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Review Article

The Design of a Stem-Themed Model for a Smart Home Integrated with AI & IoT Technologies for High School Students

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Abstract: The application of AI (Artificial Intelligence) and IoT (Internet of Things) technologies in teaching and learning has become a powerful trend, positively impacting and transforming both teaching methods and students' learning approaches. In the field of education, the use of AI and IoT technologies is still relatively new and is being gradually implemented. Therefore, this paper focuses on the design of STEM themes, specifically regarding AI & IoT technologies. Particularly, designing STEM topics around smart homes controlled by AI & IoT technology will help students understand real-world applications, as well as the operational principles of control circuits. It will also enable them to grasp automation techniques that enhance device monitoring, ultimately guiding career paths and fostering creative thinking skills while developing students' competencies in high school.
Keywords: STEM themes, Artificial Intelligence (AI), AI & IoT technologies.

1. BASIC ISSUES IN STEM EDUCATION

1.1. Some Basic Concepts of STEM

a. The term STEM

STEM is an acronym for Science (S), Technology (T), Engineering (E), and Mathematics (M); it is a shortened term used when discussing the development policies related to Science, Technology, Engineering, and Mathematics in the United States. This term was first introduced by the U.S. National Science Foundation (NSF) in 2001 [3].

b. STEM Education

STEM education is an educational model based on an interdisciplinary approach, helping students apply knowledge in Science, Technology, Engineering, and Mathematics to solve practical problems in specific contexts.

c. STEM Themes

A STEM theme is one that integrates knowledge from the fields of Mathematics, Science, Engineering, and Technology to address real-world issues. In the general education curriculum, these fields are represented in subjects such as Mathematics, Natural Sciences (for middle school), Physics, Chemistry, Biology (for high school), Technology, and Informatics. A STEM theme that fully integrates all four areas—Science, Technology, Engineering, and Mathematics—is called a full STEM theme, while one that lacks one or more of these areas is referred to as an incomplete STEM theme [8, 9].

STEM themes provide the foundation for implementing STEM educational activities in high schools through various forms of organization, such as teaching science subjects through STEM lessons, organizing STEM experiential activities, and conducting research in science and engineering.

1.2. Objectives and Orientation of STEM Education in the General Education Program

a. Objectives of STEM Education

The general education system helps students master general knowledge, effectively apply the knowledge and skills they have learned to real life, engage in lifelong learning, make informed career choices, build and develop harmonious social relationships, and cultivate a well-rounded personality and rich intellectual life. This enables them to lead meaningful lives and make positive contributions to the development of the country and humanity. General education aims to develop the qualities and abilities of learners through educational content that includes basic, practical, and modern knowledge and skills, promoting

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a balanced development of moral, intellectual, physical, and aesthetic qualities. This educational goal is achieved through all subjects and educational activities in the general education curriculum. Like other educational activities in schools, STEM education is one of the activities that contributes to fulfilling the broad and comprehensive educational objectives outlined in the general education program. STEM education is considered one of the most effective activities in forming and developing the qualities and competencies of students [8,9].

STEM education in secondary schools aims to promote education in the fields of science, technology, engineering, and mathematics across all aspects of curriculum, teacher teams, facilities, and policies. It seeks to raise awareness among schools and society about the role and importance of STEM subjects in secondary education, attract students' interest, and improve the quality of their learning. Additionally, it is combined with career orientation activities for high school students.

b. Orientation of STEM Education in the General Education Program

In the general education program, STEM education not only promotes education in the fields of science, technology, engineering, and mathematics but also reflects an interdisciplinary approach aimed at developing the learners' competencies and qualities [1]. Specifically:

Promoting Education in STEM Fields:
- The general education program includes all subjects related to the STEM fields: Mathematics, Natural Sciences, Technology, and Informatics. Informatics is considered part of the technology field (in the ICT content stream).
- The Mathematics curriculum focuses on applying mathematics to real-life situations and allocates significant time for experiential activities within the subject. This perspective forms the basis for organizing STEM educational activities within the Mathematics curriculum.
- The position and role of the Technology and Informatics subjects in the general education program have been significantly enhanced. This not only reflects the STEM educational philosophy but also represents a timely adjustment in general education in response to the 4.0 Industrial Revolution.

Interdisciplinary Approach in Teaching STEM Fields:
- There are several STEM topics integrated into the curriculum of basic education subjects, such as Social and Natural Sciences, Science, Informatics, and Technology (at the primary

school level), and Natural Science (at the middle school level).
- There are specialized STEM learning modules and STEM career topics for grades 10, 11, and 12, focusing on science, technology, engineering, and mathematics. These include experiential activities in the form of scientific research clubs, including STEM research activities.
- The open nature of the current general education program allows for some STEM educational content to be developed through local educational content, school educational plans, and through STEM programs and activities organized via educational socialization.
- The orientation towards renewing educational methods in the current general education program is also compatible with STEM education at the integrated, interdisciplinary teaching level, applying interdisciplinary knowledge to solve real-world problems.

2. UNDERSTANDING AI & IoT TECHNOLOGIES
2.1. Artificial Intelligence (AI) Technology

Artificial Intelligence (AI) is a field of computer science focused on creating systems that can simulate and perform tasks typically requiring human intelligence, such as perception, learning, reasoning, and decision-making. AI has become an integral part of modern life, with applications spanning industries, services, and daily life.

Applications of AI in Practice:
- Healthcare: AI is used to diagnose diseases, predict treatment outcomes, analyze medical images, and develop personalized treatment methods. For example, AI can assist doctors in early cancer detection from X-ray images.
- Transportation: AI is at the core of self-driving car technology, with capabilities to recognize obstacles, read signs, and make navigation decisions. Machine learning algorithms help autonomous vehicles make real-time, accurate decisions.
- E-commerce: AI supports optimizing supply chains, recommending products based on individual preferences, and automating customer service processes through chatbots and virtual assistants.
- Finance: In finance, AI is used for fraud detection, risk prediction, and investment decision-making. AI systems can analyze complex financial data and forecast market trends.
- Entertainment and Media: AI plays a key role in content recommendations on platforms like YouTube, Netflix, and Spotify, helping users discover content tailored to their preferences.

AI is also used to create new content, such as music, videos, and even artworks.

- In the Field of Education: With the rapid development of technology, AI is becoming an indispensable part of various sectors, including education. The application of AI in education is a global trend and plays a crucial role in Vietnam's national digital transformation strategy. However, the adoption of AI faces challenges related to technology infrastructure and human resource training, requiring educational institutions to invest heavily and develop systematic training strategies to meet the growing market demand. Moreover, online learning platforms in Vietnam have integrated AI into their programs, personalizing the learning experience for students. AI can assess each student's learning abilities, suggest appropriate content, and adjust the pace of learning. For general education: AI has been applied in teaching, such as creating AI videos, generating electronic lesson plans using AI tools like Gramma AI, Canva, ChatGPT; converting text to AI-generated speech, and creating animations using AI. In general, AI is opening up numerous development opportunities for Vietnam, contributing to the digital transformation across various industries and social sectors. However, to effectively leverage this technology, further investment in research, training, and infrastructure development is required for effective application in various fields.

2.2. Internet of Things (IoT) Technology

The Internet of Things (IoT) is a network of interconnected devices through the Internet that can collect, share, and exchange data without direct human intervention. IoT enables physical devices such as machines, sensors, electronics, and software to communicate with each other, helping to automate processes and create smarter systems.

Key Components of IoT:
- Smart Devices: IoT devices can be any objects capable of connecting to the Internet and equipped with sensors and software to collect and transmit data. Examples include smartphones, smartwatches, temperature sensors, health monitoring devices, or household appliances like refrigerators and washing machines.
- Connectivity: To enable data exchange between devices, they must be connected to the Internet or other networks through various methods such as Wi-Fi, Bluetooth, 5G, mobile networks, or LoRa networks.
- IoT Platforms: IoT platforms provide the infrastructure for managing, collecting, and analyzing data from IoT devices. These platforms also offer tools for application development and system performance monitoring.
- Data Analytics: The data collected from IoT devices can be analyzed to provide valuable insights that aid in decision-making and improve operational performance. AI and Machine Learning technologies are often integrated into IoT to process and analyze data.
- User Interface: Users need an interface to interact with the IoT system. This could include smartphone applications, websites, or specialized interfaces that help control devices and monitor data.
- Applications of IoT Technology in Practice:
- Smart Homes: IoT devices in smart homes include smart lights, smart locks, security systems, and smart home appliances. Users can control these devices remotely via smartphones or automate them according to pre-set routines (e.g., automatically adjusting the temperature when someone arrives home).
- Smart Cities: IoT plays a key role in developing smart cities, including traffic management, public lighting systems, and air quality monitoring. For example, sensor systems can adjust traffic lights based on vehicle flow or provide air quality data to warn residents.
- Smart Healthcare: In healthcare, IoT helps remotely monitor patients, manage medications, and deliver personalized healthcare. Wearable devices can track a patient's heart rate, blood pressure, and blood sugar levels, sending data to doctors for continuous monitoring.
- Smart Agriculture: IoT helps farmers manage crops, irrigation, and harvesting more effectively. IoT sensors can monitor soil moisture, predict weather patterns, and automatically adjust irrigation systems to optimize crop yields.
- Smart Manufacturing: IoT in manufacturing, also known as Industrial IoT (IIoT), helps monitor and optimize production processes, equipment maintenance, and improve safety. IoT sensors can predict machine failures before they occur, helping to prevent downtime.
- Smart Vehicles: Modern vehicles integrate IoT technology to provide autonomous driving services, connect to other systems such as traffic lights, and collect data about the vehicle's condition. These systems help improve safety and energy efficiency

3. SURVEY ON THE CURRENT STATUS OF IMPLEMENTING STEM TOPIC MODELS INTEGRATING AI & IoT TECHNOLOGY IN HIGH SCHOOL EDUCATION

Through a survey of 34 teachers in high schools specializing in Information Technology & Technology, and Natural Sciences, we obtained the following results from the survey questions:

Question 1: Have you ever applied AI & IoT technology in lesson design and teaching? The survey results are as follows:

Table 1: Survey Results on the Application of AI & IoT Technology in Teaching

STT	of Application	Survey Results	
		Quantity	%
1	Theory	9	⁹
2	Practice	6	⁰⁄₀
3	Never Applied in Teaching	19	55,9%

The results show that 55.9% of teachers have never applied AI & IoT technology in their teaching. Therefore, designing STEM topics that integrate AI & IoT technology into teaching is a highly necessary task in today's digital age.

Question 2: During the implementation of STEM topics in Information Technology & Technology for high school students, have you used AI & IoT technology to control models as technological products? The survey results are as follows:

Table 2: Survey Results on Implementing STEM Topic Models

STT	of Application	Survey Results	
		Quantity	%
1	Not Used	24	70,6%
2	Used one of the two technologies	7	20,6%
3	Used both technologies	3	8,8%
4	Used extensively	0	0%

In the process of implementing STEM topics in Information Technology & Technology for high school students, the application of AI & IoT technology for controlling and monitoring specific product models, as shown in Figure 1.7, reveals that 70.6% of teachers have not yet used this technology for controlling or monitoring technological product models. 20.6% of teachers have used one of the two technologies, and 8.8% have used both technologies. Therefore, the use of digital technology in teaching and implementation in high schools is still limited, with only a small number of teachers having applied technology in their teaching.

From the survey on the integration of AI & IoT technology in teaching at high schools, there are both advantages and challenges as follows:

Advantages:
- Teachers in high schools have applied AI technology in preparing theoretical lessons.
- AI videos have been created to support more dynamic lesson delivery.

Challenges when integrating AI & IoT technology:
- According to the survey, 57% of teachers in Information Technology & Technology at high schools have never applied AI & IoT technology in teaching. Therefore, the biggest challenge is the lack of exposure to AI & IoT technology for controlling devices, as teachers have not had the opportunity to engage with this technology.

- Teachers have not explored programming using AI & IoT technology for implementation.
- Limited facilities make the application of AI & IoT technology challenging.

The analysis of the survey results on the current status of STEM education at high schools shows that the surveyed teachers have extensive teaching experience, with 100% of them being teachers in Information Technology & Technology. While the level of awareness about STEM education among teachers is high, they still use it infrequently in their teaching process, especially in terms of applying AI & IoT technology in design and instruction. The use of digital technology in teaching would help students develop both general and specific competencies. It would also foster students' creativity by applying modern technologies to implement models within STEM topics.

4. DESIGNING A SMART HOME STEM MODEL CONTROLLED BY AI & IoT TECHNOLOGY FOR HIGH SCHOOL STUDENTS

4.1 STEM Topic Model Design Process [4]

Based on the objectives of STEM education, the STEM lesson plan is developed following an engineering design process consisting of 8 steps: defining the problem, researching background knowledge, proposing solutions, selecting solutions, creating models, testing and evaluating, sharing and discussing, and adjusting the design. The implementation process of the STEM topic model is divided into 5 main activities as follows:

- Activity 1: Defining the Problem - Developing the Idea
- Activity 2: Researching Background Knowledge and Proposing Solutions
- Activity 3: Selecting the Design Approach
- Activity 4: Building, Testing Features, and Evaluating
- Activity 5: Discussion and Product Improvement

4.2 Designing a Smart Home STEM Model Controlled by AI & IoT Technology
Activity 1: Defining the Idea - Creating the Smart Home
a. Objective

The goal is to mobilize students' knowledge about smart homes, which they have previously explored in specialized topics and through practical applications.

b. Organizing the Activity

Teacher's Task Assignment	Student Task Implementation	Report on Results
Guiding Students into 4 Groups (Each group has 7-8 students):	Students will form groups with assigned roles, including a group leader, secretary, and team members.	Group list.
-The teacher (GV) will send a video about the smart home and distribute a worksheet to each group. -After watching the video, each group will complete the questions in the worksheet designed by the teacher.	Students will watch the video provided by the teacher and complete the corresponding worksheet.	Completed worksheets.
-The teacher will provide common questions in the worksheet, highlighting the features that allow control over the smart home.	They will carefully observe the video and answer the questions in the worksheet.	The teacher randomly calls on students from each group to answer. The teacher observes, gives feedback, and standardizes the knowledge.
-The teacher will introduce sensors and control methods such as AI, IoT, Wi-Fi, and Bluetooth.	Students should take notes on key information while watching and listening to the video.	
The teacher will set scenarios, such as asking students to observe their home and identify devices that can be controlled remotely (via a control panel, smartphone, etc.) and which devices are capable of connecting to the internet.	Students will volunteer to share their answers and ideas. They will select their preferred method of controlling the smart home based on the options given, such as remote control, smartphone control, or using AI/IoT technology.	The teacher observes, provides feedback, and standardizes the knowledge.

c. Learning Products
- The students' answers.
- The group list, including notes on the group leader and members.
- The ability to propose ideas for controlling a smart home using AI & IoT.

Activity 2: Researching Background Knowledge and Proposing Solutions
a. Objectives:
- Provide an overview of a smart home and sensors.
- Present a block diagram and the operating principles of the smart home control system.
- Describe the structure and operating principles of various types of sensors used in a smart home.
- Be able to read documentation on the proper and effective use of the sensors in a smart home.
- Be able to read blueprints and circuit diagrams of the control system for a smart home.

b. Organizing the Activity:

Teacher assigns the learning tasks	Students perform learning tasks	Report on Results
- The teacher asks the groups of students to answer questions after watching the teacher's presentation video. - The teacher poses the question: Which devices are used for control and monitoring?	Students observe, take notes, and answer questions.	The teacher listens, provides feedback, and emphasizes the key knowledge points.

The teacher shows a slide introducing sensors: their concept, functions, and some common types of sensors.	Students write down the content.	Students' notes.
The teacher asks students to bring the worksheets from the previous lesson to identify which sensors are needed for the smart features their group has proposed. They should explain their choices.	Students discuss in groups, make decisions, and record them in their worksheets.	Worksheets.
The teacher introduces programming software for control, such as Ohstem (via ESP32 control, AIoT, or Yolo UNO – Arduino).	Students listen and take notes.	
The teacher asks each group to select a real sensor for their project.	Each group selects two representatives to make a choice.	Chosen Sensors
The teacher assigns tasks for the groups to research the structure, principles of operation, and programming software for the selected sensors.	The group assigns tasks, takes notes, and designs a report slide.	
Each group presents their research findings.	Groups present their findings one by one.	The remaining groups write their answers in their notebooks.
The teacher summarizes key knowledge about sensors and asks students to take notes.	Students listen and take notes.	Students' notes.
The teacher introduces the device.	Students listen and take notes.	
The teacher guides students in practical activities: Designing a smart home control system using AI & IoT.	Each group creates a product.	The teacher provides support and gives feedback during students' practice.

c. Learning Products
- Worksheets
- The control system for a smart home using AI & IoT
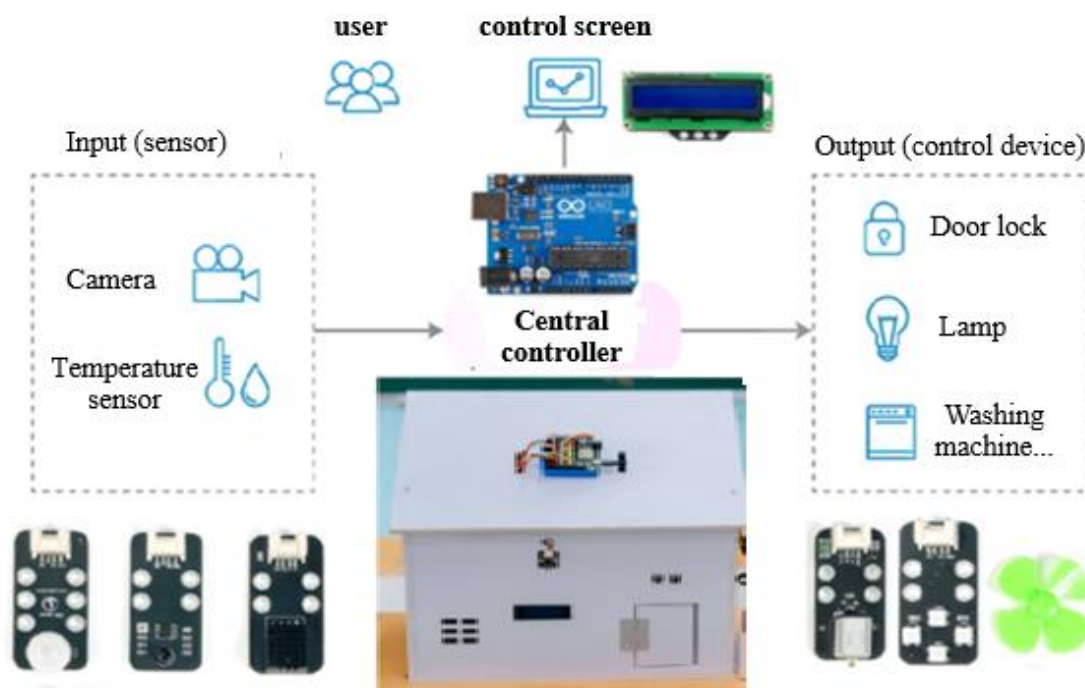
Figure 1: Device and control system diagram for the smart home

Activity 3: Choosing a Design Plan for the Smart Home Model
a. *Objectives*
- Select the design plan for the hardware of the smart home.

- List the main tasks when designing the control system for the smart home.

b. Activity Organization

- The teacher requires students to choose a hardware design plan for the smart home (Design a 3D drawing using AutoCAD or SolidWorks, as preferred).

- Students choose the programming plan to control the smart home using AI & IoT.
- The teacher asks groups to complete their designs and the features for the smart home
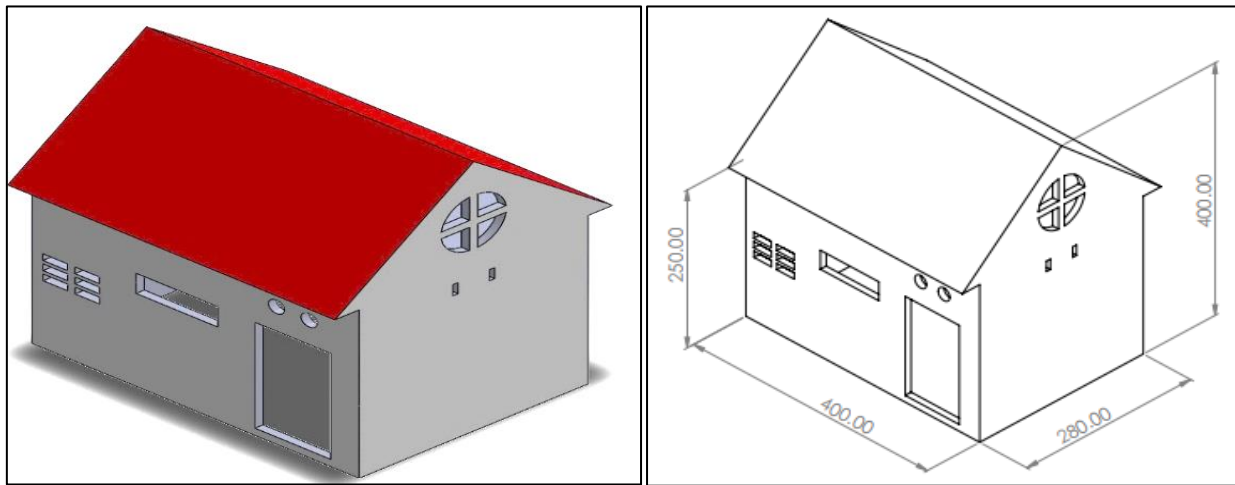

Figure 2: Hardware design for the smart home model

c. Learning Outcomes:
- 3D technical drawing
- Smart home model and features of the smart home

Activity 4: Creating, Programming, and Testing Features of the Smart Home Controlled by AI & IoT Technology
a. Objectives
- Create, program, and test the features of the smart home using AI & IoT technology.

b. Activity Organization

- The teacher provides materials for students to create the smart home model.
- The teacher requires students to proceed with the construction and programming of the smart home according to the design process agreed upon within the group.
- Students can record a video of their product and submit it according to their group's designated location.
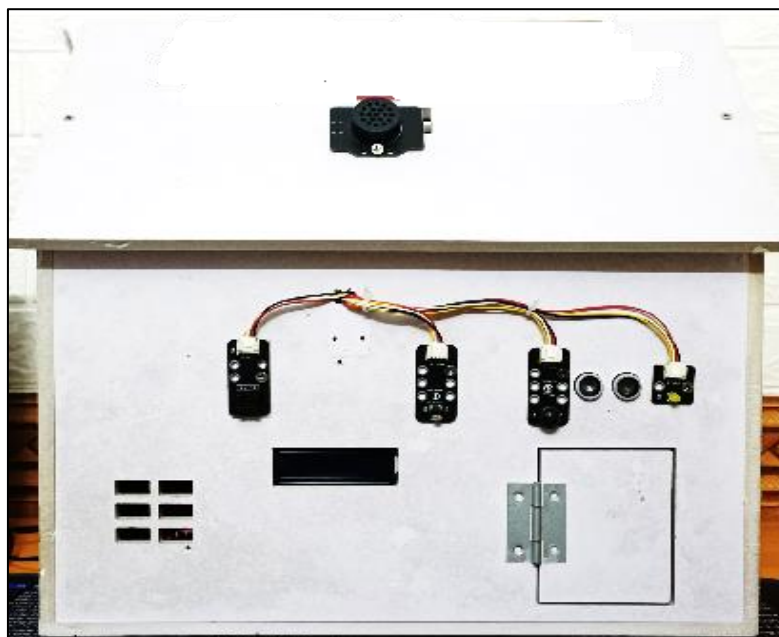- Design a poster to introduce the group's product.

Figure 3: Smart Home Model Product

```
 1  from mqtt_as import MQTTClient, config
 2  from machine import RTC
 3  import ntptime
 4  import time
 5  from sound_player import *
 6  from ultrasonic import *
 7  from pins import *
 8  from lcd1602 import *
 9  from dht20 import *
10
11  cfg = config.copy()
12
13  async def on_mqtt_msg_V1(topic, msg):
14      if msg == '1':
15          rgb_led_D3.show(0, hex_to_rgb('#ffffff'))
16      else:
```

Figure 4: Smart Home Control Programming Code

```
 1  function mqtt_check_connection() {
 2      client.on("connect", function () {
 3          console.log("Connected")
 4      })
 5  }
 6
 7  function mqtt_check_message() {
 8      client.on("message", (topic, message, packet) => {
 9          console.log("Received Message: " + message.toString() + " on topic: " + topic)
10      })
11  }
12
13  function mqtt_subscribe(topic) {
14      client.subscribe(options.username + /feeds/ + topic, { qos: 0 }, function (error, granted) {
15          if (error) {
16              console.log(error)
17          } else {
18              console.log(`${granted[0].topic} was subscribed`)
```

Figure 5: AI-Based Smart Home Control Programming Code

Activity 5: Discussing Control Features with AI & IoT and Improving the Product

a. Objectives:
- Compare and evaluate the smart home products of different groups.
- Identify and assess the product in terms of durability, aesthetics, effectiveness, and safety when using the smart home systems created by the groups.

b. Organizing the activity:
- The teacher requests that each group display their product in the designated area as instructed.
- The teacher asks students to present, explain, and demonstrate the products that the groups have created, focusing on the control system programming for the smart home using AI & IoT.
- The teacher reminds students to complete the evaluation forms and self-assessment scales

according to the criteria that the group initially set.

5. CONCLUSION

AI (Artificial Intelligence) and IoT (Internet of Things) technologies are transforming all areas of life, particularly in STEM education. Designing a smart home model controlled by AI & IoT not only helps high school students access advanced technologies but also encourages creative thinking, problem-solving abilities, and the application of interdisciplinary knowledge into real-world scenarios. Through this paper, we have researched and implemented a smart home model with features such as remote device control via IoT, automation through AI, temperature sensors, lighting sensors, security, and more. This practical approach helps students develop programming skills, circuit design, logical thinking, and gain a deeper understanding of AI applications in daily life.

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