberasi hasil exsperimen dengan teori dan (2) analisis respon pengguna terhadap penggunaan EWB dalan kegiatan praktikum. Diperoleh kesimpulan bahwa 1) EWB mudah digunakan untuk pembelajaran praktikum, 2) nilai reaktansi kapasitif yang diperoleh dari hasil perhitungan dan pengamatan sesuai dengan teori (mendekati sama), 3) waktu yang dibutuhkan untuk satu kali pengambilan data percobaan sampai tahap analisis dalam kegiatan praktikum ini adalah 10 menit artinya percobaan dengan EWB sangat efeisien. Berdasarkan hasil yang diperoleh menunjukan bahwa EWB layak digunakan sebagai alternatif pembelajaran fisika di massa pandemi COVID-19.

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Laboratorium Virtual; *Electronic Workbench*; EWB; Pandemi Covid-19

I. Introduction

The government has adopted a physical distancing policy in suppressing the broad spread of the co-19 pandemic in Indonesia [1]. The consequence of this policy is that some gathering activities forced to be limited, one of which is an appeal to carry out the process of learning activities both from elementary to tertiary level from home online [2]. Choosing an online learning process requires educators to be more creative in selecting the type of learning and virtual media that will use during the learning process so that learning activities both theory and practice can run effectively and efficiently but still quality.

The selection of effective and efficient virtual practicum media is to consider several factors, including internet networks, computer specifications, digital literacy of students and learning time, because some of these are the main factors for the success of online learning to be carried out [3], [4]. Virtual practicum media is a device that helps students interact with experiments or activities that do not have direct physical reality but can work almost the same as the original [5], [6]. An example of a virtual laboratory that meets these criteria is the Electronic Workbench (EWB) software.

EWB chose with consideration of having all the components needed in online learning. This software can run without an internet network (offline), this software can be run on a computer with low specifications, easy to use because it only uses the click and drag concept, so it does not require a long time to apply. The results of previous research, this software recommended in learning activities. Its application is proven to be able to increase the productivity of students in learning, effective in engaging understanding concepts and helping students verify the theory by independently experimenting at home [7]–[9]. However, from some of the research conducted, this software is only utilized to introduce electronic circuit simulations that no one has used to test the characteristics of components and theories in physics learning; besides, the potential for online learning in sync with this software has not utilized.

II. Research Methodology

This research aims to describe the potential of virtual laboratories with the assistance of EWB in fundamental physics practicum. The research methods are 1) analysis of user responses to the use of EWB using the ease of perception questionnaire and time efficiency questionnaire. 2) calibration of the capacitive reactance theory. The response data collected through the Perceived Ease of Use questionnaire with five statements included 1) I find it easy to learn EWB, 2) I need a lot of consultation in operating EWB, 3) I can easily remember what what has been done with EWB, 4) I feel frustrated when using EWB, 5) I feel proficient after using EWB once [10]–[12]. Calibration applies by comparing the results of capacitive

reactance values applied to the series of experimental and calculation results. The capacitive reactance equation used is:

$$Xc = \frac{1}{2\pi fC} \quad (1)$$

The capacitive reactance experiment shown in Figure 1 performed virtually using the EWB application, making The capacitive reactance experiment shown in Fig performed using EWB.

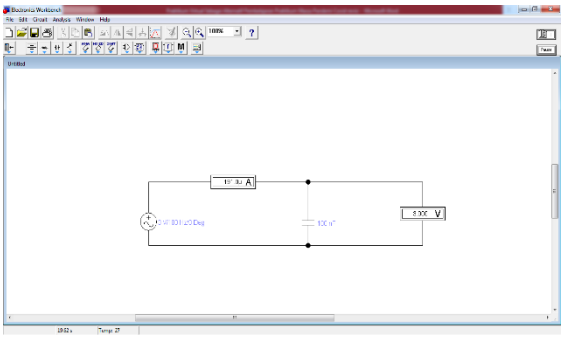


Figure 1. the series of capacitors on EWB

The process of making a circuit is quite simple, just simply clicking and dragging on the component screen used. The circuit is quite simple, just simply clicking and dragging on the component screen used. Setting the component specifications used are done by right-clicking on the component select the component properties set as needed, including the input voltage, frequency, capacitor capacity, and a voltmeter and amperemeter in AC mode. Click the power button on the right corner of the screen to run a circuit simulation. The magnitude of the capacitive reactance value results from the distribution of the experimental data output voltage and current from the simulation-based on Ohm's law concept. The trial process carried out by applying the frequency range from low to high, which shown so that it can plot a graph of the relationship between frequency and capacitive reactance.

III. Results and Discussion

EWB Use Facility in Learning

The EWB simulation application is effortless to use, only uses the concept of clicks and drags on components to be made in series. That can work according to the original device, four measuring tools with necessary analytical skills, four sweeping analyzes, two high-level analyses, and two statistical analyzes[13], [14].

This software can operate on PCs with specifications that tend to be low, namely with 50MB hard drive specifications, 1GB RAM, Windows7 32 bit, screen resolution of 800 x 600 [15]. This small operating system makes software tend to run when

integrated with video conversion applications such as Google Meet so that virtual practicum activities can carry out with synchronous online approaches. The form of testing a virtual laboratory activity with this approach can see in Figure 2.

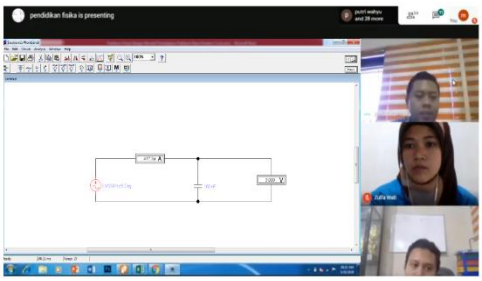


Figure 2. Testing integration of EWB with google meet

Response data collected through the Perceived Ease of Use questionnaire with five statements can see in Figure 3.

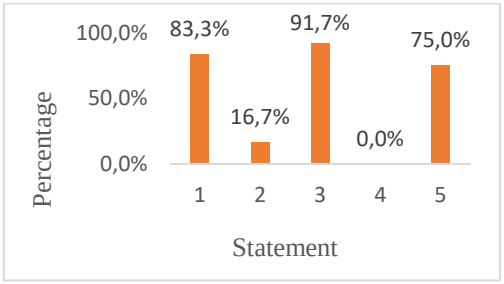


Figure 3. Percentage of perception of ease of response

Figure 3 shows that 83.3% of respondents said this application was easy to learn, and only 16.7% of respondents needed consultation in operation. Meanwhile, 91.7% stated it was easy to remember what had done with this software, 0% or all respondents did not experience frustration in testing this software, and 75% felt proficient after one use. This results means that from the trials conducted by respondents gave a natural perception of EWB. Based on the results, this software is suitable for the transition from real to virtual learning. It is easy to use, does not require students' high digital literacy abilities, and can be operated simultaneously with Google meet to create online learning.

Experimental data

The capacitive reactance practicum with EWB shown in this article takes one of the practicum samples with a capacitance value of 100 nanofarads, an input voltage of 3 volts a frequency range of 100 Hz, 200 Hz, 300 Hz applied. A comparison of practicum and calculation data shown in table 1.

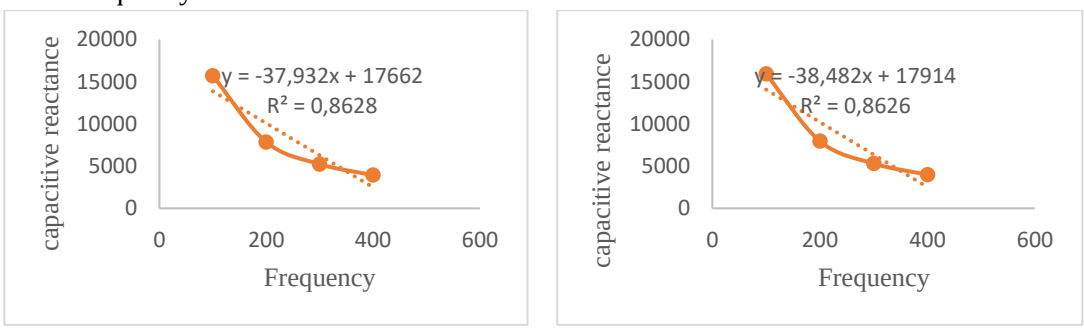
Table 1. Experimental data for capacitive reactance

V_{in} (Volt)	Frequency (Hz)	Capacitor (Farad)	I (Ampere)	V_{out} (Volt)	Xc (Ohm) Experiment	Xc (Ohm) Calculation
3	100	0,0000001	0.0001911	3	15699	15924
	200		0.0003819	3	7855	7962
	300		0.0005729	3	5237	5308
	400		0.0007638	3	3928	3981

The experimental data in table 1 was obtained from the results of experiments with an EWB application of data processing using Microsoft Excel. V_{In} and frequency (F) data are taken from the alternator value applied to the circuit, Current strength (I) from the Ammeters measuring instrument values installed in series against the Alternator and capacitors, V_{Out} values from the Voltmeter measuring instrument mounted parallel to the capacitor, $Xc_{Experiment}$ obtained from the calculation of observational data V_{in} / I while $Xc_{Calculation}$ is obtained from calculation of equation 1.

The results of data analysis in table 1 show that at a frequency of 100 Hz the value of $Xc_{Experiment}$ 15699 Ω and $Xc_{Calculation}$ 15924 Ω with a difference of 1.4%, at a frequency of 200 Hz the value of $Xc_{Experiment}$ 7855 Ω and $Xc_{Calculation}$ 7962 Ω with a difference of 1.3%, at a frequency of 300 Hz the value of $Xc_{Experiment}$ 5237 Ω and $Xc_{Calculation}$ 5308 Ω with a difference of 1.3%, at a frequency of 400 Hz the value of $Xc_{Experiment}$ 3928 Ω and $Xc_{Calculation}$ 3981 Ω with a difference of 1.3% means that overall the experimental data generated from this application is very accurate and thorough. Experimental data in table 1 if observed $Xc_{Experiment}$ and $Xc_{Calculation}$ values both of them show smaller values along with the Frequency value that is fed, meaning that the results of this experiment are in accordance with the capacitive reactance theory.

Graphical analysis of the relationship of frequency with capacitive reactance in figures 4.(a) and 4.(b) represents the results that are in accordance with the theory that the capacitive reactance value of 100 nano farad capacitors is inversely proportional to frequency.



(a) (b)

Figure 4. (a) Graph of the Relationship between F and Xc Experiments. (b) Graph of Relationship of F and Xc Calculations

Time Experiment

Time efficiency was revealed by using a response questionnaire composed of 3 statements including 1) the activities that I did with EWB took less than 40 minutes, 2) the activities that I did with the EWB took more than 40 to 50 minutes, 3) the activities that I do with EWB take between 50 and 60 minutes. Data collected through the response questionnaire is shown in Figure 5.

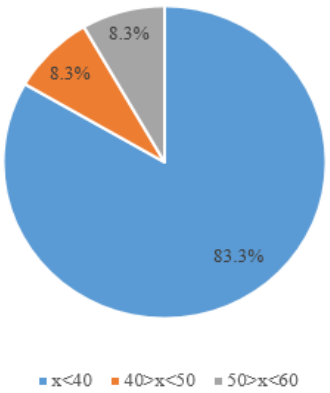


Figure 5. Diagrams of student responses to individual trials

Figure 5 shows that 83.3% of respondents completed the activity in less than 40 minutes, 8.3% stated that they completed the activity within 40 to 50 minutes, and another 8.3 percent said they completed the range of 50 to 60 minutes. in general the data shows that the activities carried out starting from the process of making circuit simulation to the stage of graph data analysis in the sampling activities in this practicum only takes 40 minutes. If it is assumed in this capacitive rectification practicum activity every time the voltage variation takes only 10 minutes. Some research results also state that many other benefits of activities with this virtual laboratory include giving students many opportunities to learn while doing [16], low operational costs, easy to use and safe to use [17]–[19].

IV. Conclusion

The results show that respondents easily perceive this software. The low operating system makes this software smooth when integrated with Google Meet to create online learning with asynchronous approach.

Data analysis results by comparing the experimental data results and calculations show compliance with the capacitive reactance theory. The high frequency fed to the

capacitor makes the capacitive reactance values go down. The difference in the Xc value calculated by the Xc experiment is small.

This virtual practice's effectiveness and efficiency can also see from the time requirements, namely during the sampling process, until the analysis phase only takes 10 minutes. Based on these results, the virtual laboratory is feasible to apply in the COVID-19 Pandemic

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THE DEVELOPMENT OF PHYSICS EDUCATION GAME ON DIRECT CURRENT ELECTRIC CIRCUIT FOR LEARNERS

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ABSTRACT

This study is the research of the development of physics education game application. This study has two purposes, namely to (1) developing multimedia for physics learning in the form of a physics education game on direct current electric circuits, (2) knowing the quality of educational game applications that have been produced according to experts, (3) knowing the user's (student's) response to the media of physics learning in the form of educational game applications related to direct current electrical circuit. The development procedure in this study refers to the Luther-Sutopo procedure consisting of the stage of concept, design, material collecting, assembly, testing, and distribution. Data collection techniques in the research in this study using a questionnaire. The research instrument in this study was a validation and assessment sheet which was adapted from the rubric for evaluating C. Stewart's educational game, student response sheets, and the game tester response sheet. Product validation and assessment uses a Likert scale with 4 scales and students' responses use the Guttman scale, while the game tester response sheet uses descriptive analysis. The results of this study are products in the form of simulation physics education game applications in direct current electric circuits, the results of the validation and assessment of material experts and media experts, the educational game application scored 3.8 and 3.3 in a very good category. The results of the user's (student's) response to the direct current electric circuit educational game application developed got an average score of 0.97 with the agreed category.

INTISARI

Penelitian ini merupakan penelitian pengembangan aplikasi game edukasi fisika. Penelitian ini memiliki tiga tujuan yaitu untuk (1) menghasilkan media pembelajaran fisika berbentuk aplikasi *game* edukasi yang berkaitan dengan materi rangkaian listrik arus searah, (2) mengetahui kualitas dari aplikasi *game* edukasi yang telah dihasilkan menurut para ahli, (3) mengetahui respon pengguna (peserta didik) terhadap media pembelajaran fisika berbentuk aplikasi *game* edukasi yang berkaitan dengan materi rangkaian listrik arus searah. Prosedur pengembangan dalam penelitian ini mengacu pada

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prosedur pengembangan multimedia Luther versi Sutopo yang terdiri dari tahap pengonsepan, perancangan, pengumpulan bahan, pembuatan, pengujian, dan pendistribusian. Teknik pengumpulan data pada uji coba dalam penelitian ini menggunakan kuesioner. Instrumen uji coba dalam penelitian ini berupa lembar validasi dan penilaian yang diadaptasi dari rubrik untuk evaluasi *game* edukasi milik C. Stewart, lembar respon peserta didik, serta lembar respon *game tester*. Validasi dan penilaian produk menggunakan skala Likert dangan 4 skala dan respon peserta didik menggunakan skala Guttman, sedangkan lembar respon game tester menggunakan analisis deskriptif. Penelitian pengembangan ini menghasilkan produk berupa aplikasi *game* edukasi fisika berjenis simulasi pada materi rangkaian listrik arus searah untuk peserta didik pada jenjang SMA dengan menggunakan metode pengembangan multimedia versi Luther yang telah dimodifikasi oleh Sutopo. Kualitas aplikasi *game* edukasi fisika yang dikembangkan berdasarkan hasil validasi dan penilaian oleh ahli materi dan ahli media mendapat skor rata-rata sebesar 3,80 untuk konsiderasi pedagogik dan 3,33 untuk konsiderasi pengguna dengan kriteria sangat baik (SB). Hasil respon peserta didik terhadap aplikasi *game* edukasi rangkaian listrik arus searah yang dikembangkan mendapat skor rata-rata 0,97 dengan kategori setuju (S).

I. Introduction

Indonesia is one of the large industrial game markets in the world, ranked top 16 in terms of gamers with 43.7 million gamers. Studies conducted by a research institute of the global game industry, Newzoo, in 2017 found 36% of gamers in Indonesia were individuals aged from 10 to 20 years old. The remaining percentage consisted of gamers aged from 21 until 50 years old [1]. The survey result of Infografis Indikator TIK 2016 Rumah Tangga dan Individu about the internet activity uses by individuals in the year showed 44.10% of Internet users in Indonesia used the internet to play mobile and PC games. Then, 48.40% of the Internet users were mostly students or learners [2].

The data show many Indonesian people especially learners like to play the game. However, most accessible games on the Internet only concern with amusement element. Unfortunately, most educative games were limited to recognizing numbers, letters, colors, animals, vegetables, and fruits. Games that study certain lessons, such as physics or chemistry, are still limited.

Many types of research about a video game. Some of them correlated video games with violence but some of them proved there was no significant correlation." It meant different games could provide positive or negative impacts for children. It

depended on the portion and how an individual used it. He also explained that appropriate games could provide positive impacts on children. The game could also be designed specifically for learning media [3]. Paul J.C. Adachi (2013) found the correlation between playing games toward the improvement of the problem-solving skills of learners [4]. It indirectly caused the learners' academic skills to improve. Harsono (2014) found a child that played the game would develop reading, mathematics, and problem-solving skills [5].

Based on the game search in Google, September 8, 2018, 19.23, with the applied keywords: physics, physics educative game, physics learning game, game education physics, game physics education, education game physics, education physics game, and physics education game, the researchers could notice the numbers of games labeled as physics games as shown below:

Table 1. The Numbers of the Labeled Games as Physics Game

No	Link	TOTAL (RESULTS)
1	physicsgames.net	977
2	Freewebarcade	865
3	permainan.co.id	560
4	games.co.id	565
5	permainanonline.com	84
6	crazygames.com	491
7	y8.com	1230
8	m.onlinegame.co.id	497
9	gameedukasi.com	13
10	Playstore	254
11	Phyfun.com	998
12	Planeta42.com	27

The table shows many games with the label of physics game. However, the games do not provide physics concepts. The games had the physics label because they used the physics concepts to describe the reality in the game, for example, the Successful Experiment. This game has a mechanic and motion theme. The point of the game is to create the ball moving to the designated point. However, the game does not provide learning about the mechanics and motion materials. The other examples were Angry Bird, Cut the Rope, and Physics Duluxe. They did not provide learning or discussion about physics materials. The physics aspect of the games was used as the side effect to describe the reality in the game, for example, the effect of a rolling ball, parabolic motion, and falling down the object. The games emphasize on amusement element than the education element. From those games, the game that provides physics concept learning is Planeta42.com. It has 17 game selections. Then, gameedukasi.com. It has 2 games but they tend to focus on motion materials, such as Newton law, measurement, energy, and work. Then, a game that brings the material

about a direct current electric circuit was not found. From the explanation, the use of the game for learning physics is seldom to do.

A study conducted by Rahmawati et al (2017) in Islamic Senior High School 1 Jember in its XII Science 1 learning group about the conceptual understanding of the learners on the direct current electric circuit with the sub-discussion of current and Ohm law obtained the percentage of 39.2%, electrical resistance with 42.2%, a simple electrical circuit with 42.7%, and parallel electrical circuit with 50.6%, and power with 43.6% based on Bloom taxonomy indicators [6]. From the results, the learners' conceptual understanding of the direct current electric circuit based on the Bloom taxonomy indicator was very low. A study by Ira Nofitasari and Yuliana Sihombing (2017) in the X-1 of Public SHS 2 Bengkayang found the learners had difficulties on sub-discussion of current, voltage, and electrical resistance with a percentage of 55.35%, Ohm law, and conductor resistance with a percentage of 58.03%, the serial and parallel resistor with a percentage of 53.57%, and Kirchoff law with 71.42% [7]. This finding was also supported by Yustiandi and Duden Sepuzaman (2016) that found 73% of learners at Public SHS Serang, Banten had difficulties in analyzing the current and voltage of a resistor after being added by other resistors that were installed in serial or parallel manners [8]. Then, more than 68% of learners had difficulties analyzing the total resistance in a serial-parallel circuit [8].

II. Research Methodology

The development model

This research is a research and development study. It developed an educative game for learning physics with a Construct 2 application for a direct current electric circuit. The applied method to develop the game was the multimedia development method proposed by Luther-Sutopo.

The development procedures

The procedures to develop adopted the procedures of multimedia development proposed by Luther-Sutopo. The applied method consists of six stages. They are concept, design, material collection, assembly, testing, and distribution [9]. In this research, the procedures of the research method were adjusted with the research needs. The researchers added validation and judgment stages to find the truth of the content and quality of the products based on the experts' judgment. The promoted activities for each development stage of the product were:

1. Concept. This stage consisted of a preliminary study both theoretically and empirically to determine the users of the game, the materials to take, the objectives of the game, and the concept of game presentation.
2. Design. This stage dealt with designing or arranging the storyboard. A storyboard is an initial stage to create a game application. Thus, there were possibilities to

revise the final result of the developed game. A storyboard is used as the reference to create the storyline and navigation path in the game.

3. Material collection. This stage dealt with collecting the required materials to develop the game, such as figures, animations, and audios based on the needs.
4. Assembly. In this stage, the game was designed with Construct 2. All collected materials were imported to the software and they were arranged based on the storyboard. Then, they were given behaviors based on their roles and functions. After that, each arranged material, the researchers designed the logical function.
5. Testing. This stage consisted of three stages. They were alpha, beta, and theta tests.
   a. The alpha test. In this stage, the researchers did it. It was done in the middle of the assembly process during the creations of logical function in the event sheet. The test aimed to check the logic in the created even sheet whether it ran as expected or not.
   b. The beta test. This stage was done by 10 students. They were from Physics Education Department and Game Design Department as the game testers. They were asked to find glitches or errors in the game. They also had to find what elements to be revised from the non-technical aspect of the game after undergoing the alpha test. Then, the game should be revised based on the review results of the material and media experts.
   c. Validation and Judgment Stage. Before being tested in the third stage, the theta test, the game should be validated and judged by the experts of material and media. It had the purpose to obtain suggestions and advice. After that, the game was revised based on suggestions and advice.
   d. The theta test. This test involved the final users. It was to check the responses from the final target users toward the developed game. The result was the game was eligible during the beta test specifically in its distribution stage.
6. Distribution. The distribution was done online. The application was created in an apk format. It was then distributed via Google Drive, Google+, Whatsapp, and Facebook

Product test

The Trial Test Design. This test was done during the beta test and the theta test. In the beta test, the product was introduced and presented to the game testers. Then, they tried and explored the product and after that, they were given sheets to write their criticisms and suggestions. The beta test was conducted after the game was distributed online. The mechanism of the theta test consisted of (1) distributing the product via social media, WhatsApp; (2) downloading the product and trying the product by respondents, and (3) filling the assessment questionnaire of the product related to the menu interface of the product.

The Trial Test Subjects. The subjects consisted of two experts. They were media and material experts that validated and judged the product. The respondents were 10

game testers of the Physics Education and Game Design Department for the beta test and fifteen learners for theta test.

The Data Type of the Trial Test. The trial test data were grouped into qualitative and quantitative data. The qualitative data showed the quality of the data in terms of situations, processes, events, etc. They were stated into statements or words. The qualitative data were from the material and media experts. They took forms into suggestions and statements about the game quality of the validation and judgment. Here are the scoring system criteria. SB (Very excellent) B (Excellent) TB (Not excellent) STB (Extremely not excellent) The qualitative data of the game testers were suggestions and criticisms during the beta testing. The qualitative data of the learners were suggestions and responses in the form of statements of agreement (S) and disagreement (TS). The quantitative data were then obtained scores from each category scoring result on the validation sheet and the physics education game application judgment filled by the material and media experts. The scoring system applied the Likert scale They were 4=very excellent, 3=excellent, 2=not excellent, and 1=extremely not excellent. The responses of the learners toward the game were based on the Guttman scale with two intervals. They were 1=agree and 2=disagree.

The data analysis technique

The module quality analysis. The data obtained from the game judgment were the results of material and media experts' judgment. The judgment was based on the 4-Likert scale. The analysis procedure applied these stages:

Converting the score results. These score conversion from the qualitative forms into quantitative forms was done during the validation and judgment stage based on the proposed requirement by Widoyoko [10].

Table 2. The scoring regulation

No	Criteria	Scores
1	SB (Very Excellent)	4
2	B (Excellent)	3
3	TB (Not Excellent)	2
4	STB (Extremely Not Excellent)	1

The average score of each judged aspect was calculated with the following equation:

$$\bar{X} = \frac{\sum X}{N.n} \quad (1)$$

with

$\bar{X}$: The judgment average score

$\sum X$: The total judgment score

N : Numbers of assessors

n : Numbers of question items

Calculating the Interval. The interval between the attitude to determine the classification of the attitude toward the product was done by using this equation [10]:

$$\text{Interval Range } (i) = \frac{\text{maximum score} - \text{minimum score}}{\text{number of interval class}} \quad (2)$$

Transforming the average scores. The obtained average scores were in the form of qualitative data. They were transformed based on the applied criteria in Table 3.

Table 3. the Product Judgment Categories

No.	Average scores ($\bar{X}$)	Criteria
1	$3{,}25 < \bar{X} \leq 4{,}00$	Very Excellent
2	$2{,}50 < \bar{X} \leq 3{,}25$	Excellent
3	$1{,}75 < \bar{X} \leq 2{,}25$	Not Excellent
4	$1{,}00 < \bar{X} \leq 1{,}75$	Extremely Not Excellent

The Data Analysis of the Learners

The questionnaire of the learners' responses was analyzed to find out the learners' responses toward the developed game. Here are the applied stages:

Scoring. The applied statements in the Guttman scale were to find the learners' responses whether they had positive or negative responses. The answers were categorized into agreeing (S) and disagree (TS). The scoring was done on the learners' response sheets (Table 4).

Table 4. the Scores of the Learners' Responses based on Guttman's Scale

No	Statements	Scores
1	Agree	1
2	Disagree	0

The score conversion. Converting the obtained average scores into qualitative forms was done based on the judgment criteria in Table 3. It was done by finding the interval score between agree (S) and disagree (TS) with equation (2). Thus, the obtained criteria for learners' responses are shown in Table 5.

Table 5. the Learners' Response Categories

No.	Average scores ($\bar{X}$)	Criteria
1	$0{,}50 < \bar{X} \leq 1{,}00$	Agree
2	$0{,}00 < \bar{X} \leq 0{,}50$	Disagree

If the learners' responses were agreed, the product could be considered as the final product. However, if the learners disagreed, then the e-module had to be revised until it was ready to be the final product.

III. Results and Discussion

The validation of the developed game was done with two experts: the material and media experts.

The validation and material judgment

The material judgment and validation were in the form of criticism.

1. Please add the objective of the game to the menu interface.
2. Please add remarks to put the battery during the simulation.
3. Revise the typing errors in the material and hint parts.
4. Clear the bugs in the simulation selection menu. They were found in the simulation navigation button of the serial-parallel circuit that sometimes did not work properly.
5. Provide an additional explanation for each variable of the equation and the figures for each material.
6. Please add relevant graphics with Ohm law and provide more question examples and figures about Kirchoff law.

It could be concluded that the material judgment of the product was reliable to use with revision. Here are the detailed scores.

Table 6. the Results of Pedagogy Consideration Judgment

Considerations	Categories	Scores
Pedagogy	1	3
	2	4
	3	4
	4	4
	5	4
Total Scores		19
Average score		3,80
Criteria		Very Excellent

The validation and Median judgment

The results of the media validation and judgment were criticism and suggestions.

1. Keep the consistency of the display aspect with a certain theme.
2. Keep the consistency of the foreign term (the English terms), for example, play.
3. Give the animation of a video about how to use the application at the beginning of the application load. Thus, the users can find out how to interact.
4. Please also provide the figures of the resistors instead of the value (ohm).

It could be concluded that the media validation and judgment of the product were reliable to use with revision. Here are the scores.

Table 6. the Results of Users' Consideration

Considerations	Categories	Scores
Pengguna	1	3
	2	4
	3	3
Total Scores		10
Average score		3,33
Criteria		Very Excellent

Testing

The Beta Test. This test involved eight students of the physics education department and two students of the Game Tech department. The beta test was done by filling out the criticism and suggestion sheet from the beta testers of the game. The criticisms and suggestions were: (1) the game did not run well. The white screen appears on some certain smartphones, such as Zenfone, Maxplus, and all Samsung types, (2) the handwriting on material and hint parts are overlapped and difficult to read, (3) there should be material addition about serial, parallel, and serial-parallel circuit set up, (4) there was two background music in one layout that made the background music unclear, (5) the audio effect when a user succeeded or failed to do a level in-game was unclear, (6) the unaccomplished game levels were not saved after logging out, (7) the users could open the game until level 6 (level 7 and so on could not be opened), (8) there were bugs in some navigations, such as material buttons. They were sometimes difficult to press, (9) the bug resistor could not be obtained or moved in some levels, (10) the opportunities to play the game sometimes turned into zero although the users did not do any mistake, (11) It is important to change the game icon in the smartphone to attract.

The suggestion and observed problems by the testers became the principles to revise and improve the product. After all, the product was revised and improved, the product was validated and judged by the experts.

The Theta Test. This test involved 16 learners in an online manner after the game was distributed by the developer via social media. The data of the learners' responses toward the application game rangkaian listrik DC adalah sebagai berikut:

Table 7. the Data of Learners' Response Results during the Theta Test

Response aspect	Scores per aspect	Average	Criteria
Users	78	0,98	Agree
Design	29	0,91	Agree
As a reference	48	1,00	Agree
Total	155	0,97	Agree

The data analysis results

The physics game judgment by the material experts referred to the product scoring category criteria (see Table 5). Based on the calculation, the pedagogical consideration of the developed game based on material experts obtained the average score of very excellent (SB). The average score comparisons of each aspect of the material expert's judgment are shown in Figure 1.

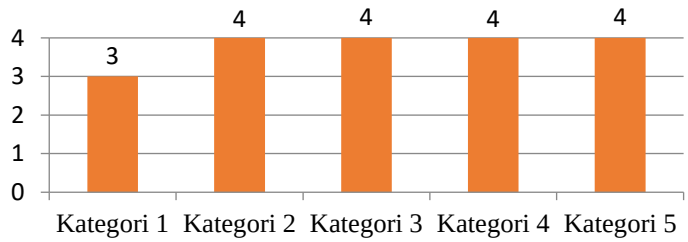

Figure 1. the Graphic of Consideration Judgment Results The pedagogy toward the game application

Remarks

Category 1 : The correlation of the game content toward the learning objectives
Category 2 : Problem-solving characteristics
Category 3 : The science content integration in the game (knowledge content)
Category 4 : The science content integration in the game (system thinking)
Category 5 : Feedbacks

The physics e-module selection of the experts was based on the product judgment category criteria in Table 6. Based on the calculation, the pedagogical consideration of the developed game based on material experts obtained the average score of very excellent (SB). The score average comparison of each aspect could be seen in Figure 2.

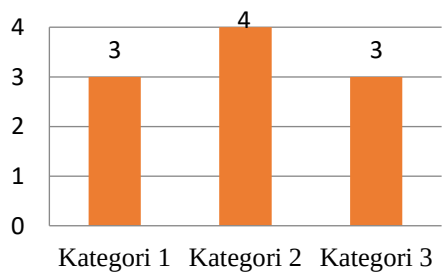

Figure 2. the Graphic of Users' Consideration Judgment Results

Toward the Game Application

Remarks

Category 1 : The easiness

Category 2 : The correlation of the developed game (knowledge) and the game control with the learners' skill levels.

Category 3 : The participation of learners' while playing the game

The learners' response results

The results obtained the average score for the utility aspect with 0.93; the design aspect with an average score of 0.91; and the aspect for reference material with 1.00. Therefore, the learners' responses for each aspect were categorized as agreed. The obtained average score is 0.97 so that the learners' responses toward the game were 'agree' (S). The calculation results could be seen in attachment 9, the calculation of learners' response results.

The strengths and weaknesses of the product. The developed product has strengths, such as:

1. The developed game could be used as an exercise in learning direct current electrical circuits because the game concept is a simple simulation.
2. The developed game was completed by simulation and material menu features so the application users could do an experiment and learn autonomously.
3. The developed game could be run on Android Smartphone with a minimum spec fo 4.0 Android System (Jellybean). Thus, the game could be used for most smartphone types today.
4. The size of the game has a smaller scale, lesser than 50Mb.
5. The game application does not require a high-spec smartphone to run the application.
6. The game application could be run on a laptop or computer by using the browser in a laptop or computer.
7. The regulations to play the game were simple so the game was simple to understand.
8. The game application could be run on a smartphone without the assistance of other applications.

The developed product has these limitations:

1. The game is only about Ohm law and resistor set circuit.
2. The application cannot play videos so players should use the internet to see the tutorial video that is linked to YouTube.

IV. Conclusion

This research succeeded to develop an educative game with simulation type on direct current electric circuit material for SHS learners with multimedia development

proposed by Luther modified by Sutopo. The developed game quality based on the validation results and judgment of the experts obtained the average score of 3.80, the pedagogical consideration with 3.33, and the user consideration with a criterion of "very excellent" (SB). The learners' responses toward the developed game about the given material could improve their achievement with an average score of 0.97, categorized as 'agree."

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