ECE 445

Project Proposal

Teaching Heat to Student

Team#26

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1. Introduction

1.1 Problem:

The understanding of fundamental concepts of heat transfer and thermal energy conversion among elementary and middle school students is often limited due to the abstract nature of these concepts. Traditional teaching methods rely heavily on theoretical explanations, which may not effectively engage students or provide a practical understanding of the subject matter. As a result, there is a need for an innovative educational tool that can bridge this gap and foster a deeper understanding of thermal science among students.

1.2 Solution:

Our proposed solution is the design and manufacture of an Integrated Thermal Experiment Platform. This platform aims to provide students with a hands-on learning experience that demonstrates key concepts of heat transfer and thermal energy conversion in a visually engaging manner. Through practical experimentation, students will gain a deeper understanding of heat conduction, convection, radiation, and thermoelectricity. The platform will include interactive demonstrations and experiments that allow students to explore these concepts firsthand, fostering curiosity and interest in the field of thermal science.

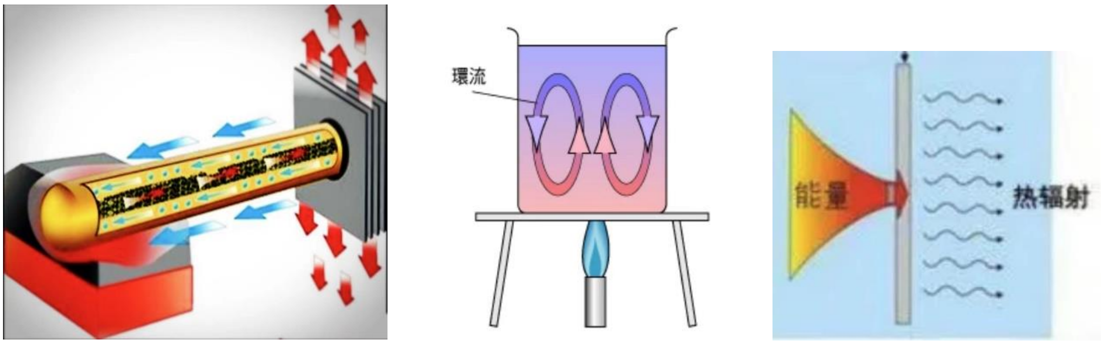

Figure 1. Visual Aid for Solution

1.3 High-level requirements list:

The platform must effectively demonstrate heat conduction, convection, radiation, and thermoelectricity.

The platform must be safe for use by elementary and middle school students.

The platform must be user-friendly and intuitive to operate, ensuring accessibility for all students.

2. Design

2.1 Block Diagram:

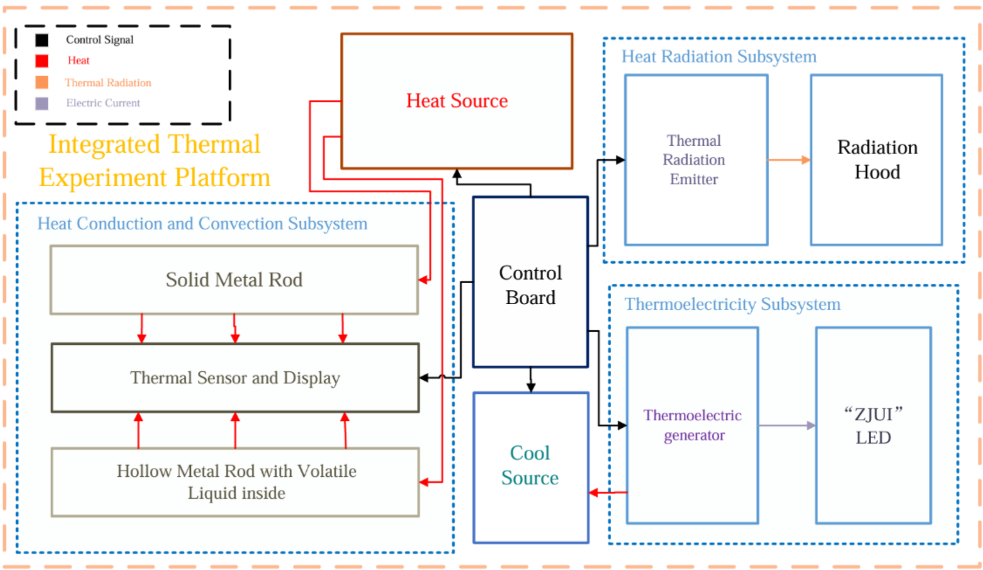

Figure2. Block Diagram

2.2 Subsystem Overview:

<u>Heat Conduction and Convection Subsystem</u>: The main components of this subsystem include two metal rods, a heat source, and a temperature display. One end of each metal rod is connected to the heat source. One rod is solid, indicating that heat transfer primarily occurs through conduction, while the other rod is hollow and contains a volatile liquid, indicating that heat transfer primarily occurs through convection. The temperature display will show the temperature curves of both metal rods.

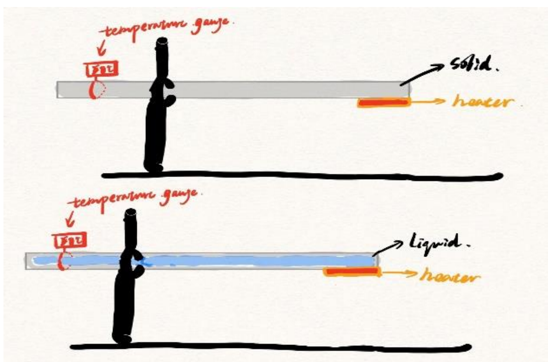

Figure 3. Overview of Heat Conduction and Convection Subsystem

Thermoelectricity Subsystem: This subsystem will showcase the conversion of thermal energy into electrical energy through thermoelectric materials. It will include a thermoelectric generator connected to an LED light, demonstrating the generation of voltage. When students touch the thermoelectric material with their hands, the LED light, shaped like "ZJUI," will illuminate.

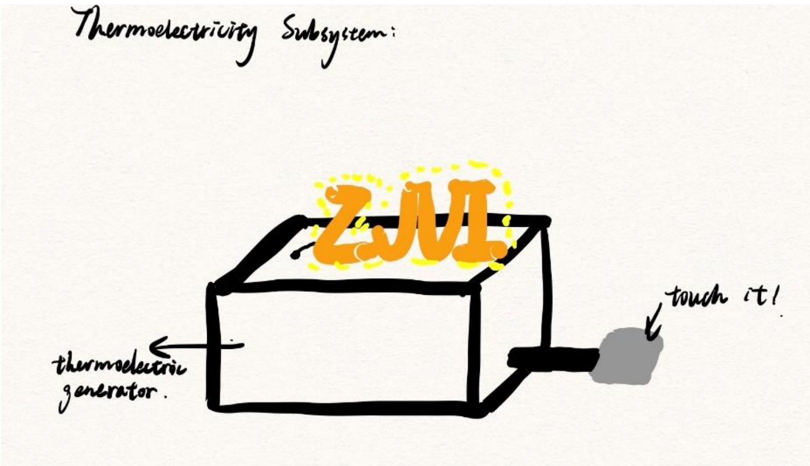

Figure 4. Overview of Thermoelectricity Subsystem

Heat Radiation Subsystem: This subsystem will illustrate the concept of heat radiation and its dependence on wavelength. It will feature a heat source emitting radiation at a fixed wavelength and a hood with a special coating that reflects specific wavelengths while allowing others to pass through.

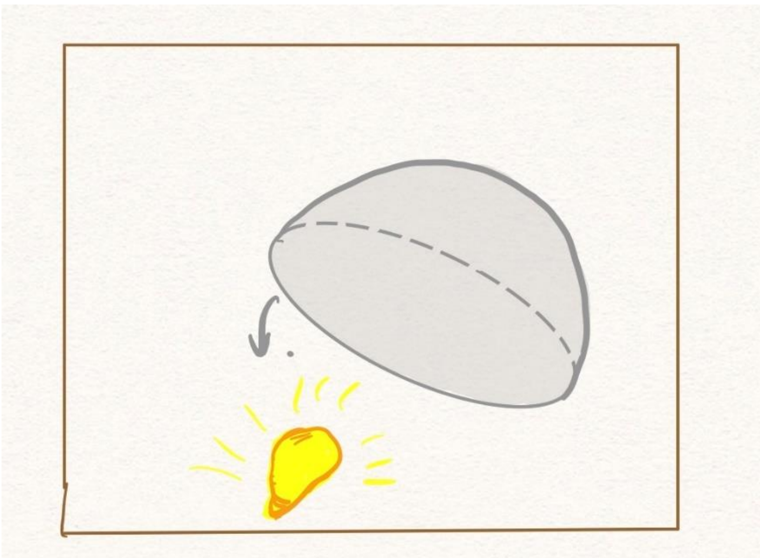

Figure 5. Overview of Heat Radiation Subsystem

2.3 Subsystem Requirements:

Heat Conduction and Convection Subsystem: Must accurately measure and display temperature differentials between solid and fluid mediums. Must provide a clear visua l representation of heat transfer mechanisms.

Thermoelectricity Subsystem: Must generate sufficient voltage to illuminate the LE D light. Must operate within a safe temperature range.

Heat Radiation Subsystem: Must accurately reflect specific wavelengths of radiatio n while allowing others to pass through. Must provide a cooling effect when the hood is placed over the heat source.

2.4 Tolerance Analysis:

For tolerance on dimensions, the foremost requirement is that our project should follow the specification of tolerance to ensure every key component has desired dimension and parameter. Following these regulated rules could allow our project to assemble successfully. For our project, the first subsystem involved the assembly of metal tubes or heat pipe and the heating of a water, therefore it should be under strict specification of tolerance to avoid leaking of water and wrong result of experiment. Besides, since it involves the measurement of temperature, the inaccuracy of temperature sensors should be in a suitable range. In this part, we can use mathematical models, simulation tools, and 3D modeling methods to predict the variations of tolerance that have on our project. Worst case analysis, Monte Carlo simulation and finite element analysis could also be used to test the structural performance of our project.

As for the second subsystem and the third one, the requirement of dimension is not so strict, due to the fact that one contains the thermoelectric materials for power generation and the other involves the materials allowing infrared radiation from the human body to pass through. They both have high requirements on the properties of materials instead of dimensions. For the second subsystem, we need to test the sensitivity of power generation due to the temperature difference, cause temperature difference between human body and environment is not so obvious and can sometimes be unpredictable. If human temperature could not trigger the circuit, we can solve this by adding ice bag to increase the difference. As for the third subsystem, the major problem is to find such a material that satisfy our demand and test whether it can cool down the temperature. So, we need to do a large number of experiments to find the desired material and determine its dimensions that suitable for display.

3. Ethics and Safety

The ethic and safety issuses in this project are electric shock caused by short circuit and burn and explosion caused by the heat. When developing our project, incorrect construction of the circuit can result in a short circuit. Prolonged use of this item can cause overheating which can lead to burns and explosions. We prefaced each experiment with a detailed operational demonstration and an automatic power failure occurs when the device overheats. We will use high-temperature resistant materials and use insulation outside the circuit. Water droplets entering the line may cause a short circuit and even cause a fire. We should put a waterproof layer outside the circuit.