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Street Light Dimmer with PIR Sensor

Age: 10- 18 years old

Topics: Micro-bit, Led-dimming, PIR Sensor, inquiry based learning, environmental education, smart cities, coding, energy conservation, real-world application, project showcase

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Explore the fascinating world of LED dimming with the micro:bit in this innovative educational project. Uncover the magic of coding, basic electronics, and matrix display LEDs to qualitatively estimate ambient light, emphasizing the balance between precision and practicality. Though the micro:bit lacks a dedicated light sensor, discover its unique ability to gauge reflected light, offering valuable insights for engaging student exploration despite its inherent precision limitations.

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Module: Energy Resources & Light Pollution Mitigation	
Topic: Energy conservation & efficiency	
Lesson Plan Title: Street Light Dimmer with PIR Sensor	
Duration: 45 minutes	
Short Description of the Lesson	Students will engage in an experiential learning activity involving the simulation of LED dimming on a micro:bit device. This entails utilizing the LEDs of the matrix display to qualitatively assess ambient light, complemented by the integration of a specialized light sensor. Through this pedagogical approach, students acquire coding proficiency, simultaneously navigating the delicate equilibrium between precision and pragmatic considerations in the realm of light measurements.
Learning Goals	• Grasp the concept of simulating LED dimming in response to ambient light variations. • Acquire familiarity with the micro:bit platform. • Understand the process of estimating ambient light using the matrix display LEDs. • Investigate the balance between precision and practicality in qualitative light measurements. • Cultivate coding skills for the implementation of light estimation algorithms on the micro:bit platform.
Green Competences Linked	• Valuing sustainability: promote an understanding of the importance of energy efficiency and the potential of smart lighting solutions in reducing energy consumption. • Problem framing: analyze the various factors that influence lighting needs, such as ambient light levels, time of day, and occupancy; focusing in the understanding of the complex interplay between these factors and the operation of the LED dimming system. • Exploratory thinking: research potential improvements to the LED dimming system, a brainstorm with the group could help on it. The solutions could include the use of more energy-efficient LEDs, implementation of smarter dimming algorithms, and integration with other smart home systems. • Political agency: From a model implemented by the LED dimming simulation on a micro:bit, show commitment to questioning the effectiveness of the streetlights and to becoming an agent of change to achieve the best option of streetlights considering the light pollution problem.
Target Group	Students aged 10–18 years old.
Educational Approach	The project is based on Inquiry-Based Learning, which emphasizes an exploration-driven methodology. Additionally, it adheres to the STEAM educational framework, promoting an interdisciplinary approach to foster a holistic understanding of the subject matter.

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Link to School Curricula (if applicable)	• Environmental Education: This project integrates concepts related to environmental awareness and sustainable practices, particularly in the context of efficient lighting systems. • Physics: The project pertains to various physics subdomains, including Electronics, Energy, and Light, fostering a multidisciplinary understanding of physical principles and their practical applications.
Facility/ Equipment	• Classroom • Internet access • Projector • White board • Personal computer
Tools/ Materials	• micro:bit • 3 LED • 1 protoboard • 2 connector cables
Main Tasks **45 minutes**	**Task 1: Light Level** With the micro:bit device, students will assess and qualify light levels from a cell phone flash. **Task 2: Controlling a LED with a micro:bit** Using the micro:bit device, students will modulate the activation and deactivation of an LED based on light levels. **Task 3: Using a movement sensor (PIR)** With the micro:bit device and a motion sensor, students will emulate a dimming process akin streetlights.
Extracurricular Activities	• Project Showcase: Encourage students to create a visual or interactive presentation showcasing their LED dimming simulation projects. Include details such as the code used, the rationale behind their design choices, and any modifications or improvements they made. • Extended Coding Challenges: Provide optional coding challenges that go beyond the basic project requirements. This could involve incorporating additional sensors, creating dynamic light patterns, or implementing user interaction features. • Collaborative Project: Facilitate collaboration among students to work on a larger-scale project that involves multiple micro:bits and interconnected systems, creating a more complex and integrated simulation. • Real-World Application: Challenge students to identify real-world scenarios where LED dimming based on ambient light levels could be implemented for practical purposes, such as energy conservation in smart cities.

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Introduction

In the realm of modern education, the integration of innovative and interactive technological tools has become imperative for fostering a dynamic learning environment. As educators of students from XXI Century, you may find yourselves venturing into uncharted territory with the prospect of introducing a project that explores LED dimming simulation using a micro:bit (Fig.1) as a control device.

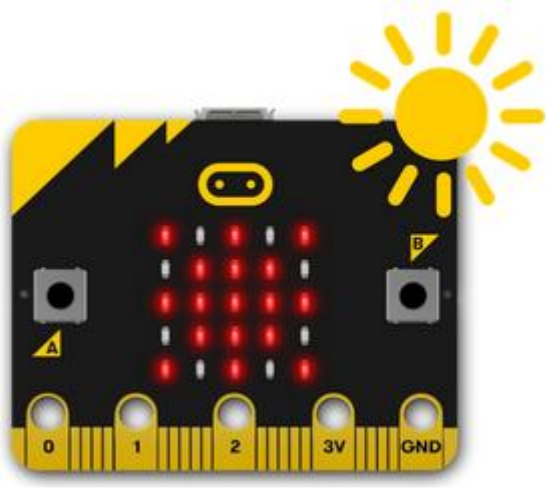

Figure 1 - The micro:bit.

This project endeavours to guide both you and your students through a captivating exploration of LED dimming, utilizing the matrix display's LEDs to gauge ambient light qualitatively, coupled with the incorporation of a dedicated light sensor. Throughout this journey, students will not only cultivate essential coding skills but also grapple with the delicate balance between precision and practicality in the domain of physical quantities. This activity aims to lay the groundwork for an engaging educational experience, demystifying the coding, the micro:bit and the basic electronics, beside setting the stage for an insightful exploration of LED dimming simulation in the context of ambient light estimation and so on.

For those unfamiliar with micro:bit

It is a versatile and accessible microcontroller that serves as an excellent entry point for coding and electronics. A good place to start is the website https://makecode.microbit.org/, the home of micro:bit; and a possible video to see a short and direct introduction is available in https://www.youtube.com/live/6gp3y34BFAQ?si=MzoyBrq3e_2AFyoq.

The undertaken activity involves the simulation of LED dimming in direct correlation with the ambient light level detected by a sensor. Notably, the micro:bit lacks an inherent specialized light sensor device. Nonetheless, it harnesses the matrix display's LEDs for approximating ambient light levels. This capacity arises from the micro:bit's capability to gauge the reflected light quantity when the LEDs operate at low power. It is imperative to acknowledge that while this methodology provides a qualitative estimation of ambient light, its precision is inherently inferior to that of a dedicated light sensor. Nevertheless, it proves to be a valuable approach when qualitative measurements suffice for the intended purposes of the project.

It is important to recognize a noteworthy divergence in LED column and row mapping between the micro:bit version V2 and its predecessor. Specifically, the V2 iteration designates the top row of LEDs exclusively for light sensing purposes, whereas in the V1 version, this function is distributed across the entire display. This distinction carries practical implications, wherein, for instance, the act of covering the top row of LEDs on a V2 micro:bit results in a registered light level of 0, underscoring the altered configuration and behaviour in comparison to the V1 version.

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Equipment and Materials

- micro:bit board.
- 3 LED.
- 2 connector cables.
- 1 movement sensor PIR (Fig. 2A).
- 1 protoboard adapter for micro:bit (Fig. 2B)
- 1 protoboard (Fig. 2C)

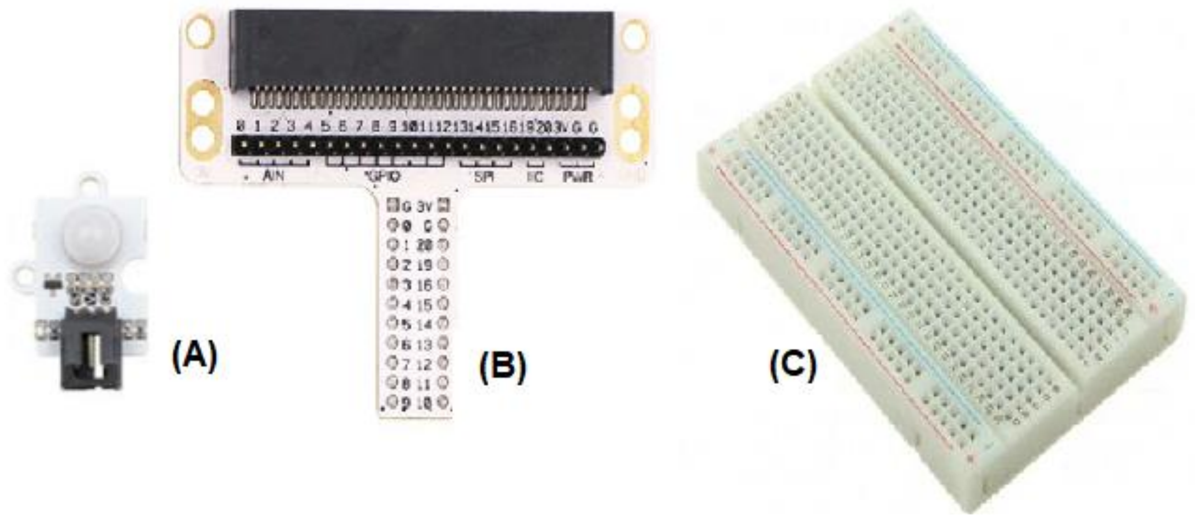

Figure 2 – (A) A movement sensor PIR, (B) a protoboard adapter for micro:bit and (C) a protoboard.

Suggested Ages

10 to 18 years old. Younger children may need to be given the code blocks during an example in the classroom.

Prior Knowledge

The basic about micro:bit, electronic and LEDs.

Activity

Task 1: Light Level

This first task involves the quantification of light levels utilizing the micro:bit in conjunction with a mobile phone functioning as the light source, specifically utilizing the LED flash. It is pertinent to note that, in the context of Light Level measurement, the micro:bit employs a value interval ranging from 0 to 255. Although this range does not precisely represent the actual light intensity, it serves qualitative purposes, as elucidated earlier.

In practical terms, directing the LED flash of a mobile phone towards the front of the micro:bit should yield a recorded value of 255. Conversely, when the front of the micro:bit is obscured or covered, the registered value should descend to 0. This exercise serves as an introductory exploration of the

For those unfamiliar with micro:bit

In addition to all the information available on the Internet, the makecode website contains step-by-step tutorials to help you get started in the micro:bit world.

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micro:bit's light sensing capabilities, utilizing the qualitative value range for practical assessments in the context of ambient light estimation.

The micro:bit microcontroller can be programmed using the online editor available at https://makecode.microbit.org/. This platform not only offers a repository of extensive code examples but also allows the connection of the micro:bit device to a computer, enabling the transfer of the code from the website to the micro:bit. This integrated online editor serves as a comprehensive resource for programming the micro:bit, offering both educational support and practical functionality for educators and students alike.

Figure 3 illustrates a method to program the micro:bit using block coding, displaying information about the Light Level on its integrated display. This coding approach provides a visual and accessible means for educators and students to engage with the micro:bit's functionalities, enhancing the learning experience in the context of light measurement and display presentation.

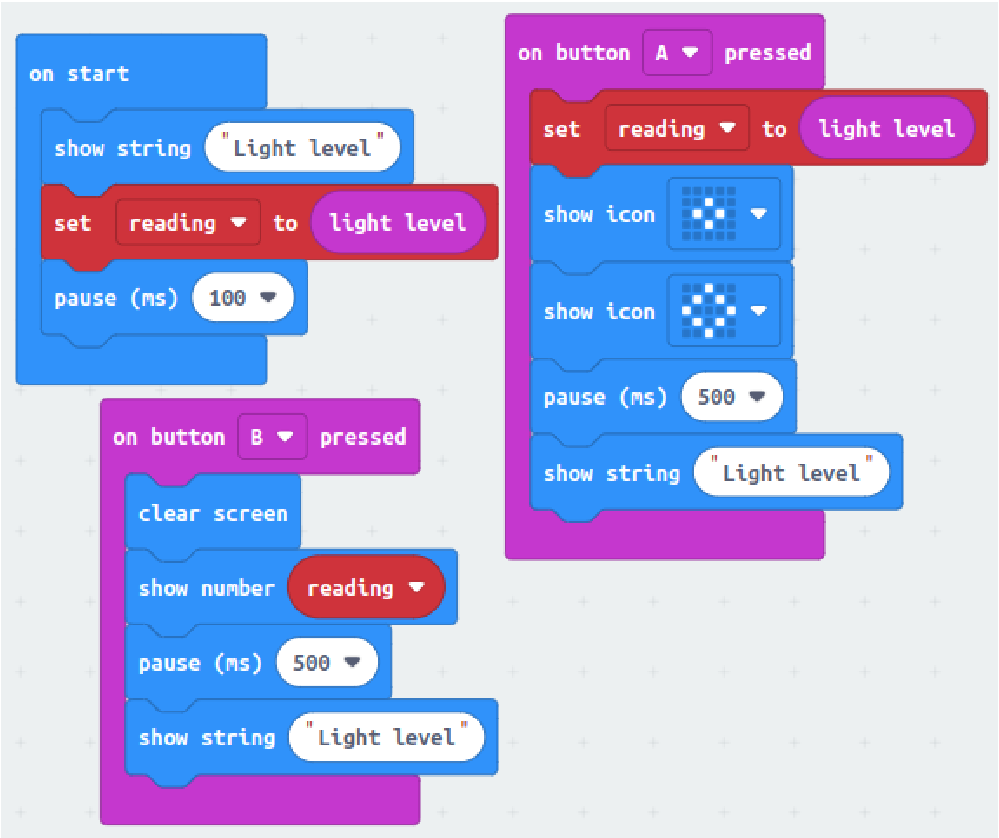

Figure 3 - An example of block coding that shows light level information on the micro:bit display.

Task 2: Controlling a LED with a micro:bit

The second task of the project involves the integration of a Light Emitting Diode (LED) with the micro:bit, enabling the LED to illuminate in low-light conditions. The lengthier leg of the LED is to be connected to PIN 0 on the micro:bit, employing

For those unfamiliar with micro:bit

Don't forget to delete all the information/codes you had before each time you start a new code on the makecode website.

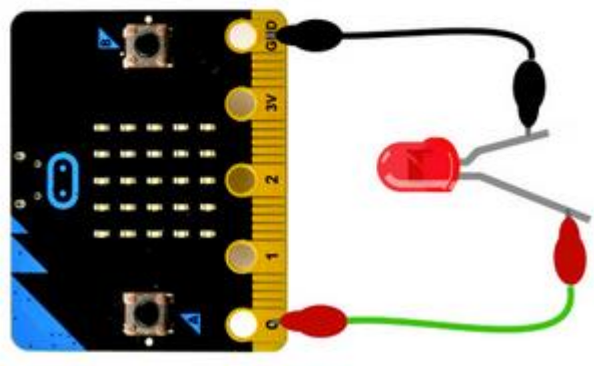

Figure 4 - Assembly scheme for a LED linked to a micro:bit.

alligator clips for secure attachment, as visually indicated in the figure 4. The shorter leg, should be connected in the PIN GND, it means, the 'ground' to make the circuit.

This configuration establishes a direct correlation between the micro:bit's light sensing capabilities and the LED, facilitating a responsive illumination mechanism contingent upon ambient light levels. Certainly, a code is imperative for this purpose, and Figure 5 depicts an illustrative example. The provided code activates the LED when the detected "amount of light" reaching the micro:bit falls below the specified threshold of 128.

Figure 5 - An example of block coding to turn on a LED.

The adjustable threshold, ranging from 0 to 255, holds significant importance as it allows for the customization of the light activation criteria. Implementing such a method is particularly relevant in the field of urban planning, as it facilitates the precise determination of the light level at which public lights will be triggered to illuminate. This adaptability is crucial given the varying daylight conditions throughout the day, across seasons, and under different weather circumstances. The method accommodates the dynamic nature of environmental lighting requirements, contributing to more efficient and responsive urban lighting systems.

Task 3: Using a movement sensor (PIR)

The third task of the project involves the utilization of three LEDs to emulate a dimming process akin to streetlights. This simulation is contingent upon the input from a motion sensor strategically positioned at the starting point of the street. In the event of the sensor detecting the presence of a person, a bicycle, or a car, all LEDs will illuminate at their full capacity, reaching 100% of their illuminance power. Conversely, when no motion is detected, the LEDs will persist at a reduced energy level around of 30%, effectively minimizing energy consumption and mitigating approximately 70% of potential energy waste. This task addresses the need for an adaptive and energy-efficient lighting system responsive to the dynamics of human presence within the urban environment.

Figure 6 exemplifies a circuit configuration for this task, incorporating a protoboard adapter to facilitate access to the 16 available ports on the micro:bit, we need more than the three usual ports. In this schematic representation, the GND PIN is linked to the negative terminal of the protoboard using a black wire. The motion sensor (PIR) features three connections: the GND is connected to the

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negative terminal of the protoboard (black wire), the POWER is linked to the micro:bit's 3V PIN using a red wire, and the SIGNAL is designated for connection to PIN 0 using a green wire.

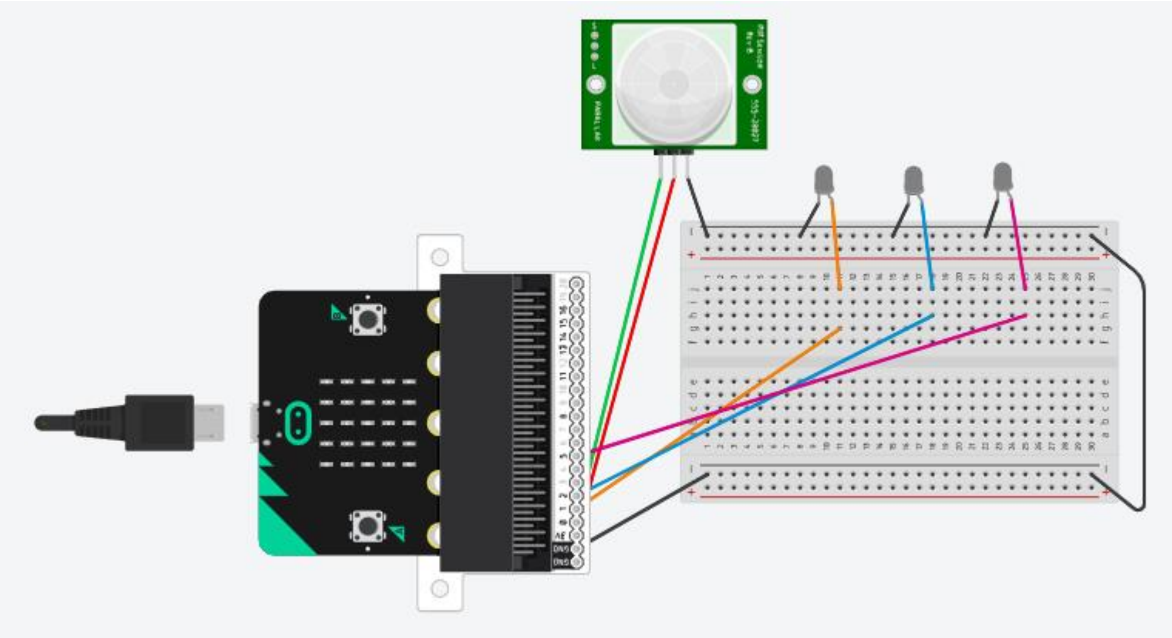

Figure 6 - An example of a circuit with three LEDs and a sensor PIR connected in a micro:bit.

The LEDs are to be connected to PINs 1 (orange wire), 2 (blue wire), and 5 (purple wire) with their longer legs. The shorter legs of the LEDs are connected to the negative terminal of the protoboard using a black wire. This configuration establishes the necessary electrical connections for the proper functioning of the LEDs and the motion sensor within the micro:bit circuit.

The operational concept involves activating the LEDs to 100% power when movement is detected (PIN 0 activated), and conversely, adjusting the power output of these PINs to 33% in the absence of detected motion. This configuration establishes a responsive and energy-efficient system, aligning with the project's objective of simulating a streetlight dimming process based on motion sensor input.

The program depicted in Figure 7 provides a potential implementation for integrating the motion sensor and controlling the three LEDs in the micro:bit. Notably, the displayed values for analog signals in the code correspond to approximately one-third of the maximum value of 1023. This adaptation aligns with the desired functionality of adjusting the LED power output to 33% in response to the absence of detected motion. The program structure reflects the intended dynamic of the streetlight simulation, where the LEDs respond to the input from the motion sensor, promoting energy-efficient operation.

If you want to see a simulation of this, go to https://bit.ly/48SGjAY.

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Figure 7 - Example of a block code to control 3 LEDs.

Certainly, the utilization of analogue signals in this context is imperative, as they afford the capacity to finely adjust the power values for the LEDs. Unlike digital signals, which can only assume values of 0 or 1, analogue signals permit a spectrum of values. In the context of this task, the objective is not to simply turn the LEDs on or off; rather, the intention is to modulate the LED power, specifically reducing it to save energy. This nuanced control facilitated by analogue signals enables a more granular and energy-efficient management of the LEDs' illumination levels in response to the motion sensor input.

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Extra

With all the necessary materials in place, the inclusion of a physical street model for this project, as shown in Figure 8, adds a tangible and immersive dimension to the simulation. In this illustrative example, the model street is equipped with a movement sensor (PIR) and three LED lights labelled as 1, 2, and 3. When the PIR sensor detects a person in proximity to the first building, the microcontroller issues a signal to activate all LEDs at 100% power. Subsequently, after a predetermined interval, the microcontroller transmits a new command, causing all LEDs to switch to 33% of their full power. This hands-on application not only enhances the project's experiential aspect but also reinforces the practical implications of the implemented code and circuitry in a real-world scenario.

Figure 8 - A model of a street equipped with a movement sensor and LED lamps.

Certainly, the choice of materials and the construction of the street model can be adapted based on the available resources and preferences. A cardboard model, for instance, offers a simple yet effective approach. By creating a single street with three LEDs and a building, fixed PIR sensor placement can be achieved. Alternatively, other materials such as 3D printed models or wood can be utilized for a more customized and durable representation. The flexibility in material selection allows for creativity and adaptation based on the resources and constraints of the project environment.

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