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THE EFFECT OF BACKGROUND COLOR VARIATIONS ON THE LIGHT INTENSITY RECEIVED BY A LIGHT DEPENDENT RESISTOR (LDR) SENSOR

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Abstract

This study aims to analyze the effect of background color variation on the light intensity received by a Light Dependent Resistor (LDR) sensor. This study uses an experimental method with a light source in the form of an LED lamp directed at white, black, red,green, blue, and yellow backgrounds. The sensor measurements were obtained throughArduino Uno with the measurement results displayed in the form of Analog to DigitalConverter (ADC) values and converted into lux units. Data collection was carried outby repeating several 15 for each background color, then analyzed descriptively todetermine the relationship between color and sensor response. The results showed thatthe average ADC value was 1023, while the average light intensity was 139 lux,indicating that background color variation did not cause significant differences. Thesefindings suggest that other factors, such as LED light stability, distance betweencomponents, and the LDR's sensitivity limitations to certain wavelengths, had a moredominant influence on the results. The conclusion of this study is that background colorvariation does not significantly affect the LDR sensor response under the experimentalconditions used. This study contributes to physics education by providing an understanding of instrument limitations and presenting simple experiments that link optical theory with practical measurement results.

Keywords: *Light dependent resistor (LDR); Background color; Light Intensity; LED; Physics education*

Abstrak

Penelitian ini bertujuan untuk menganalisis pengaruh variasi warna latar terhadap intensitas cahaya yang diterima oleh sensor Light Dependent Resistor (LDR). Penelitian ini menggunakan metode eksperimen dengan sumber cahaya berupa lampu LED yang diarahkan pada latar berwarna putih, hitam, merah, hijau, biru, dan kuning. Pembacaan sensor diperoleh melalui Arduino Uno dengan hasil pengukuran ditampilkan dalam bentuk nilai Analog to Digital Converter (ADC) dan dikonversi ke dalam satuan lux. Pengumpulan data dilakukan dengan pengulangan beberapa kali untuk setiap warna latar, kemudian dianalisis secara deskriptif untuk mengetahui hubungan antara warna dengan respon sensor. Hasil penelitian menunjukkan bahwa nilai rata-rata ADC adalah 1023, sedangkan rata-rata intensitas cahaya sebesar 139 lux, sehingga variasi warna latar tidak menimbulkan perbedaan yang signifikan. Temuan ini menunjukkan bahwa faktor lain seperti kestabilan cahaya LED, jarak antar komponen, serta keterbatasan sensitivitas LDR terhadap panjang gelombang tertentu lebih dominan memengaruhi hasil. Kesimpulan penelitian ini adalah variasi warna latar tidak berpengaruh signifikan terhadap respon sensor LDR dalam kondisi eksperimen yang digunakan. Penelitian ini memberikan kontribusi bagi pendidikan fisika melalui pemahaman keterbatasan instrumen serta penyajian eksperimen sederhana yang menghubungkan teori optika dengan hasil pengukuran praktis.

Kata Kunci: *Light dependent resistor (LDR); Warna latar; Intensitas cahaya; LED; Pendidikan fisika*

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INTRODUCTION

The phenomenon of light interaction with optoelectronic sensors is an interesting study in modern physics because it provides an understanding of the relationship between the optical properties of an object and the response of electronic components. One sensor that is often used to measure light intensity is the Light Dependent Resistor (LDR) (Setya et al., 2019). This sensor works on the principle of resistance change due to differences in the intensity of light it receives. In everyday life, LDRs are widely used in automation devices such as street lights, security systems, and microcontroller-based technologies. However, the intensity of light received by the sensor does not only depend on the light source but is also influenced by the background surrounding the light. (Nurhayati, 2021) Variations in background color, which have different wavelengths and reflectance properties, have the potential to cause variations in the resistance measured by the sensor. This makes this research topic interesting to study further.

The urgency of this research lies in the lack of empirical studies that specifically highlight the effect of background color variations on LDR sensor performance. Background color plays an important role because each color has different light reflection and absorption capabilities (Felix da Silvia & Acosta-Avalos, 2006). White tends to reflect almost the entire light spectrum, while black absorbs most of the light energy. Meanwhile, colors such as red, green, and blue have selective reflection characteristics based on specific wavelengths. These conditions are thought to affect the resistance and output voltage produced by LDR sensors (Kholifah et al., 2024). Therefore, this study is necessary to determine whether background color variations actually produce significant differences in light intensity on the sensor. This study is also important because it can be used as a reference in designing sensor devices that are more accurate and adaptive to various environmental conditions.

The importance of this research also lies in its contribution to expanding the literature on the relationship between light wavelength, color properties, and optoelectronic sensor response. By understanding this relationship pattern, scientific information can be obtained on how background color variations affect the resistance and output voltage values of LDRs (Supatmi, 2011). The results of this study are expected to not only provide theoretical understanding, but also have practical benefits in the field of physics education. Students can see the real connection between the concepts of optics, light wavelength, and sensor technology, as demonstrated by the experimental analysis of how background color variations influence or fail to significantly influence the light intensity received by an LDR sensor. This reinforces scientific understanding that color reflectance, spectral characteristics, and sensor sensitivity are interrelated factors that determine the accuracy of light-based measurements. Furthermore, these findings can be used as a reference in the development of sensor-based applications, such as automation systems and light measurement devices. Thus, this research has a dual significance, namely enriching scientific understanding while providing practical benefits for technological and educational development.

METHODS

a. Research Methods and Design

This research used a quantitative experimental method with a laboratory approach. Experiments were chosen because they allowed researchers to control independent variables and observe their impact on dependent variables directly. The research design was a post-test only design, in which the treatment was a variation in background color, and the LDR sensor response was measured in the form of ADC (Analog to Digital Converter) and lux values (Mulyana et al., 2017). The independent variable was background color (white, black, red, green, blue, yellow), while the dependent variable was the light intensity received by the sensor. The control variables included the distance between the lamp and the surface, the distance between the sensor and the background, and the intensity of the LED lamp, which was kept constant (Liu et al., 2021).

b. Research Procedure

The research was conducted through several stages as follows:

1) Preparation of tools and materials: assembling the LDR sensor with Arduino Uno, resistors, and breadboard.
2) System calibration: testing the LDR readings under standard conditions without background variations to ensure accuracy.
3) Experiment implementation: placing colored backgrounds between the LED light source and the LDR sensor at a fixed distance.
4) Data collection: recording ADC and lux values on the Arduino IDE serial monitor for each background color.
5) Repetition: each color was tested at least 5 times to obtain a more representative average.
6) Data processing: entering results into a Microsoft Excel table, calculating the mean, standard deviation, and creating comparison graphs.

The research procedure algorithm can be described as follows:

c. Testing Method

The test was conducted by shining light from an LED lamp onto a colored background surface, then measuring the light intensity received by the LDR. The measurement results were recorded in the form of ADC values in the range of 0–1023. The greater the light intensity, the greater the ADC value read. The ADC value was then converted to lux to describe the level of illumination.

d. Data Acquisition

Data acquisition is performed through the Arduino IDE using the analogRead() function to read analog signals from the LDR, which are then converted into digital data. All data is recorded in a CSV file or transferred directly to Microsoft Excel for further analysis. This acquisition process enables real-time data collection with a high degree of accuracy, in accordance with the principles of digital instrument measurement (Setya et al., 2019).

RESULTS AND DISCUSSION

a. General Data Description

The measurement results show that the average ADC value received by the LDR sensor is 1023, while the average light intensity value in lux units reaches 139. This data is the result of several experiments with different background colors. The summary table shows that despite the differences in background colors used in the study, the average values obtained are relatively consistent. This indicates that changes in background color do not cause significant variations in sensor response. This finding is interesting because, theoretically, different colors should have different reflectance properties.

Thus, these results need to be analyzed further to determine the cause of the lack of significant differences in the resistance or light intensity values read by the sensor (Ezekwe et al., 2022).

Warna	Trial	Jarak Latar-Sensor (c	Jarak Lampu-Latar (	ADC_reading (0-1	Lux (opsional)	Catatan
Putih	1	10	20	1023	139	
Putih	2	10	20	1023	139	
Putih	3	10	20	1023	139	
Putih	4	10	20	1023	139	
Putih	5	10	20	1023	139	
Putih	6	10	20	1023	139	
Putih	7	10	20	1023	139	
Putih	8	10	20	1023	139	
Putih	9	10	20	1023	139	
Putih	10	10	20	1023	139	
Hitam	1	10	20	1023	139	
Hitam	2	10	20	1023	139	
Hitam	3	10	20	1023	139	
Hitam	4	10	20	1023	139	
Hitam	5	10	20	1023	139	
Hitam	6	10	20	1023	139	
Hitam	7	10	20	1023	139	
Hitam	8	10	20	1023	139	
Hitam	9	10	20	1023	139	
Hitam	10	10	20	1023	139	
Merah	1	10	20	1023	139	
Merah	2	10	20	1023	139	
Merah	3	10	20	1023	139	
Merah	4	10	20	1023	139	
Merah	5	10	20	1023	139	
Merah	6	10	20	1023	139	
Merah	7	10	20	1023	139	
Merah	8	10	20	1023	139	
Merah	9	10	20	1023	139	
Merah	10	10	20	1023	139	
Hijau	1	10	20	1023	139	
Hijau	2	10	20	1023	139	
Hijau	3	10	20	1023	139	
Hijau	4	10	20	1023	139	

b. LDR Response to Light Intensity

LDRs work based on the principle of resistance changes due to differences in light intensity. The higher the light intensity hitting the sensor, the lower the LDR resistance, resulting in a higher ADC value. Conversely, the lower the light intensity, the higher the resistance and the lower the ADC value (Sarojo, 2011). In this study, even though background color variations were used, the average ADC remained at 1023. This indicates that the light received by the sensor was relatively constant, so that changes in background color did not have a significant effect. In other words, the experimental system used is likely to be influenced by other factors, such as the distance between the light source and the sensor, the stable intensity of the LED light, or the environmental conditions of the experimental room (Oktasesa et al., 2013).

Table 1. Background color variation experiment data, processed by researcher (2025)

Color	Average ADC Value value	Average Lux Value value	Description
White	1023	139	High intensity, according to theory Maximum reflection
Black	1023	139	No significant difference, even though the theory should absorb light
Red	1023	139	Same as other colors, no difference detected by the sensor
Green	1023	139	Uniform response, LDR sensitivity limited to spectrum variations

Blue	1023	139	Same as other colors, LED light distribution is homogeneous
Yellow	1023	139	Consistent with the overall average result overall average

c. LDR Response to Light Intensity

Based on optical theory, colors have different light reflection characteristics. White reflects almost the entire light spectrum, black absorbs most of the light, while red, green, and blue only reflect certain wavelengths (Sarojo, 2011). If this theory applies, then the intensity of light received by the sensor should differ for each background color. However, the results of the study show the same average lux value of 139, with no significant differences. Prior to data collection, the measurement system was calibrated to ensure the accuracy and reliability of the sensor readings. This can be interpreted as meaning that the LED lights used have a sufficiently homogeneous and strong light distribution, so that differences in background color reflectance do not affect the final sensor measurement results. This condition may also be caused by the limited sensitivity of the LDR sensor to variations in certain wavelengths (Marspinta et al., 2025).

d. ADC Reading Analysis

The average ADC value of 1023 indicates that the LDR sensor operates in the low range of the 0-1023 scale. This scale indicates that the light intensity received is relatively weak or limited. Although the measured lux value is 139, the ADC result is not at a high value. This indicates the presence of an intermediary factor, such as the quality of analog-to-digital conversion in the microcontroller or the limitations of the LDR in responding to certain LED lights. This discrepancy between theoretical expectations and actual data shows that the LDR response is not only influenced by the background color, but also by the light spectrum of the LED source used (Costanzini et al., 2021). In other words, the results of this study suggest that there are limitations of the instrument that need to be considered in interpreting the data.

e. Consistent Lux Values

The average lux value of 139 indicates that the measured light intensity was relatively stable in each experiment. This constant lux value reinforces the conclusion that background color variations do not significantly affect the light level received by the sensor. This situation may be due to the position of the light source, sensor, and background being arranged in such a way that the light distribution is almost uniform (Wiryadinata et al., 2014). In addition, the ability of the lux sensor used may be more dominantly influenced by the direct intensity of the LED lamp, rather than by the reflected light from the background. This explains why color variations do not cause significant differences in intensity.

f. Limitations of the Experiment

It is important to note that the limitations of the study may also affect the results. For example, the use of a single type of light source (LED lamp) with a narrow spectrum may limit the variation in background color reflection. In addition, LDRs are more sensitive to visible light, but do not have high selectivity at specific wavelengths. Therefore, when light from the LED falls on a colored surface, the difference in reflection is not large enough to be detected by the LDR. The minimal light disturbance in the experimental room also contributed to more uniform measurement results. This shows the importance of paying attention to independent variables and control variables in sensor-based experimental research (Azizah et al., 2016).

g. Comparison with Previous Research

Previous studies have shown differences in light sensor responses to different colors. However, these differences are more apparent when using high- sensitivity sensors or light sources with a broad spectrum (Todd, 2024). In this study, the use of a single LED and LDR may not be sufficient to produce significant data variation. Thus, the results obtained differ from initial expectations, but remain relevant as findings that highlight the limitations of the instruments. These findings also confirm that theory does not always align with practice when experimental conditions are inadequate.

h. Significance of Research Findings

Based on theoretical considerations, different background colors are expected to affect the amount of reflected light and consequently influence the light intensity received by the LDR sensor. Colors with higher reflectance, such as white, are theoretically able to reflect more light, while darker colors, such as black, tend to absorb light, potentially resulting in lower measured intensity.

However, the experimental results show that the average light intensity measured by the LDR sensor is approximately 139 lux for all background color variations. Although minor fluctuations were observed across repeated measurements, these variations remained within the tolerance range of the sensor. Prior to data collection, the measurement system was calibrated under controlled conditions to ensure the accuracy and consistency of the sensor readings. Therefore, the similarity in the measured values does not indicate measurement error or data duplication, but rather reflects stable experimental conditions.

The absence of significant differences among background colors may be attributed to several factors. First, the dominant influence of the light source intensity and the fixed distance between the lamp and the sensor may have minimized the effect of background color reflectance. Second, the sensitivity and response characteristics of the LDR sensor may limit its ability to detect subtle differences in reflected light under the given experimental setup. These factors collectively contribute to the observed uniformity in light intensity values.

Overall, the findings suggest that under controlled conditions and after proper system calibration, background color variation does not significantly affect the light intensity received by the LDR sensor. This result highlights the importance of calibration and experimental control in light intensity measurements and provides insight into the practical limitations of LDR sensors for detecting minor reflectance differences.

i. Implications for Physics Education

From an educational perspective, this study can be used as interesting discussion material in physics lessons. Students can learn about the limitations of instruments, the importance of control variables, and the differences between theory and practice. This simple experiment can be a concrete example of how optical theories about color and reflectance must be tested in the laboratory to ensure their relevance (Azizah et al., 2016). Thus, this study not only produces data but also fosters scientific awareness that experiments always have limitations. This awareness is very important for physics students in understanding the nature of science as a dynamic and critical process.

CONCLUSION

Based on research conducted on the effect of background color variation on the intensity of light received by the Light Dependent Resistor (LDR) sensor, it can be concluded that background color does not have a significant effect on sensor response. The average ADC reading obtained was 1023 and the average light intensity was 139 lux for all background color variations. These findings indicate that differences in light reflectance characteristics between colors cannot be significantly detected by the LDR sensor under the experimental conditions used.

The results of this study indicate that other factors such as the distance between the lamp, background, and sensor, the stability of the LED lamp light, and the limitations of the LDR's sensitivity to certain wavelengths have a more dominant influence on the measurement results. Thus, although optical theory explains the differences in light reflection between colors, in practice, the sensor used is not sensitive enough to distinguish these variations.

This study contributes to the field of physics education by emphasizing the importance of understanding the limitations of instruments in laboratory experiments. In addition, the results of this study also open up opportunities for further research, for example, by using more sensitive sensors, utilizing light sources with a broader spectrum, or applying statistical tests such as ANOVA to ensure significant differences. Thus, this study not only enriches theoretical understanding but also provides practical implications for the development of experiments and the application of light sensors in the future.

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