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Low Cost Solar Irradiance Meter with Automatic Closing System

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Abstract This study investigated on constructing a low cost solar irradiance meter that can be protected by automatic closing system. It determined the needed features of the device, the difference between the measurements recorded by the constructed device as compared to the PASCO/ IR Light Sensor, the experiments that may be performed using the constructed device and the evaluation of the experts and professionals on the device as to functionality, and design & marketability. The instruments used underwent expert validation. The study employed experimental and descriptive methods. The data were gathered from 30 experts who evaluated the constructed device in terms of features and marketability. On the other hand, 30 students of EARIST Manila evaluated the constructed device in terms of functionality and marketability. Results revealed that the Low Cost Solar Irradiance Meter with Automatic Closing System has an innovative design and has new features based on the evaluation. It can measure solar irradiance or intensity efficiently. The measurement of the device is comparable to the result of the IR Light Sensor of the PASCO. There is no significant difference between the result of the calibrated device and the PASCO IR Light Sensor. The constructed device is more affordable compared to the commercial solar irradiance meter.

Keywords: *Low Cost Solar Irradiance Meter, Automatic Closing Systems, Functionality, Design and Marketability.*

1. Introduction

Solar radiation is the main driving force for the earth's weather and climate. It is also the prime source of renewable energy technologies. Solar energy technologies can satisfy the current energy demand and at the same time reduce anthropogenic greenhouse gas emissions (Lysko 2006). Because of geographical, temporal, and angular fluctuation, assessing solar energy at the earth's surface is challenging. These fluctuations highlight the importance of localized sun radiation observations and simulations. Total Solar Irradiance (TSI) or extraterrestrial solar irradiance refers to the total quantity of solar radiation received at normal incidence at the top of the earth's atmosphere at the mean sun-earth distance. The TSI changes over time, although by a modest amount, and its amplitude and fluctuations have an impact on many atmospheric and biological processes on Earth. Since November 1978, a complete collection of TSI observations from several space-borne radiometers has been available, producing a 26-year time series. (Kopp, 2016)

Pyranometers, Pyrheliometers, and Albedometers are the three primary types of equipment used to measure sun irradiance across the Earth's surface. These instruments, which measure irradiance in W/m2, are exceedingly precise and hence costly. In reality, the cost of these sensors is a significant cost for the process of gathering solar data, particularly for nonprofit organizations such as schools or colleges (Korevaar, 2022). This is the driving force behind the study, which intends to show how to create a low-cost Pyranometer or global irradiance sensor with performance, accuracy, and durability on par with those of commonly employed sensors. Commercial systems utilize thermopiles, whereas pyranometers use a variety of sensors to detect sun irradiation (Driesse & Zaaiman, 2015).

This method, however, recommended employing a phototransistor as a solar sensor, in contrast to earlier ones. Equipment for solar research is quite costly in the present day. Therefore, it was decided to develop and manufacture a low-cost solar irradiance meter that is both more sophisticated and integrated with an automated closing mechanism than the commercial one while being more affordable. With the help of the closing system, the device was designed to be protected from rainwater (Mancilla-David et.al, 2014)

A low-cost solar irradiance meter with an automated closure mechanism was the goal of this study's construction. The research covers the built-in features, performing tests to confirm its performance, and lastly assessing the device's usability, design, and marketability.

2. Methodology

The study's Low-Cost Solar Irradiance Meter with Automatic Closing System is an experimental instrument. Because the device and its mobile application were evaluated by both experts and consumers, descriptive

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methodologies were also employed. The judges include physicists and electronics experts. The sampling technique is deliberate since the experts picked are engineers and industry specialists. A total of 30 specialists evaluated the characteristics and marketability of the built-in gadget. On the other hand, 30 students evaluated the marketability and usability of the built-in gadget. The researchers employed a survey questionnaire to evaluate the created device and its monitoring system.

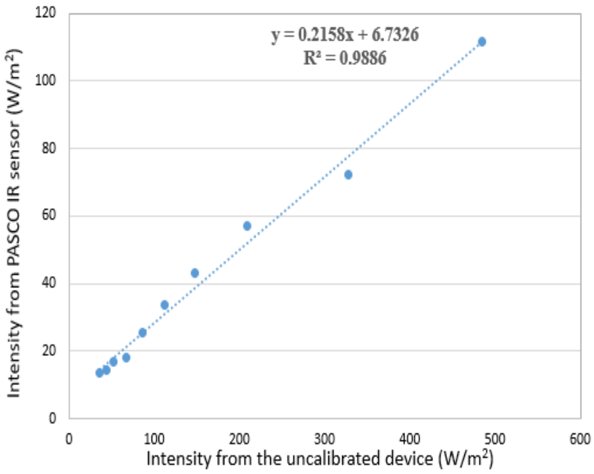
3. Results and Discussion

The constructed device includes a solar Irradiance sensor. This sensor is calibrated using PASCO IR Light Sensor and also the sensor is made up of a phototransistor. It also has a rain sensor that detects rain and sends data to Arduino. Utilizes a single Arduino 5 microcontroller board. Output measures can be gathered through mobile applications connected to Arduino.

The results of intensity measurements from the constructed (uncalibrated) device and from the standard PASCO IR light sensor. Large differences between the two measurements were obvious since the constructed device was not yet calibrated. Nevertheless, the measurements from the two devices follow the same trend (i.e. both devices exhibited larger intensity measurements for smaller distances and smaller intensity measurements for larger distances from the light source).

A. Solar intensity measurements from the constructed (uncalibrated) device and from the standard PASCO IR light sensor

Trial	Intensity from uncalibrated sensor(W/m2)	Intensity from the PASCO IR sensor (W/m2)
1	484.3	111.4811
2	328.2	72.10648
3	208.7	57.0274
4	147.1	43.07947
5	112.5	33.76548
6	85.9	25.41768
7	67.7	18.00729
8	52.5	16.77908
9	43.8	14.37479
10	36.2	13.46235

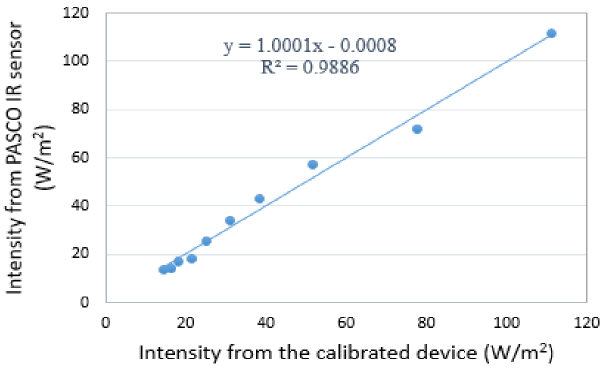


Solar intensity measurements from PASCO device versus solar intensity measurements from the constructed device

B. Calibrated solar intensity measurements from the constructed device and from the standard PASCO IR light sensor

Trial	Intensity from the calibrated sensor (W/m2)	Intensity from the PASCO IR sensor (W/m2)
1	111.2445	111.4811
2	77.55816	72.10648
3	51.77006	57.0274
4	38.47678	43.07947
5	31.0101	33.76548
6	25.26982	25.41768
7	21.34226	18.00729
8	18.0621	16.77908
9	16.18464	14.37479
10	14.54456	13.46235

Table above shows the calibrated intensity measurements from the constructed device and the intensity measurements from the standard PASCO IR light sensor. It can be seen that the intensity measurements were almost of equal values. Evidently, the result of t-test show that there is no significant difference between the measurements from the calibrated device and the standard PASCO IR light sensor.



Solar intensity measurements from PASCO device versus the calibrated solar intensity measurements from the constructed device.

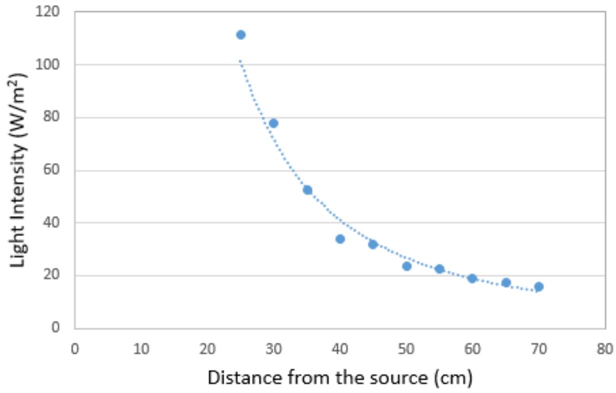
C. T-test result of the calibrated solar intensity measurements from the constructed device and from the standard PASCO IR light sensor

	Variable 1	Variable 2
Mean	40.546302	40.55011
Variance	996.2888818	1008.007
Observations	10	10
Pearson Correlation	0.994283205	
Hypothesized Mean Difference	0	
df	9	
t Stat	- 0.003553114	
P(T<=t) one-tail	0.498621271	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.997242542	
t Critical two-tail	2.262157163	

This means that the constructed device can be used to accurately measure solar irradiance or solar intensity just like other commercial devices do. There is no significant difference between the constructed device and the PASCO IR Light Sensor.

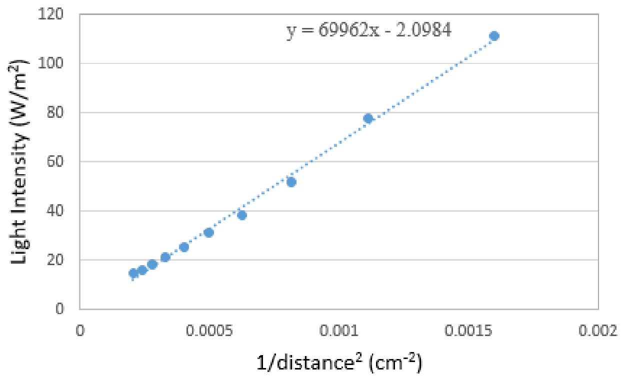
D. Experiments that may be performed using the constructed Low Cost Solar Irradiance Meter with Automatic Closing System

The calibrated device was tested in an experiment that determined how light intensity from a bulb (light source) vary with distance from the source.



Light intensity measurements as a function of distance from the light source

This shows a hyperbolic trend where the value of solar intensity decreases as the distance from the light source increases. The linearized graph evidently shows that light intensity is inversely proportional to the square of the distance squared (i.e. I α 1/d2). This supports the inverse square law of electromagnetic radiation. This means that as the distance from a light source increases, the intensity of the light decreases. Solar irradiance is a visible light. Visible light is part of the electromagnetic spectrum, and the inverse square law is true for any other waves.



Linearized Data

4. Conclusion

A Low Cost Solar Irradiance Meter with Automatic Closing System is made of incredibly inexpensive materials. The experts thought the Low Cost Solar Irradiance Meter with Automatic Closing System design was good and most of them agreed. The tool has a case that automatically closes when it detects rain and can measure sun intensity or solar irradiance (W/m2). The data is being transmitted from a mobile device in it. The PASCO IR Light Sensor and the built sensor are virtually identical. Solar intensity can also be accurately measured with a phototransistor. In an experiment using the gadget, the light intensity shows a linear relationship with the square root of the reciprocal of the distance from the source.

According to the evaluation's findings, the Low Cost Solar Irradiance Meter with Automatic Closing System has a unique design and novel functions. It is capable of accurately measuring sun intensity or irradiance. The measurement made by the apparatus is equivalent to the findings of the PASCO IR Light Sensor. Between the calibrated device's output and that of the PASCO IR Light Sensor, there is no significant difference. Comparing the created gadget to a commercial solar irradiance meter reveals that it is more cost-effective.

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