Design of AI-Enabled STEM Education Kit for Interactive Learning and Innovation

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**Abstract:**This project presents an AI-Integrated STEM Kit, a versatile and interactive educational tool designed to teach fundamental concepts in electronics and physics through practical demonstrations. The kit incorporates a combination of sensors, actuators, and a microcontroller to showcase the working principles of Ohm's Law, logic gates, SONAR, electromagnetism, and temperature-dependent behaviors. Key components include two touch sensors, an ultrasonic sensor, an NTC thermistor, an IR sensor, and a relay module, alongside supporting elements like the LM317 voltage regulator and LEDs for visual feedback. The touch sensors illustrate logic gate operations (OR gate), the ultrasonic sensor demonstrates SONAR-like distance measurement, and the relay showcases electromagnetism by switching a load. Additionally, the thermistor detects temperature variations, triggering an LED response, while the IR sensor detects motion, activating alarms or indicators. A dummy port allows for the integration of additional three-pin sensors for extended experimentation. The kit aims to foster hands-on learning, encouraging students and hobbyists to explore STEM (Science, Technology, Engineering, and Mathematics) concepts in a tangible, application-driven manner. By combining real-world examples with programmable control, the kit bridges theoretical knowledge with practical implementation, making complex ideas accessible and engaging. This project provides an invaluable resource for educators and learners alike, promoting innovation and a deeper understanding of foundational scientific principles.

**Keywords-** STEM Kit, Artificial Intelligence, Interactive Learning, Sensor Technology, Microcontroller Applications, Logic Gate Simulation, Electromagnetic Control

# Introduction

In the rapidly evolving technological landscape, fostering a strong foundation in STEM (Science, Technology, Engineering, and Mathematics) education is paramount. Hands-on learning tools that effectively integrate theory with practical application play a crucial role in engaging learners and promoting a deeper understanding of complex scientific principles. This project presents an AI-Integrated STEM Kit, an educational platform designed to teach fundamental electrical, electronic, and physical concepts through interactive demonstrations and real-world applications [1-6]. The kit is structured around a microcontroller-based system that combines multiple sensors and actuators, enabling users to explore a variety of scientific phenomena. By incorporating components such as touch sensors, ultrasonic sensors, thermistors, IR sensors, relays, and voltage regulators, the kit covers essential topics like Ohm's Law, logic gates, SONAR, electromagnetism, and temperature-dependent behavior. With LEDs providing visual feedback and programmable logic driving the functionality, users gain insights into both the hardware and software aspects of modern technology [7-18]. A unique feature of the kit is its modular design, which includes a dummy port for integrating additional sensors. This flexibility allows learners to expand the system, encouraging creativity and innovation. The kit’s versatility also makes it suitable for diverse educational levels, from high school physics classes to introductory engineering courses. The primary objective of this project is to enhance engagement in STEM education by making abstract concepts tangible and relatable. By combining hands-on experimentation with programmable control, the AI-Integrated STEM Kit bridges the gap between theoretical learning and practical application, fostering problem-solving skills and critical thinking in a dynamic learning environment [19-26].

# Literature Review

STEM (Science, Technology, Engineering, and Mathematics) education has become an integral approach to preparing students for future challenges in technology driven industries. Recent studies emphasize the importance of hands-on learning tools in enhancing conceptual understanding and fostering creativity among students. According to a study by Honey et al. (2014), project-based STEM kits are particularly effective in helping students visualize and apply abstract principles in electronics, physics, and engineering. These tools bridge the gap between theoretical concepts and real-world applications by encouraging critical thinking and problem-solving [27-30]. Electronics play a pivotal role in STEM education by introducing learners to basic electrical and electronic concepts. Ohm’s Law, for instance, is fundamental for understanding current, voltage, and resistance relationships in circuits. STEM kits often utilize simple components like resistors, LEDs, and potentiometers to illustrate such concepts   
[31-38]. Few researchers highlights the importance of interactive components, such as sensors and microcontrollers, in making learning more engaging and practical. The integration of these components not only teaches circuit assembly but also demonstrates the principles of automation and control systems, as seen in real-world applications like robotics and IoT [39-41]. The use of sensors in STEM kits has grown significantly in recent years. IR sensors, ultrasonic sensors, and thermistors enable students to explore diverse fields, from motion detection to temperature monitoring. Lim et al. (2019) emphasized that incorporating sensors into educational tools helps students grasp the fundamental principles of physics and engineering, such as how sound waves are used for distance measurement in ultrasonic sensors or how temperature affects resistance in thermistors. The versatility of sensors also allows for real-world simulations, such as detecting human presence or measuring environmental parameters [42-45].

Relays are essential for demonstrating the principles of electromagnetism and switching mechanisms. A relay uses a small current to control a larger one, an essential concept in electrical engineering. Studies by Sharma et al. (2018) discuss how electromechanical relays help students understand the relationship between electricity and magnetism while introducing practical automation concepts. In STEM kits, relays are often paired with microcontrollers to enable tasks like switching lights, motors, or alarms based on sensor inputs [46]. The integration of AI into STEM kits introduces learners to cutting-edge technology, promoting a deeper understanding of data processing and decision-making. AI enables the analysis of sensor inputs to trigger specific actions, providing students with insights into how modern smart systems operate. Research by Nguyen & Lee (2020) highlights that AI-powered educational tools are highly effective in fostering computational thinking, as they allow students to create automated systems and analyze sensor-based datasets. For example, combining temperature sensors and AI algorithms can help simulate real-world applications like smart thermostats or climate control systems [47]. Microcontrollers, especially Arduino, are commonly used in STEM kits due to their simplicity, flexibility, and ease of programming. According to Smith & Johnson (2016), Arduino-based projects are ideal for introducing students to coding and hardware integration. These microcontrollers allow for seamless interaction between components, such as sensors, LEDs, and relays, making them an excellent choice for beginners. By programming Arduino, students learn fundamental coding concepts such as conditional statements, loops, and analog/digital signal processing [48]. Interactive STEM kits are proven to improve retention rates and student engagement. A study by National Academy of Sciences (2021) found that hands-on projects involving electronic components, sensors, and AI technologies increase curiosity and motivation among learners. These tools encourage experimentation and innovation, giving students the freedom to design and test their ideas in a controlled environment [49-50].

## Problem Definition

The focus of this project is on addressing the challenges faced in teaching foundational STEM concepts, particularly in making theoretical knowledge more tangible and accessible. STEM education often suffers from a lack of engagement and practical exposure, which hinders students' ability to connect classroom learning with real-world applications. Students often struggle to visualize and apply theoretical concepts like Ohm’s Law, logic gates, or electromagnetism due to insufficient hands-on experience. Abstract concepts in electronics and physics require simplified and interactive methods for effective understanding. Many existing STEM kits lack the modularity and adaptability needed to cater to diverse educational levels and learning objectives. Traditional teaching aids or commercial STEM kits can be expensive, limiting accessibility in resource-constrained environments. The AI-Integrated STEM Kit addresses these challenges by combining hardware and software to create an interactive and user-friendly platform for learning STEM concepts.

# Methodology

The methodology for this project focuses on the systematic development of an AI-Integrated STEM Kit designed to demonstrate core scientific principles and practical applications through an interactive and educational platform. The project follows five key stages: Conceptualization, Design, Implementation, Testing, and Evaluation. The initial stage involved identifying the objectives and scope of the STEM kit. The aim was to develop an educational tool that combines artificial intelligence (AI), electronics, and sensors to enhance STEM education with hands-on learning experiences. The key objectives of this initiative are to introduce AI and automation by teaching students how sensors and AI algorithms can work together in practical scenarios, demonstrate core scientific principles such as Ohm’s Law, electromagnetism, and sensor functionality, and encourage hands-on learning through the provision of kits that allow students to build and experiment with real-world applications of STEM concepts. To achieve these objectives, requirements gathering will focus on selecting suitable hardware components—including sensors, microcontrollers such as Arduino, and actuators—to ensure a comprehensive learning experience, along with the incorporation of AI-driven decision-making to automate tasks like object detection and environmental monitoring.

The design phase of the STEM kit development covered both hardware and software aspects, ensuring a user-friendly and efficient learning tool. On the hardware side, the design emphasized compactness, modularity, and functionality. Key components included a regulated power supply module with portable battery integration for mobility, various sensors such as thermistors to measure temperature changes, ultrasonic sensors for object proximity detection, and IR sensors to identify motion. The control unit was built around an Arduino microcontroller for programming and integration, while output components like LEDs provided visual feedback and relays enabled control of high-power devices such as motors. On the software side, programming was carried out in the Arduino IDE with a focus on clarity, modularity, and interactivity. Core features included continuous sensor data processing, AI-driven decision-making logic for automating outputs like LEDs or motors, and debugging support via Serial Monitor integration for real-time troubleshooting.

During the implementation phase, the hardware was assembled by soldering sensors, resistors, capacitors, and relays onto a PCB, and the complete circuit was enclosed in a durable yet portable housing with external connection ports. The Arduino was programmed with the finalized code, sensor thresholds were calibrated for real-world conditions, and debugging tools were added to support user experiments.

Testing was conducted extensively to ensure that the kit met functional, safety, and educational objectives. Functional testing verified accurate sensor performance, correct relay switching for high-power devices, and real-time responses from LEDs and relays under different conditions. System integration testing confirmed smooth communication between sensors, the Arduino microcontroller, and output devices, as well as the stability and responsiveness of the power system. In the evaluation phase, the kit’s effectiveness was assessed in educational environments. Students successfully used it to understand basic electronics concepts such as Ohm’s Law, relay mechanisms, and circuit design, as well as practical automation through AI-driven sensor-based decision-making. Feedback led to improvements including a more robust enclosure design for durability and accessibility, along with enhanced documentation that featured detailed user manuals and sample projects to encourage experimentation and independent learning.

# Working principles

## Ohm’s Law

Ohm’s Law is a fundamental principle in electronics that relates voltage (V), current (I), and resistance (R) through the formula:

V=I⋅R (1)

The STEM kit integrates an LM317 adjustable voltage regulator to provide students with a hands-on demonstration of how resistance influences voltage and current in a circuit. By adjusting the resistance with a potentiometer, users can observe corresponding changes in voltage and current using a multimeter. The LM317 ensures a regulated voltage output, allowing learners to clearly see how variations in resistance directly affect circuit behavior. This setup not only makes the concept of Ohm’s Law tangible but also reinforces its practical application in real-world electronic systems.

## Relay Mechanism

The relay mechanism in the STEM kit serves as a practical demonstration of electromagnetism and its role in automation. A relay functions as an electromechanical switch that uses a low-current signal to control high-current circuits. Its working principle is based on the fact that when current flows through the relay’s coil, a magnetic field is generated, which attracts the armature and closes the circuit, thereby allowing current to flow through the load. In the kit, the relay is triggered by low-current signals from the microcontroller (such as an Arduino), enabling students to activate it using touch sensors. This setup allows users to observe how electromagnetism is applied in real-world contexts like motor control and home automation. Additionally, LEDs are integrated as visual indicators, helping students easily understand and monitor the relay’s operation.

## Thermistor Functionality

The thermistor in the STEM kit is used to illustrate temperature monitoring and control, helping students understand how sensors translate physical changes into electrical signals for automation. A thermistor is a temperature-sensitive resistor whose resistance varies with temperature, and in the case of an NTC (Negative Temperature Coefficient) thermistor, resistance decreases as temperature increases. This change in resistance modifies the circuit voltage, which can be measured and interpreted. In the kit, the thermistor is connected to an analog input of the microcontroller, which processes the voltage data to calculate temperature values. When the temperature exceeds a predefined threshold, an LED blinks, demonstrating how thermistors can be applied in real-world temperature-based automation systems such as cooling devices, alarms, or climate control mechanisms.

## Ultrasonic Sensor for Distance Measurement

The ultrasonic sensor in the AI-integrated STEM kit plays a vital role in teaching students how distance measurement and object detection are applied in modern technologies. It operates on the principle of echolocation, where the sensor emits high-frequency sound waves and measures the time taken for the echo to return after striking an object. This time delay is then converted into distance using the formula Distance = (Speed of Sound × Time)/2. In the kit, the ultrasonic sensor is used to detect objects within a predefined range and trigger automated responses, such as lighting LEDs or activating relays. This allows learners to explore real-world applications like parking sensors, obstacle detection in robotics, and automated safety systems. Key features include non-contact measurement for accurate detection without physical interaction, a broad range that spans from a few centimeters to several meters depending on the model, and real-time operation that enables continuous monitoring for dynamic environments, making it both educational and practical.

## Touch Sensor for Capacitive Sensing

The touch sensor in the STEM kit is designed to introduce students to the principle of capacitive sensing and its role in modern user interfaces. It works by detecting changes in capacitance when a conductive object, such as a human finger, comes into contact with or approaches its surface. This variation in capacitance generates a signal that is interpreted by the microcontroller to perform specific actions. Within the kit, the touch sensor is used to trigger relays for controlling devices like motors or LEDs, providing a clear demonstration of how touch sensing is applied in everyday technologies such as smartphones, touch panels, and interactive systems. Its features include high sensitivity to detect even subtle touches or proximity, strong user interactivity that makes the learning process engaging, and robust durability to withstand repeated use in educational settings.

## LED Indicators

LED indicators are an essential part of the STEM kit, serving as real-time visual feedback tools that help users monitor system operations. They work on the principle that when an electric current passes through the semiconductor material of the LED in a forward-biased direction, it emits light. This makes LEDs effective visual indicators for signaling specific system states or events. In the kit, LEDs are used to provide feedback signals by showing when relays are activated or when sensors respond, making them useful both as educational tools to demonstrate basic electrical principles and as debugging aids to help users quickly determine whether the system is functioning properly. Key features include low power consumption for energy-efficient operation, bright light output that ensures visibility even in well-lit environments, and the use of multiple colors such as red, green, and blue to represent different system states, thereby enhancing clarity and interactivity in the learning process.

# Design Calculations

The design calculations for the AI-integrated STEM kit involve determining the electrical, thermal, and functional parameters of the components to ensure efficient and safe operation.

Below are the key calculations performed:

Ohm’s Law for Resistor Selection

Ohm's Law is applied to select the appropriate resistors for the circuit.

V=I⋅R

Where:

V= Voltage (Volts)

I = Current (Amperes)

R = Resistance (Ohms)

Power Supply Design

To ensure stable operation, the voltage regulator LM317 is used to supply a constant output voltage.

The LM317 output voltage is determined using:

V out = 1.25.(1+R1/R2) + Iadj.R2

Where:

Vout = Output Voltage

R1and R2= Resistors in the feedback loop

Iadj = Adjustment pin current (typically negligible)

Example Calculation:

For R1=220 Ω and R2=330 Ω

The circuit will supply 3.1V to low-voltage components.

Relay Activation Current

The relay requires a specific current for activation. Using the transistor driver circuit:

Ibase=Icoil/β

Where:

Icoil = Relay coil current (typically 50 mA)

β = Current gain of the transistor (e.g., 200 for BC547)

These design calculations ensure that the AI-integrated STEM kit operates effectively, teaching key scientific principles while maintaining functionality and safety.

# Fabrication

The fabrication of the AI-integrated STEM kit involves the careful selection of materials and the meticulous manufacturing process to ensure the final product is both functional and durable. The fabrication process is divided into two primary phases: material selection and manufacturing.

## Material selection

Material selection plays a vital role in ensuring the kit's functionality, durability, and ease of use. The chosen materials for the electronic components, the printed circuit board (PCB), and the final enclosure all contribute to the overall performance and usability of the STEM kit.

## Electronic Components

The core electronic components selected for this project were carefully chosen to balance educational value, reliability, and cost-effectiveness, ensuring that students can learn key STEM concepts through practical application. At the heart of the kit is the Arduino microcontroller, selected for its flexibility, ease of programming, and widespread adoption in educational environments. To provide a stable power supply, the LM317 voltage regulator is included, ensuring all components receive the correct voltage for consistent operation. The TTP223 touch sensors introduce capacitive sensing and allow users to trigger actions such as LED control or relay activation, making the kit interactive. For distance measurement and object detection, the ultrasonic sensor was selected to demonstrate the principles of sonar, while the IR sensor adds motion detection, highlighting real-world applications of light-based sensing. A 5V relay, paired with a BC547 transistor, illustrates the principle of electromagnetism and enables the control of higher-powered loads. To demonstrate temperature-based automation, the NTC thermistor is used, enabling LED blinking when a predefined threshold is crossed. Finally, LED indicators provide real-time visual feedback, helping learners observe system behavior and troubleshoot effectively. Collectively, these components are widely available, affordable, and fully compatible with Arduino-based systems, making them an ideal foundation for an educational STEM kit designed to bridge theoretical knowledge with hands-on experimentation.

## Printed Circuit Board (PCB)

The Printed Circuit Board (PCB) forms the backbone of the STEM kit, serving as a compact and reliable platform for integrating all electronic components. Standard FR4 (Fiber Reinforced Epoxy) material was selected for its excellent electrical insulation properties, durability, and cost-effectiveness, making it well-suited for educational applications. The design was carried out using professional tools such as KiCAD, which enabled optimal track routing, efficient component placement, and minimization of signal interference to ensure stable performance. The PCB was carefully sized to be compact yet spacious enough to accommodate all components securely, allowing for easy connections and reducing the likelihood of soldering errors during assembly. To guarantee accuracy and durability, the board was fabricated through a professional PCB manufacturing service, resulting in a high-quality and reliable final product. Figure-1 illustrates the layout of the PCB used in this project.

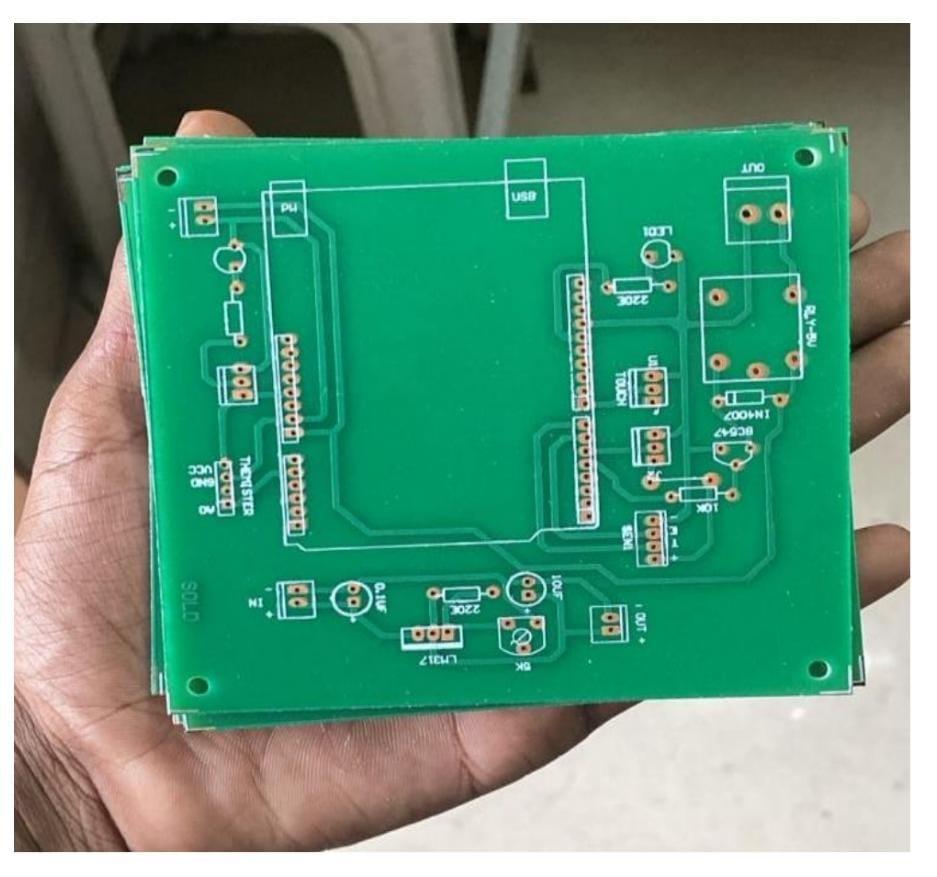


Figure-1 PCB Board

## Final Enclosure

The final enclosure plays a crucial role in safeguarding the circuit and electronic components while ensuring user-friendly access for educational demonstrations. Constructed from ABS plastic or polycarbonate, the enclosure offers durability, electrical insulation, and ease of molding, making it well-suited for repeated classroom use. The design is compact, lightweight, and ergonomically shaped to provide ease of handling, with precise cutouts for sensors, LEDs, and buttons that allow seamless interaction with the kit. To enhance portability, the enclosure includes lightweight features or handles, enabling students and instructors to carry it effortlessly. Additionally, ventilation slots were integrated into the design to maintain airflow around critical components such as the relay and microcontroller, preventing overheating during extended operation. This thoughtful combination of durability, usability, and portability ensures that the enclosure not only protects the kit but also enhances the overall learning experience.

## Manufacturing

The manufacturing phase marks the transition from design to a fully functional STEM kit, encompassing circuit design, microcontroller programming, component integration, and final assembly into the protective enclosure. The circuit design was meticulously developed to incorporate all selected components, ensuring reliable connections and seamless operation. As illustrated in Figure-2, the design focused on several critical aspects:

*Power Distribution:* The circuit was structured to provide stable and regulated power to each component, guaranteeing consistent operation of the Arduino microcontroller and all sensors.

*Signal Routing:* Clear and efficient signal paths were established so that inputs from sensors such as the touch sensor, ultrasonic sensor, IR sensor, and thermistor are accurately transmitted to the microcontroller for processing and control.

*Relay Control:* A dedicated relay control circuit was included to respond to sensor inputs and manage the switching of high-power devices such as LEDs and motors, reinforcing concepts of electromagnetism and automation.

*Testing Points:* Key test points were strategically placed throughout the circuit, allowing for straightforward debugging and verification during assembly, thereby reducing errors and ensuring reliability.

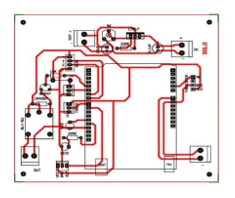


Figure-2 Circuit Design

# Component assembly

The component assembly phase focused on the precise integration of all electronic parts onto the PCB, ensuring both functionality and durability of the STEM kit. The process began with soldering, where resistors, capacitors, sensors, and connectors were securely mounted on the PCB. Extra care was taken to avoid short circuits and guarantee strong, reliable joints that would withstand repeated educational use. Next, component placement was carried out according to the circuit design specifications, ensuring that power and signal paths were efficient while maintaining sufficient spacing between components to minimize electrical interference. Finally, wire connections were established using jumper wires to link input and output devices—including LEDs, sensors, and the relay module—to the microcontroller and supporting circuits. This structured approach to assembly ensured a clean layout, reliable performance, and ease of troubleshooting for users.

## Code and Final Assembly

The code and final assembly stage marked the completion of the STEM kit, bringing together the hardware and software into a fully functional system. Once the components were securely mounted and wired, the Arduino microcontroller was programmed using the Arduino IDE. As illustrated in Figure-3, the programming focused on three main areas. First, sensor input handling was implemented so the system could continuously monitor values from the thermistor, ultrasonic sensor, IR sensor, and touch sensor, and then process these inputs to trigger appropriate actions. Second, output control logic was developed to ensure real-time responses such as turning on LEDs, activating the relay, or controlling motors whenever environmental changes like object proximity, motion, or temperature variations were detected. Finally, full system integration was carried out, where the code was refined and tested to confirm that all components worked cohesively. This ensured smooth interaction between hardware and software, resulting in a reliable, interactive, and educational STEM kit ready for classroom use. Once the code was programmed into the microcontroller, the entire system was assembled within the final enclosure, with all sensors, LEDs, and components securely mounted and accessible for user interaction.



Figure-3 Code

## Uniqueness and Innovation

The AI-integrated STEM kit distinguishes itself by blending foundational electronics with modern sensor technologies and AI-driven functionality, offering students a hands-on pathway into advanced STEM concepts. Its uniqueness lies first in sensor fusion, where multiple sensors—including thermistor, ultrasonic, touch, and IR—are integrated to simulate real-world applications in areas such as robotics, automation, and environmental monitoring, features rarely included in traditional STEM kits. Another innovative aspect is AI-enabled automation, which empowers the system to deliver automated responses based on sensor inputs, giving students exposure to machine learning concepts and real-time decision-making in an accessible format. The kit also promotes interactive learning, enabling learners to configure sensors in various ways and directly observe how data inputs lead to practical outputs, such as LED activations or relay control. Additionally, its modular design allows for easy scalability, supporting future enhancements like wireless communication, extra sensors, or more sophisticated AI algorithms, ensuring continued relevance and adaptability. Together, these innovations make the STEM kit not only a powerful educational tool but also a forward-looking platform that bridges the gap between classroom learning and real-world technological applications. The final model of the AI-integrated STEM kit is presented in Figure-4.

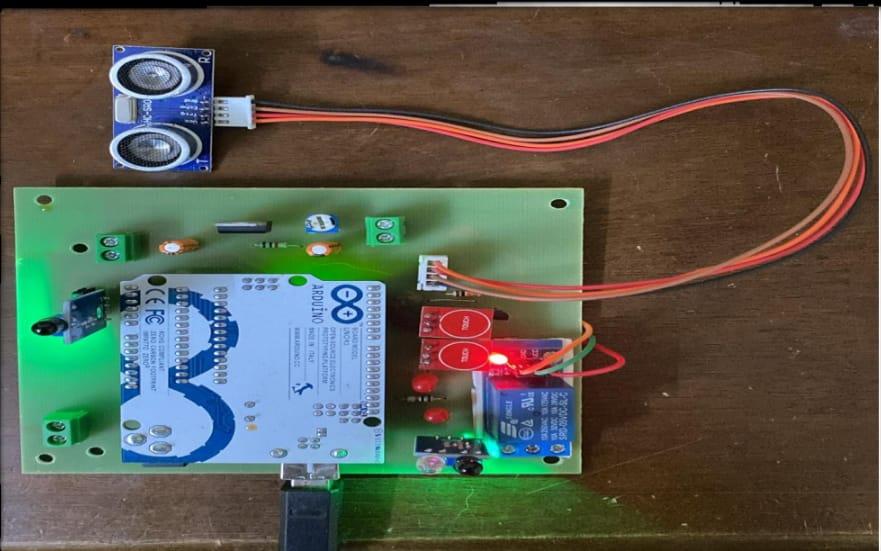


Figure 4: Final Product

# Conclusion

The AI-integrated STEM kit project successfully combines electronics, sensor technology, and artificial intelligence to create an educational tool that enhances the learning experience in STEM subjects. By applying core principles such as Ohm's Law, electromagnetism, and real-world sensor technologies like thermistors, ultrasonic sensors, and capacitive touch sensors, the kit provides hands-on learning opportunities for students. Throughout the design process, the project followed a systematic approach from conceptualization to implementation, ensuring that each component was carefully selected and integrated. The key features of the kit—such as the use of AI for automation, interactive sensors for real-time feedback, and the incorporation of a variety of sensors for different scientific experiments—offer a dynamic and engaging way to understand fundamental STEM concepts. In conclusion, the AI-integrated STEM kit is an innovative and effective educational tool that provides students with a comprehensive understanding of essential STEM concepts. Its modular design and scalability offer the potential for future expansions, such as the addition of wireless communication, data logging, or more complex AI functions. This project demonstrates the power of combining practical learning with technology, making STEM education more interactive and accessible for students of all levels.

# REFERENCES

1. Singh et al., (2024). Enhancing Mobile Robot Speed Control: PID Controller Optimization with Bio-Inspired Algorithms. In 2024 International Conference on Expert Clouds and Applications (ICOECA) (pp. 365-370). IEEE. https://doi.org/10.1109/ICOECA62351.2024.00071
2. Chakrapani et al., (2024). Optimizing sample length for fault diagnosis of clutch systems using deep learning and vibration analysis. Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, 09544089241272791. https://doi.org/10.1177/095440892412727
3. Deepthi et al., (2024). Deep Learning-Enabled Human Resource Analytics in Predicting Employee Performance. In 2024 Ninth International Conference on Science Technology Engineering and Mathematics (ICONSTEM) (pp. 1-5). EEE. https://doi.org/10.1109/ICONSTEM60960.2024.10568716
4. Selvan et al., (2024). Investigation of the Use of Renewable Energy in Microgrid Applications. In 2024 Ninth International Conference on Science Technology Engineering and Mathematics (ICONSTEM) (pp. 1-5). IEEE . https://doi.org/10.1109/ICONSTEM60960.2024.10568631
5. Vinodh, D et al., (2024). Experimental investigation on tensile strength of novel metal matrix composite of aluminium alloy 5083 with SiC and eggshell powder reinforcement. In International Conference on Medical Imaging, Electronic Imaging, Information Technologies, and Sensors (MIEITS 2024) (Vol. 13188, pp. 297-306). SPIE.  https://doi.org/10.1117/12.3030843
6. Kalam, S. A., Sheela, S., Paramasivam, P., & Shanmugam, K. (2024). Bio-synthesis of nano-zero-valent iron using barberry leaf extract: classification and utilization in the processing of methylene blue-polluted water. Discover Applied Sciences, 6(12), 1-15. https://doi.org/10.1007/s42452-024-06327-w
7. Padhy et al., (2024). Enhancing IoT-Enabled Healthcare with Genetic-based Encryption and Authentication for Secure and Efficient wireless Data Transmission. In 2024 International Conference on Inventive Computation Technologies (ICICT) (pp. 1873-1878). IEEE. https://doi.org/10.1109/ICICT60155.2024.10544722
8. Rafi et al., (2024). Improving Prostate Cancer Diagnosis with Weakly Supervised Learning and Radiology-Confirmed Negative MRI Data. In 2024 International Conference on Inventive Computation Technologies (ICICT) (pp. 1183-1188). IEEE. https://doi.org/10.1109/ICICT60155.2024.10544551
9. Lakshmaiya, N. (2024). Detection and impact of stochastic anomalies in investigations of urban pollution. In International Conference on Medical Imaging, Electronic Imaging, Information Technologies, and Sensors (MIEITS 2024) (Vol. 13188, pp. 269-277). SPIE. <https://doi.org/10.1117/12.3030839>
10. Venkatesh, R., "Synthesis and Machining Characteristics Evaluation of Silicon Nitride Made Magnesium Alloy Composites," SAE Int. J. Mater. Manf. 18(3), 2025, https://doi.org/10.4271/05-18-03-0017.
11. Melvin Victor De Poures et al., Processing and Characteristics Study of Hydrogen from Sewage and Waste Municipal Water via Gasification Process" SAE Technical Paper 2024-01-5257, 2024, https://doi.org/10.4271/2024-01-5257
12. Melvin Victor De Poures et al. Influences of Zinc Oxide Doping on Functional Characteristics Study of Thin Film Solar Cell for Hybrid Solar Electric Vehicle Utilization" SAE Technical Paper 2024-01-5256, 2024, https://doi.org/10.4271/2024-01-5256
13. Mohan et al., (2024). Image Quality Enhancement using Deep Convolutional Network. In 2024 International Conference on Inventive Computation Technologies (ICICT) (pp. 1272-1277). IEEE. https://doi.org/10.1109/ICICT60155.2024.10544980
14. Lakshmaiya, N. (2024). Perovskite photovoltaic cells with freezone zone carbon-based instruments: state of review. In International Conference on Medical Imaging, Electronic Imaging, Information Technologies, and Sensors (MIEITS 2024) (Vol. 13188, pp. 351-358). SPIE. https://doi.org/10.1117/12.3030837
15. Almatrafi et al., (2024). Reducing metastasis ability of gastric cancer cell line by targeting MMP16 using miR-193a-5p and 5-FU. Advances in Medical Sciences, 69(2), 463-473. https://doi.org/10.1016/j.advms.2024.09.008
16. Melvin Victor De Poures et al. Effect of Gasification Temperature on Biohydrogen Derived from Waste Agro Products for Alternative Fuel Application " SAE Technical Paper 2024-01-5260, 2024, https://doi.org/10.4271/2024-01-5260
17. Meshram et al., (2024). Investigation of Mechanical and Thermal Properties of Bamboo Fiber Reinforced with Epoxidized Soybean Oil for Automotive Seat Bases (No. 2024-01-5009). SAE Technical Paper. https://doi.org/10.4271/2024-01-5009
18. Prasad et al., (2024). Deep Learning based Channel Assignment with Load Balancing in MANET for Improved Performance. In 2024 International Conference on Inventive Computation Technologies (ICICT) (pp. 1172-1177). IEEE. https://doi.org/10.1109/ICICT60155.2024.10544447
19. Ali, H. M., Mothilal, T., & Reddy, V. (2024). Evaluation of Lightweight Cotton Textiles for Durable and Comfortable Automotive Interior Applications (No. 2024-01-5015). SAE Technical Paper. DOI: https://doi.org/10.4271/2024-01-5015
20. Kelagadi et al., (2024). An Analysis on the Integration of Machine Learning and Advanced Imaging Technologies for Predicting the Liver Cancer. In 2024 4th International Conference on Pervasive Computing and Social Networking (ICPCSN) (pp. 1082-1086). IEEE. <https://doi.org/10.1109/ICPCSN62568.2024.00180>
21. Logesh, K., Vinayagam, M., Kumar, A., Chaturvedi, R., Prabagaran, S., Soudagar, M. E. M., Salmen, S. H., and Al Obaid, S. (2025). "Solar collector featured dryer performance enriched by the adaptations of phase change material embedded with fin collector absorber." ASME. J. Thermal Sci. Eng. Appl. doi: https://doi.org/10.1115/1.4067631
22. Agrawal et al., (2024). Deep Learning Methods for Detecting ImageBased Defects in Manufacturing Processes. In 2024 Ninth International Conference on Science Technology Engineering and Mathematics (ICONSTEM) (pp. 1-5). IEEE. https://doi.org/10.1109/ICONSTEM60960.2024.10568644
23. Lakshmaiya, N. (2024). Influence of small non-capillary washing activity on flow boiling essential heat transfer. In International Conference on Medical Imaging, Electronic Imaging, Information Technologies, and Sensors (MIEITS 2024) (Vol. 13188, pp. 224-231). SPIE.  https://doi.org/10.1117/12.3030838
24. P. Sharma et al. Effect of paraffin with salt hydrates PCM and hybrid Al2O3/Tio2 nanofluid on thermal and energy storage characteristics of solar thermal heat exchanger. J Therm Anal Calorim (2025). <https://doi.org/10.1007/s10973-025-14224-6>
25. M. Aruna et al. Integration of Magnesium Fluoride and Nano Alumina–Silicon Carbide Actions on Properties of AZ91 Alloy Hybrid Nanocomposites. Inter Metalcast (2025). <https://doi.org/10.1007/s40962-025-01617-4>
26. A. Sharma et al. Structural Modification and Enhancement of Optoelectronic Behaviour of ZnO Nanofilms Featuring Cu and Ti Particles. J. Electron. Mater. (2025). <https://doi.org/10.1007/s11664-025-11951-2>
27. Socrates, S., Bharathi, G. B., & Aluvala, S. (2024). A Framework for Automated Diagnosis and Management of Autoimmune Disorders with Neural Networks. In 2024 International Conference on Advancements in Smart, Secure and Intelligent Computing (ASSIC) (pp. 1-6). IEEE. https://doi.org/[10.1109/ASSIC60049.2024.10507903](https://doi.org/10.1109/ASSIC60049.2024.10507903)
28. P. P. Singh et al. Hybrid Thin Film Coating Performance and Functional Characteristics of Silicon Nitride (SiNx) Layer for Solar Cell Application. J. Electron. Mater. (2025). <https://doi.org/10.1007/s11664-025-11888-6>
29. N. Nagabhooshanam et al. Influences of Potassium Fluoride and Ultrasonic Vibration on Functional Performance of AZ91 Alloy Hybrid Nanocomposite with Nano-SiC/TiO2. Inter Metalcast (2025). <https://doi.org/10.1007/s40962-025-01552-4>
30. Ahmad et al., (2024). IoT-Enabled Smart E-Healthcare System with Predictive Prescription Algorithm for Automatic Patient Monitoring and Treatment. In 2024 4th International Conference on Pervasive Computing and Social Networking (ICPCSN) (pp. 1076-1081). IEEE. https://doi.org/[10.1109/ICPCSN62568.2024.00179](https://doi.org/10.1109/ICPCSN62568.2024.00179)
31. Saadh M J et al., (2024). Recent progress and the emerging role of lncRNAs in cancer drug resistance; focusing on signaling pathways. Pathology-Research and Practice, 253, 154999. <https://doi.org/10.1016/j.prp.2023.154999>
32. Manzoore Elahi M. Soudagar, Ravindra Pratap Singh, Nagabhooshanam Nagarajan. et al. Featuring of in-situ carbon capturing and functional performance study of hydrogen from aquaculture wastewater algae biomass via supercritical steam gasification route, Chemical Engineering Science 313 (2025) 121704. <https://doi.org/10.1016/j.ces.2025.121704>
33. Jothi Arunachalam et al. Integration of nanographene and action of fiber sequences on functional behaviour of composite laminates" International Polymer Processing, 2025. <https://doi.org/10.1515/ipp-2024-0149>
34. P. P. Singh et al. Hybrid Thin Film Coating Performance and Functional Characteristics of Silicon Nitride (SiNx) Layer for Solar Cell Application. J. Electron. Mater. (2025). <https://doi.org/10.1007/s11664-025-11888-6>
35. N. Nagarajan et al. Hybrid Stir Cast Featured with Wettability Agent and Ultrasonic Action of Magnesium Alloy Composite Composed with Nanofiller: Study Characteristics. Inter Metalcast (2025). <https://doi.org/10.1007/s40962-025-01603-w>
36. V. Mohanavel et al. Tribological characteristics and optimization of ZrB2 configured magnesium alloy composite via squeeze casting technique. J Mech Sci Technol. 39(5), 2025. <https://doi.org/10.1007/s12206-025-0425-9>
37. I. Hossain et al. (2025). Enriching performance of Al-Mg composites by incorporating nano-alumina and SiC via semi-solid stir processing. International Journal of Cast Metals Research, 1–11. <https://doi.org/10.1080/13640461.2025.2476826>
38. Manzoore Elahi M. Soudagar, et al. Enrichment of Solar Heat Exchanger Thermal Performance by the Integration of Beeswax and Hybrid Nanofluid (ZnO/MgO). ASME. J. Thermal Sci. Eng. Appl. (2025) <https://doi.org/10.1115/1.4067929>
39. M. Aruna et al. Vacuum Die Casting Process and Microstructure/Mechanical Characteristics Study of Magnesium Alloy Composite Hybridize with Zirconium Dioxide and Silicon Nitride. Inter Metalcast (2025). <https://doi.org/10.1007/s40962-025-01550-6>
40. V.V. Upadhyay et al. Trapezoidal fin featured heat exchanger performance enriched by using alumina/GNP hybrid nanofluid: thermal characteristics study. J Therm Anal Calorim (2025). <https://doi.org/10.1007/s10973-025-13997-0>
41. P. K. Singh et al. Integration of phase change material for enriching the solar collector featured with dryer configuration enhanced via alumina/titanium dioxide nanoparticle: performance study. J Therm Anal Calorim (2025). <https://doi.org/10.1007/s10973-025-14302-9>
42. P. K. Singh et al. Enhancement of silicon nitride layer performance by Gallium–Copper–Zinc tri-layer thin films structure via plasma featured chemical vapour deposition route. J Mater Sci: Mater Electron 36, 243 (2025). <https://doi.org/10.1007/s10854-025-14326-9>
43. R, Rajarajan et al. (2025). Improving Tribological Performance and Structural Analysis of Aluminium Hybrid Nanocomposites with Nano ZrO2/SiC Reinforcement via Stir Casting Assisted with Ultrasonic Vibration. International Journal of Cast Metals Research, February, 1–14. <https://doi.org/10.1080/13640461.2025.2467611>
44. Soudagar, M. Manzoore Elahi et al. Effect of electron transport layer thickness and characteristics behaviour of hybrid copper indium gallium selenide thin film solar cells, Journal of Power Sources (2025). Volume 639, 2025,236657, <https://doi.org/10.1016/j.jpowsour.2025.236657>
45. Manzoore Elahi M. Soudagar et al. Higher performance solar air dryer functioned with palmitic acid phase change material and hybrid nanofluid: Thermal performance evaluation, Applied Thermal Engineering (2025). Volume 272, 2025,126413, <https://doi.org/10.1016/j.applthermaleng.2025.126413>
46. N. Nagarajan. et al. Thermal performance assessment of dish collector-integrated cooking application using TiO2/SiO2 hybrid nano-enhanced coated receiver. J Braz. Soc. Mech. Sci. Eng. 47, 148 (2025). <https://doi.org/10.1007/s40430-025-05454-8>
47. A. Sharma et al. Hybrid Reinforcement Actions on Microstructural, Physical and Mechanical Properties of Magnesium Alloy Composite by Two-Step Stir Casting Process. Inter Metalcast (2025). <https://doi.org/10.1007/s40962-024-01537-9>
48. Lakshmaiya, N. (2024). High ionic permeability of Piper ION membrane boosts efficiency in CO2 electrolysis cells. In International Conference on Medical Imaging, Electronic Imaging, Information Technologies, and Sensors (MIEITS 2024) (Vol. 13188, pp. 172-180). SPIE. <https://doi.org/10.1117/12.3030841>
49. Kaushal et al., (2024). Evaluation of Deep Learning Approaches for Air Quality Analysis using an Image Dataset. In 2024 Second International Conference on Intelligent Cyber Physical Systems and Internet of Things (ICoICI) (pp. 1378-1383). IEEE. https://doi.org/[10.1109/ICoICI62503.2024.10696429](https://doi.org/10.1109/ICoICI62503.2024.10696429)
50. Anitha, Cuddapah, Naveena Kumar RR, Swapnil Uttamrao Deokar, Harshal Shah, and Praful V. Nandankar. Optimal Scheduling of Microgrid with Electric Vehicle Integration in Smart Grid using Progressive Graph Convolutional Network. In 2025 5th International Conference on Trends in Material Science and Inventive Materials (ICTMIM), pp. 375-380. IEEE, 2025.