

Application of Multisim Software in Wave Rectifier Circuit Learning and its influence based on Students' Visual Spatial Ability

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Abstract

This study aims to determine the effect of the National Instruments (NI) Multisim Software on students' mastery of the wave rectifier circuit viewed from students' visual-spatial abilities (KVS). A pre-experimental design was used in this study. The sample of this research was students of the Physics Education Study Program taking the Basic Electronics I course selected through saturated sampling technique. The data collection tools were in the form of a visual-spatial ability test instrument and the wave rectifier circuit mastery test instrument. Correlation tests, multiple regression, and independent-sample t-test were used to determine the effect of spatial-visual ability on the learning outcomes of the wave rectifier circuit through the application of the National Instruments Multisim Software. The results obtained indicate that: 1) Student learning outcomes on the wave rectifier circuit material by using the NI-Multisim Software has in the sufficient category; 2) Students' visual-spatial ability on the KVS-interpretation has very high-category, KVS-series pattern has high-category, KVS-reflection has high-category, KVS-rotation has high-category, KVS-projection has high-category, and KVS-drawing has medium-category; 3) The ability of students' spatial visibility has a positive and significant correlation to student learning outcomes and has an influence contribution of 76.20% to learning outcomes; 4) The learning outcomes of students who have KVS-high are better than the average learning outcomes of students who have KVS-low in learning the wave rectifier series material using the NI-Multisim software.

Keywords: Multisim Software, Visual-Spatial Ability, Wave Rectifier Circuit.

Penggunaan Multisim Software dalam Pembelajaran Rangkaian Penyearah Gelombang Ditinjau dari Kemampuan Visual Spasial Mahasiswa

Abstrak

Penelitian ini bertujuan untuk mengetahui pengaruh National Instruments Multisim (NI-Multisim) Software terhadap penguasaan rangkaian penyearah gelombang ditinjau dari kemampuan visual spasial (KVS) mahasiswa. Penelitian ini menggunakan pra-eksperimental design. Sampel penelitian adalah mahasiswa calon guru fisika yang mengambil mata kuliah Elektronika Dasar I yang dipilih melalui teknik sampling jenuh. Alat pengumpul data berupa instrumen tes kemampuan visual spasial dan instrumen tes rangkaian penyearah gelombang. Uji korelasi, regresi berganda, dan uji independent sample t-test digunakan untuk mengetahui pengaruh kemampuan spasial-visual terhadap hasil belajar rangkaian penyearah gelombang menggunakan NI-Multisim Software. Hasil menunjukkan bahwa: 1) Hasil belajar materi rangkaian penyearah gelombang menggunakan NI-Multisim Software berada pada kategori cukup; 2) Kemampuan visual spasial mahasiswa pada indikator KVS-intepretasi berkategori sangat tinggi, KVS-pola seri berkategori tinggi, KVS-refleksi berkategori tinggi, KVS-rotasi berkategori tinggi, KVS-proyeksi berkategori tinggi, dan KVS-menggambar berkategori sedang; 3) Kemampuan visul spasial mahasiswa memiliki korelasi yang positif dan signifikan terhadap hasil belajar mahasiswa dan memiliki kontribusi pengaruh sebesar 76,20% terhadap hasil belajar; 4) Hasil belajar mahasiswa yang memiliki KVS tinggi, lebih baik daripada rerata hasil belajar mahasiswa yang memiliki KVS rendah dalam mempelajari materi rangkaian penyearah gelombang menggunakan NI-Multisim Software.

Kata Kunci: Software Multisim, Kemampuan Visual Spasial, Rangkaian Penyearah Gelombang.

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INTRODUCTIONS

Online learning provides various benefits in carrying out the teaching and learning process. These benefits include increasing learning motivation (Rimbarizki, 2017). Meanwhile, facilitating access, overcoming time and learning distance constraints (Kustiani & Despa, 2019), and even being the main alternative in anticipating force major events such as the current case of the spread of Corona Virus Disease 19. Most universities in Indonesia located in areas affected by COVID-19 organize online learning to anticipate the spread of COVID-19, which can be transmitted due to direct contact activities in the classroom. Online learning or distance learning is certainly done to make it easier for lecturers to communicate learning and for students to study independently.

The implementation of online learning must be supported by a Learning Management System (Hermansyah et al., 2017), including the provision of various software that can be used in distance learning. One of the software that can be used independently and supports online or distance learning in electric-electronic learning is the NI-Multisim Software (Mahata et al., 2010). NI-Multisim software is a digital application that attracts attention in learning (Budiono, 2017). This application has twelve features of electrical instruments commonly used in engineering and science laboratories, including oscilloscopes, power generators, power supplies, digital multimeters available in one inexpensive and easy-to-use application and is equipped with SPICE simulation software integration, which can simplify circuit design work (Abu-aisheh & Eppes, 2010) without using a breadboard of real components and original instrumentation (Surahmat & Fu'ady, 2020). The various features in the NI-Multisim Software make this software suitable for use in Basic Electronics lectures, especially wave rectifier circuit material carried out through online learning.

The basic electronics course is a course that prospective physics teacher students must take at IKIP PGRI Pontianak. This course aims to provide students with insight into the basics of electronics and its applications in everyday life. Students who take this course are also expected to analyze various basic electronic circuits both theoretically and practically. Meanwhile, to master the concept of circuits in introductory electronics courses, various basic abilities and skills are needed so that the concept of the circuit can be appropriately understood.

One of the skills or abilities that students must have to learn the concept of a wave rectifier circuit is visual-spatial ability. Visual-spatial ability is the ability to process visual information about spatial relationships between objects or parts of objects, changes, and spatial manipulation. This ability will be beneficial when students make basic electronic circuits that must combine several electronic device image objects into one complete circuit. Good visual-spatial skills will better understand concepts in learning various physics concepts (Isnaeni, 2013), including electronics-electricity. Visual-spatial abilities also make students have an idea of the plan when they will make a series and change the series when an error occurs in making a series. This ability helps students understand the concept of a wave rectifier circuit and makes students more creative in solving problems (Ardian & Munadi, 2016). Meanwhile, based on the empirical and theoretical facts above, it is necessary to conduct an in-depth analysis to determine the characteristics of

students' visual-spatial abilities and their influence on learning outcomes through the NI-Multisim Software on the concept of a wave rectifier circuit.

METHODE

Pre-experimental design method with the Intac Group Comparison design used in this study (Scott & Usher, 2010). The design has chosen because the research sample contained only one class. However, it would group into two parts based on high and low visual-spatial abilities criteria. The population in this study were all students of the Physics Education Study Program who took the Basic Electronics I course, which consisted of one class. Because there is only one population class, the entire population sampled in the study (Rosdianto, 2017) or saturated sampling.

Data collection tools in the form of visual spatial ability test instruments and conceptual test of wave rectifier circuit learning. The multiple-choice visual-spatial ability test includes indicators: 1) The ability to read or interpret pictures, graphs, or diagrams; 2) Determine the spatial of images, graphs, or diagrams based on a series of images that have been displayed; 3) Determine the spatial of the reflected image, graph, or diagram; 4) Determine the spatial of the image, graph, or diagram that is rotated; 5) Determine the spatial of the cut image, graph, or diagram; and 6) Provide a clear visual picture when thinking about something. The learning outcome test is in the form of 4 essay questions that measure mastery of a wave rectifier circuit concept.

Empirical validation of data collection tools was carried out through trials and calculated using the Product Moment Correlation Equation and criteria (Arifin, 2012). Then calculations were carried out to determine the level of reliability of the visual-spatial ability test questions and learning outcomes tests using the formulas and criteria for the Alpha equation (Arikunto, 2018). The results of empirical validation concluded that the instruments in the form of learning outcomes test questions and visual-spatial tests used had valid criteria and high reliability.

The data analysis technique used is a multiple correlation test to determine the relationship of two or more independent variables (the visual-spatial ability of each indicator) to the dependent variable (learning outcomes) (Cohen et al., 2017). Regression tests were conducted to predict the magnitude of each indicator's visual-spatial ability on learning outcomes. Sample independent t-test was used to determine the difference between two groups of independent variables (high and low spatial-visual ability) on the dependent variable (learning outcomes of wave rectifier circuit with NI-Multisim Software) (Marczyk et al., 2006).

RESULTS AND DISCUSSION

Student learning outcomes were measured after learning was applied using multisim software using an essay-shaped test consisting of four questions. Table 1 presents student learning outcomes after applying multisim software.

Table 1. Description of the Learning Outcomes of the Wave Rectifier Concept

No	Description Data	Value
1	Average	63.70
2	Standard Deviation	9.53
3	Data Variance	90.95
4	Maximum Value	40.00
5	Minimum Value	75.00

Based on Table 1, it is known that the average student learning outcome on the wave rectifier material is 63.7, with a reasonably good category. This can be interpreted that the average student learning outcomes after applying to learn using NI-Multisim Software are quite good. Through the use of NI-Multisim Software, students can create circuits and understand various characteristics of wave rectifier circuits and perform measurements of various electrical quantities in a virtual circuit. This makes the use of NI-Multisim Software attract students' attention in learning (Budiono, 2017) and increase mastery of the circuit concepts being studied (Bayangkari, 2018). Students can more easily create and simplify circuits when using NI-Multisim Software (Abu-aisheh & Eppes, 2010). Students can also easily correct errors in circuit creation through the use of NI-Multisim Software. The use of NI-Multisim Software affects better concept mastery and student attitudes and skills when learning electronic circuits (Padmi et al., 2020; Sadeli, 2013).

Data on visual-spatial ability was measured using multiple-choice and essay tests. The results of students' visual-spatial abilities are presented in Table 2 below.

Table 2. Description of Spatial Visual Ability Data Based on Each Indicator

No	Indicator	Skor	Criteria
1	Read or interpret pictures, graphs, or diagrams	91,1	Very High
2	Determine the spatial of an image, graph, or diagram based on the series of images that have been displayed	84,4	High
3	Determine the spatial of the reflected image, graph, or diagram	86,7	High
4	Specifies the space of a rotated image, graph, or diagram	80,0	High
5	Determines the space of a cropped image, graph, or diagram	73,3	High
6	Gives a clear visual picture when thinking about something	57,8	Medium
Total Average		78,9	High

Based on Table 2, it is known that the visual-spatial ability of students varies for each indicator ranging from a very high to moderate category. The visual-spatial abilities of students in the very high category are indicators of reading or interpreting pictures, graphs, or diagrams. At the same time, the indicators that provide a visual picture are in the medium category. Overall, students' visual-spatial abilities are in the high category.

Visual-spatial skills are needed when students learn electronic circuits. Closely related to students' skills in drawing and interpreting graphs or electrical circuits. Students who have good visual-spatial skills will find it easy to draw or visualize an electrical circuit (Ngadimin & Sanirin, 2015), thus becoming a determinant of mastering student concepts (Wahyudi et al., 2018). Students who have good visual-spatial skills can also make a series in several different schemes. It makes students more creative in solving electrical circuit problems (Ardian & Munadi, 2016).

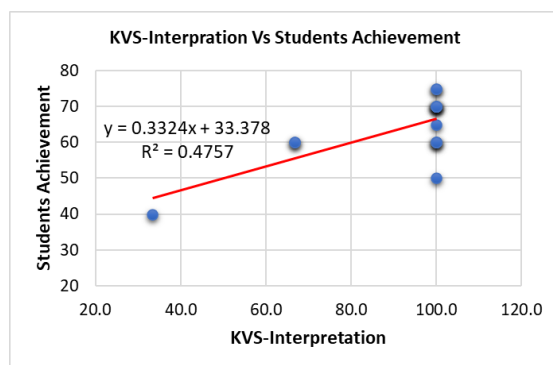
The correlation between visual-spatial ability (KVS) and student learning outcomes in the wave rectifier circuit material taught through NI-Multisim Software was analyzed using regression analysis. Correlation analysis used to determine the strength of the relationship between the variables of the visual-spatial ability of each indicator on learning outcomes. Meanwhile, regression analysis was conducted to predict the effect of visual-spatial ability on student learning outcomes in studying the wave rectifier circuit material using NI-Multisim Software. The correlation analysis results of each indicator's visual-spatial abilities on student learning outcomes have been present in the following table.

Table 3. Correlation Coefficient of Spatial Visual Ability with Learning Outcomes

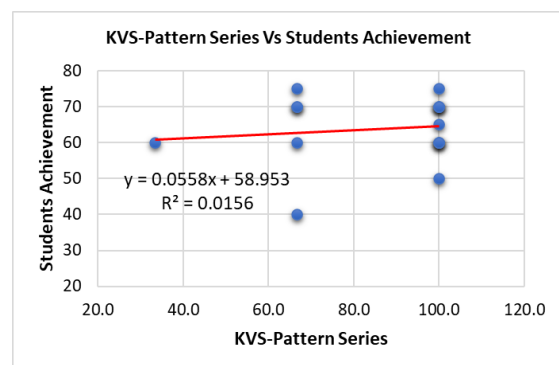
Test	KVS	Learning outcomes		
		Koefisien (r)	N	Sig (1 tailed)
Pearson Correlation	KVS-Interpretation	0.690	15	0.002
	KVS-Pattern Series	0.125	15	0.329
	KVS-Reflection	0.122	15	0.333
	KVS-Rotation	0.601	15	0.009
	KVS-Projection	0.629	15	0.006
	KVS-Drawing	0.559	15	0.015

Based on Table 3, it is known that the KVS correlation of each indicator on learning outcomes looks different. Table 3 showed that the correlation between KVS interpretation, rotation, projection, and student learning outcomes is significantly in the high category. The correlation of KVS drawing on learning outcomes is significantly in the excellent category. In comparison, the KVS series pattern and reflection on learning outcomes are in a low category. They do not correlate significantly because the significance of the calculation is smaller than the 5% (0.005) significant level. The regression equation of each KAV indicator on learning outcomes was carried out to determine the effect and contribution of each KAV indicator on learning outcomes.

Based on Figure 1 below, it is known that each KVS indicator independently contributes to student achievement (learning outcomes), the amount of which is determined by the Coefficient of Determination of R square. The significant contribution of visual-spatial abilities to learning outcomes was given by the indicators of KVS-Interpretation, KVS-Rotation, KVS-Projection, and KVS-Drawing, respectively 47.57%, 36.08%, 39.53%, and 31.29%. While KVS Series Pattern and KVS-Reflection only contributed 1.56% and 1.49%, respectively, to student achievement (learning outcomes).



(a)



(b)

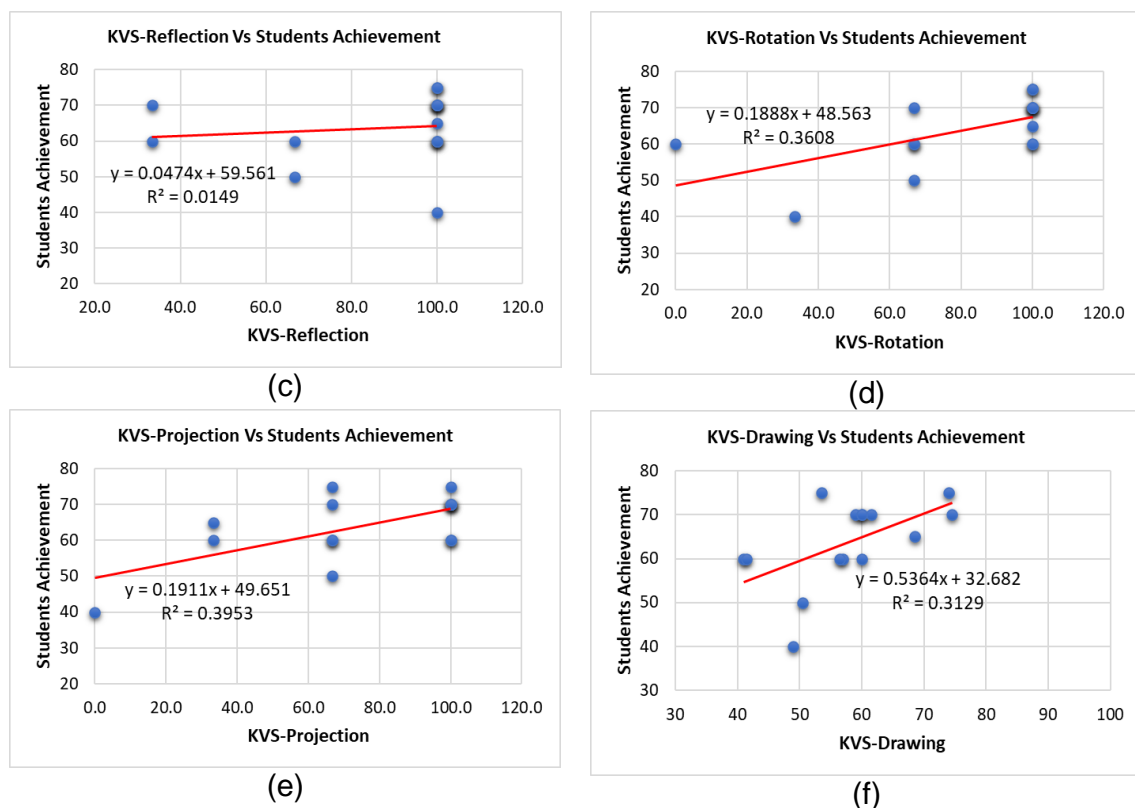


Figure 1. Regression equations between (a) KVS-Interpretation, (b) KVS-Series Pattern, (c) KVS-Reflection, (d) KVS-Rotation, (e) KVS-Projection, and (f) KVS-Drawing, with Learning Outcomes of wave rectifier circuit material.

The results of multiple regression analysis between the overall visual-spatial ability of the indicators on student learning outcomes in studying the wave rectifier circuit material through the use of NI-Multisim Software are presented in the following table.

Table 4. The Results of The Correlation Analysis Between KVS and Learning Outcomes

Model	R	R square	Adjusted R square	Std. Error of The Estimate
1	0.873 ^a	0.762	0.584	6.15124

Description:

a. Predictors: (Constant), KV-Drawing, KVS-Reflection, KVS-Series Pattern, KVS-Interpretation, KVS-Projection, KVS-Rotation

b. Dependent Variable: Learning Outcomes

Based on Table 4, the correlation between visual-spatial abilities has a correlation of 0.873 with a very high category. Based on the equation Coefficient of Determination, or the value of R square can be concluded that the visual-spatial abilities affect 76.2% on improving student learning outcomes in the study of matter-wave rectifier circuit, while other factors determine the rest. This result is higher than other findings which show the effect of the visual-spatial ability of 46.55% (Harmony & Theis, 2012). To find out the significance level of the regression, Table 5 is presented below.

Table 5. Results of ANOVA Significance Test of KVS Correlation on Learning Outcomes

Model	Sum of Squares	Df	Mean Square	F	Sig
Regression	970.631	6	161.772	4.275	0.031 ^b
Residual	302.702	8	37.838		
Total	1273.333	14			

a. Dependent Variable: Learning Outcomes

b. Predictors: (Constant), KV-Drawing, KVS-Reflection, KVS-Series Pattern, KVS-Interpretation, KVS-Projection, KVS-Rotation

Table 5 shows the significance of regression calculations for 0.031, or less than 5% significance level study that concluded that the regression between the visual capabilities of spatial learning outcomes is significant. In other words, visual-spatial ability simultaneously affects student learning outcomes on the wave rectifier circuit material. A regression prediction equation to determine the effect of visual-spatial abilities on students' learning outcomes was performed using regression plotting based on standardized residuals shown in Figure 2 below.

Table 6. Coefficient of KVS Regression Equation on Learning Outcomes

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	20.429	17.228		1.186	0.270
KVS-Interpretation	0.152	0.104	0.315	1.460	0.182
KVS-Pattern Series	-0.064	0.130	-0.144	-0.495	0.634
KVS-Reflection	0.119	0.080	0.307	1.491	0.174
KVS-Rotation	0.122	0.099	0.390	1.234	0.252
KVS-Projection	0.108	0.078	0.354	1.384	0.204
KVS-Drawing	0.118	0.243	0.123	0.485	0.641

a. Dependent Variable: Learning Outcomes

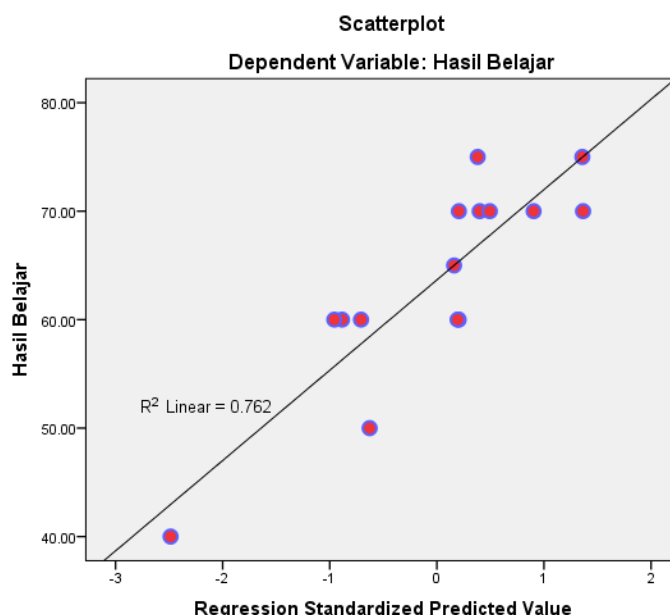


Figure 2. Regression equations between KVS with Learning Outcomes

Based on Table 6, unknown regression coefficient KVS the learning outcomes have influenced each indicator KVS as a regression predictor. The equation is obtained as follows.

$$Y = 0.152X_1 - 0.064X_2 + 0.119X_3 + 0.122X_4 + 0.108X_5 + 0.118X_6 + 20.429$$

With Y representing student learning outcomes, X_1 being KVS-Interpretation, X_2 being KVS-Series Pattern, X_3 being KVS-Reflection, X_4 being KVS-Rotation, X_5 being KVS-Projecting and X_6 being KVS-Drawing. Based on the equation, it is known that the serial pattern KVS is the smallest contributor to student learning outcomes in studying the material of wave rectifier circuits. At the same time, KVS-interpretation was the largest contributor to improving student learning outcomes in studying wave rectifier circuit material after learning is applied using NI-Multisim Software. The effect of visual-spatial ability on student learning outcomes using NI-Multisim Software on the wave rectifier circuit material was analyzed using a comparative test of two independent samples. The independent variable of visual spatial ability is categorized into high and low, so whether there are differences in learning outcomes based on high and low visual-spatial abilities will be analyzed. The description of learning outcomes data based on the categories of students' high and low visual-spatial abilities in studying the wave rectifier circuit material using NI-Multisim Software is presented in Table 7. Before the comparative test is carried out, the normality and homogeneity tests are first carried out as prerequisites for the analysis. The normality and homogeneity test results of the data are presented in Table 8 and Table 9 below.

Table 7. Learning Outcome Data Based on High KVS and Low KVS

Data	KVS Category	N	Mean	Std. Deviation	Std. Error Mean
Learning Outcome	KVS-High	8	69.375	4.955	1.752
	KVS-Low	7	57.143	9.512	3.595

Table 8. Normality Test Results of Learning Outcome Data Based on High KVS and Low KVS

KVS. Learning Outcome Data	Shapiro-Wilk		
	Statistik	df	Sig.
High KVS Learning Outcomes	0.872	8	0.156
Low KVS Learning Outcomes	0.869	7	0.183

Table 9. Results of Homogeneity Test of Learning Outcome Data Based on High and Low KVS

Factor List	Levene Test	df1	df2	Sig.
Learning Outcomes-KVS	2.101	1	13	0.171

Based on the normality test of the data using the Shapiro-Wilk Test, it is known that the learning outcomes data based on high KVS are normally distributed at a significant level of 5% ($0.156 > 0.05$). Learning outcomes data based on low KVS are normally distributed at a significance level of 5% ($0.183 > 0.05$). Levene homogeneity test showed that both learning outcomes data on category KVS high and low KVS homogenous ($0.171 > 0.05$). The results of the normality and homogeneity test as a prerequisite for the comparative analysis showed that the test could be done using statistical parametric independent sample t-test.

The results of the comparative test to determine differences in learning outcomes of students who have KVS high and low in studying the concept of wave rectifier circuit using NI Multisim software-served by following table.

Table 10. Comparative Test Results of Learning Outcome Data Based on High and Low Spatial Visual Abilities

Data	t	df	Sig. (2-tailed)
Hasil Belajar-KVS Tinggi/Rendah	3.188	13	0.007

The independent sample t-test in Table 10 above shows that the calculated sig value is 0.007 or less than the significant level of the research used, which is 5% (0.05). Thus, it has been concluded that there is a significant difference in the learning outcomes of students who have high KVS and those of students who have low KVS in studying the material of a wave rectifier circuit using NI-Multisim Software. Suppose it is seen from the average learning outcomes in Table 7. In that case, it can be concluded that the average learning outcomes of students who have high KVS (69.375) are better than the average learning outcomes of students who have low KVS (57.143) in studying the material of wave rectifier circuit using NI-Multisim Software. Similar to the findings (Prasetyo et al., 2018), visual spatial ability significantly influences learning outcomes.

The material characteristic of the wave rectifier circuit is abstract, so the use of Multisim Software can make it easier to visualize the graphs of abstract waveforms from various wave rectifier circuits. For example, a student with high KVS-interpretation ability can understand and distinguish the waveform graphs at points A (yellow-graph), B (blue-graph) and C (purple-graph) in a full-wave rectifier circuit (bridge type). (Figure 3).

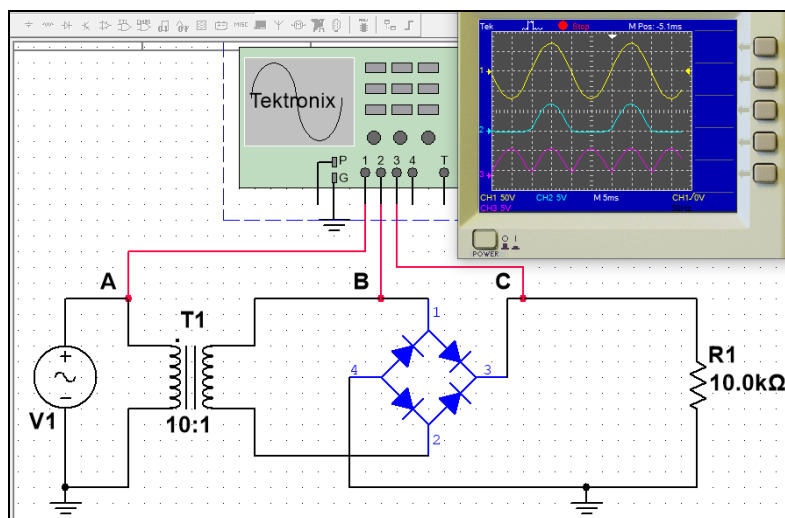


Figure 3. Simulation of Full Wave Rectifier Circuit Waveform (Bridge type) using Multisim Software

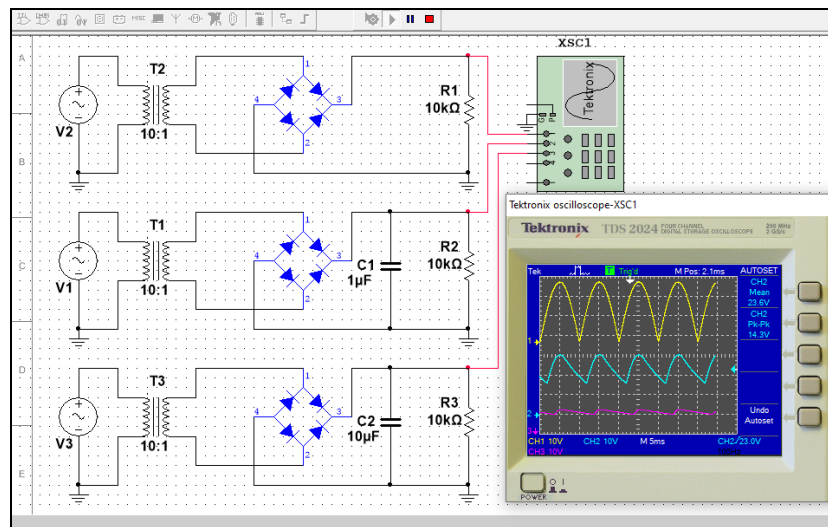


Figure 4. Simulation of Full Wave Rectifier Circuit Waveform (Bridge type) influenced by capacitor

Students who have a good KVS-interpretation can understand how the effect of capacitors on the shape of the wave signal in a wave rectifier circuit (Figure 4). So that when given a question in the form of a wave signal graph, students can easily describe the graph and predict the shape of the rectifier circuit based on the shape of the wave signal graph. In addition, students with good KVS-Series Patterns can also understand the sequence of graphs when rectifying circuits without capacitors, with capacitors and with capacitors with a larger capacity. Visual-spatial skills are used when a scientific theory that was originally presented in words or as an equation is mentally transformed into an abstract spatial representation, such as a graph or model (Andersen, 2014). So it is necessary to identify and develop visual-spatial abilities in students who can become future scientists.

NI Multisim software is closely related to visual-spatial ability students, meanwhile initial skills can be met before the study material wave rectifier circuit. Students with high spatial-visual abilities will find drawing, analyzing, and interpreting an electrical circuit easier. This ability helps students understand the concepts of a wave rectifier circuit and makes students more creative in solving problems (Ardian & Munadi, 2016). NI Multisim software can be seen as an integration technology that affects the way down and the process of education (Utari & Prima, 2019) or a student learning, especially in studying various electronic lecture material.

CONCLUSION

NI-Multisim Software in introductory electronics lectures on wave rectifier circuit material influences student learning outcomes based on students' visual-spatial abilities. The conclusions obtained in this study are;

1. Student learning outcomes on the wave rectifier circuit material after learning using NI-Multisim Software is applied are in a good category;
2. Students' visual-spatial ability (KVS) on the indicators of KVS-interpretation in the very high category, KVS-series pattern in the high category, KVS-reflection in the high category, KVS-rotation in the high category, KVS-projection in the high category, and KVS-drawing in the medium category;

3. Students' visual-spatial ability has a positive and significant correlation to student learning outcomes with a contribution of 79.40%;
4. The learning outcomes of students who have high KVS are better than the average learning outcomes of students who have low KVS in studying the material of wave rectifier circuits using NI-Multisim Software.

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