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# Technopreneur Training through Internet of Things-based Smart Energy System Application for Students

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**ABSTRACT**

*Providing technopreneurship training through Internet of Things-based Smart Energy System Applications is part of our commitment to community service, with the aim of developing entrepreneurial and technological skills among students. This program was designed to provide a deep understanding of the concepts and applications of the Internet of Things (IoT) in smart energy systems, while preparing students to become technopreneurs in the digital era. Evaluation assessments were conducted by measuring training satisfaction through a post-training questionnaire, and the results indicate that, overall, participants expressed satisfaction and derived benefits from this training. The hope is that this training will serve as a strong starting point for students as they embark on their journey as technopreneurs, drive innovation in smart energy systems and contribute to the future development of the digital economy.*
***Keywords**: Internet of Things, Technopreneur, Smart Energy, Community Services*

## 1. INTRODUCTION

The development of Information and Communication Technology (ICT), particularly the Internet of Things (IoT), presents numerous potentials in various fields, including energy. IoT revolutionizes the way we manage and consume energy through smart energy systems that provide better control, efficiency, and sustainability. In this context, knowledge and understanding of IoT-based smart energy systems become crucial, especially for the younger generation such as students who will become future leaders and decision-makers.
Various studies have shown that the use of IoT in energy systems can result in significant efficiency gains. For instance, a report from **(Globe Newswire, 2023)** highlights that IoT solutions can reduce electricity consumption by over 1.6 petawatt-hours (PWh), enough to

power more than 136.5 million homes for a year. The report also notes that the net impact of IoT on fuel consumption will achieve an annual reduction of 3.5 PWh of fuel (hydrocarbons). Additionally, IoT devices and emerging technologies are expected to save nearly 230 billion cubic meters of water. While the deployment of new and emerging IoT technologies is projected to increase global electricity usage by 34 terawatt-hours (TWh), this will be offset by the over 1.6 PWh of electricity saved by IoT solutions, as per Globe Newswire. Moreover, several studies have found that the use of IoT in energy systems can provide better control over energy consumption and contribute to achieving sustainability goals, including :

1. An article from **(Helpwire, 2023)** explains that IoT smart thermostats are an effective way to reduce heating and cooling costs. Many modern IoT smart thermostats have enhanced temperature control features that can result in greater energy savings. IoT sensors can learn through data how to adjust temperatures based on habits and occupancy.
2. An article from **(Techtarget, 2021)** discusses five main areas where IoT power management and energy control are being applied today: smart lighting & controls, energy management systems, green energy, energy storage, and connected plants.
3. **(Ahmad, 2021)** conducted a study on the use of IoT in smart energy systems applied in applications and business networks.
4. An article from **(Microsoft Azure, 2023)** offers IoT solutions that can help achieve environmental sustainability goals and advance conservation efforts. These solutions can reduce energy usage in factories or buildings, monitor water output quality, and reduce material waste.
5. **(Nanjundan, 2023)** in this article discusses how IoT and smart technologies have rapidly advanced, enabling numerous technological advancements. The primary goal of IoT is to simplify processes in various fields, improve technological efficiency and protocols, and ultimately enhance quality of life.
6. **(Hasbullah, 2022)** in this article deliver training provided material on technoprenership and IoT implementation to gain those two benefits. The training was held for 2 weeks, 2 days of which were synchronous and the rest were asynchronous. The trainees consisted of 15 UPI students and they were expected to be able to build prototypes in the end of the training. As the result, 60% of the participants were able to realize their business ideas until the prototype stage.
7. **(Muhammad, 2021)** in this article describe how to develop One of the chip platforms that is expected to improve performance in the industrial world is the STM32 where this chip produced by ST Microelectronics has a high clock frequency, generally in the lowest range of 72MHz or more so it is clearly faster and more powerful. but there are different voltage levels between the microprocessor and the voltage level in the industry where in the industrial world the voltage level is 0-24 volts while the microcontroller has a voltage level of 0 - 3.3 volts, in this paper a main board has been designed which is powered by the STM32F103RET microcontroller and equipped with industrial Shield which allows the GPIO to communicate with industry standard voltage levels (0 and 24V) as well as industrial analog voltage levels 0-10v and current levels 0-20mA.

To unlock the potential of IoT and smart energy systems, it's crucial to provide relevant training and education, particularly for future leaders. Additionally, nurturing entrepreneurial spirit among students is vital. The UPI student entrepreneurship community faces challenges in developing IoT-based Smart Energy System applications, including the need for human resource development and innovation, fostering teamwork among young technopreneurs in the IoT field, enhancing knowledge of IoT-based smart energy system development through online educational resources, and exploring the potential of IoT in the energy sector. Training in technopreneurship for smart energy applications is essential, equipping students with a comprehensive understanding of technology's role in creating innovative energy solutions and entrepreneurial skills to identify opportunities and implement them as products or services.

## 2. IMPLEMENTATION METHOD

The community service program conducted is an Internet of Things training for Smart Energy applications aimed at developing technopreneurial skills. It will be held for two sessions starting on June 19th and 21st, 2023, and will be conducted offline at the Industrial Electronics Laboratory, 5th floor, Universitas Pendidikan Indonesia.

### 2.1 Participants

Participants invited and targeted for this training are students from four specific study programs at Universitas Pendidikan Indonesia. These four programs include the Electrical Engineering Study Program, the Electrical Engineering Education Study Program, the Industrial Automation and Robotics Education Study Program, and the Computer Science Study Program. The involvement of students from these four study programs reflects an interdisciplinary synergy and collaboration among expertise areas in addressing challenges and opportunities in the era of Internet of Things technology. The training aims to accommodate 20 students from these four study programs.

### 2.2 Implementation Method

The implementation method used in this community service program follows three stages: the preparation stage, the core or implementation stage, and the evaluation or post-implementation stage. The complete stages of this community service activity are illustrated in Figure 1.

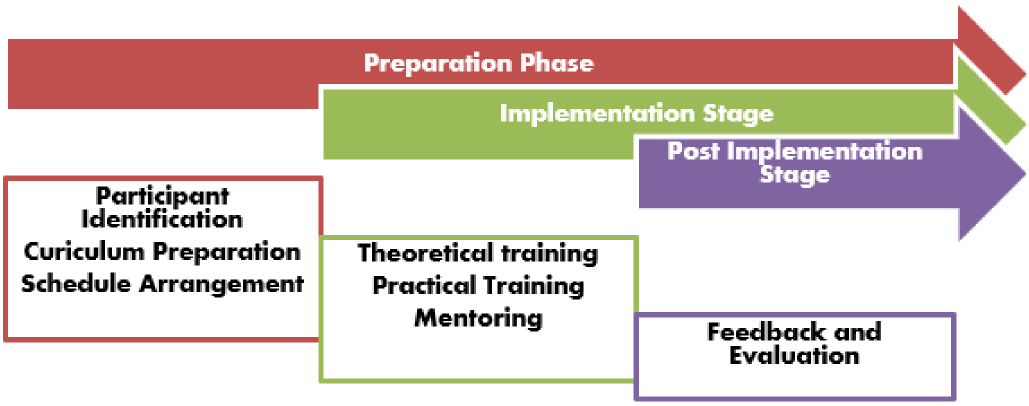


**Figure 1. Flow of Community Service Implementation Through IoT Training for Smart Energy System Applications**

Below are the details of the implementation of community service through technopreneur training using IoT-based smart energy applications:

#### 2.2.1 Preparation Phase:

A. Participant Identification: Identifying and recruiting participants who have potential and interest in technopreneurship and IoT.

B. Curriculum Development: Developing a curriculum and training materials that cover various aspects of technopreneurship and the development of IoT-based smart energy applications.
C. Schedule Arrangement: Creating a training schedule that has been adjusted to accommodate participants' availability.

### 2.2.2 Implementation Stage :

**A. Theoretical Training**: Providing theoretical explanations about technopreneurship and IoT.
This activity takes the form of a series of workshops and seminars focused on various topics, with the aim of providing participants with comprehensive knowledge and practical skills in technopreneurship and IoT.
One workshop session focuses on the technical knowledge of IoT and smart energy. Participants are introduced to the fundamental concepts of IoT, how it works, and its utilization in developing smart energy solutions. They learn how IoT sensors and devices can be used to collect data, and how this data can be analyzed and utilized to improve energy efficiency and sustainability. Participants are also introduced to various hardware and software used in the development of IoT-based smart energy applications.
Another session focuses on entrepreneurial skills. Here, participants are taught how to identify and evaluate business opportunities, how to develop innovative ideas, and how to assess and manage risks. They learn about the product or service development process from ideation to implementation, including market research, prototyping, marketing strategies, and financial management.

**B. Practical Training**: Conducting practical training or project-based learning.
After a series of workshops and seminars, we enter the phase of practical training or project-based learning. This phase is designed to provide participants with real opportunities to apply the knowledge and skills they have acquired in a supportive and goal-oriented environment.
Each participant or group of participants is tasked with designing and developing a project or prototype of an IoT-based smart energy application. This project should reflect their understanding of IoT concepts and technologies, as well as their ability to identify opportunities, develop innovative ideas, and implement them into tangible products or services.
Upon completion of the project, participants are asked to present their work to the group. They are expected to explain their ideas and the development process, demonstrate the functionality of their products or services, and discuss potential business opportunities and plans.

**C. Mentoring:** Providing guidance and support to participants throughout the training process, both in technical aspects and business development.

### 2.2.3 Post Implementation Stage:

Following the completion of training and project-based learning, a critical evaluation stage is undertaken to gauge training effectiveness and identify areas for improvement. This assessment employs various tools, including opinion and satisfaction questionnaires. Each participant receives a questionnaire that covers aspects such as training material quality, facilitator competence, practicality of knowledge and skills, and overall satisfaction. Anonymous feedback is encouraged, fostering honesty and openness. This feedback informs continuous program enhancement, with direct evaluation discussions further allowing participants to share experiences, insights, and recommendations for future training, ensuring ongoing improvement in our training program.

## 3. RESULT AND DISCUSSION

This section will explain the results of the community service that has been conducted, which consists of three stages. The results of each stage are outlined and explained as follows:

### 3.1 Result of Preparation Phase

The preparation stage is the initial and crucial step in implementing the technopreneur training program through IoT-based smart energy applications. This stage involves various activities, including planning and designing the training program, creating training flyers, participant identification and recruitment, curriculum development, and scheduling the training sessions.

Firstly, we conducted a series of meetings and discussions to design and plan the training program. We identified the objectives and target audience of the training, determined the format and training methods, and formulated strategies to ensure the effectiveness and impact of the training.

Next, we created training flyers that provide detailed information about the training program, including the objectives, topics to be covered, format and training methods, as well as registration information. These flyers were then distributed online through various channels and social media platforms, as well as through our network and contacts within the UPI student community. Figure 2 shows flyer of the activity.


**Figure 2. Entrepreneurship Training Flyer Based on IoT**

### 3.1.1 Result of Participant Recruitment

Furthermore, we proceeded with participant identification and recruitment. We searched for students who had potential and an interest in technopreneurship and IoT. The registration process was conducted online through Google Drive, where prospective participants were required to fill out a registration form and provide information about their background and interests. Based on this information, we conducted a selection and recruitment process to ensure that the chosen participants were those who were most likely to benefit from this training. Through our recruitment sessions, we successfully recruited a total of 20 students to participate in the training.

Based on the recruitment results for the training participants, it was found that the majority of prospective participants, who are students, have had experience using microcontrollers. However, they have not fully grasped how to apply it in the context of smart energy. They are capable of creating systems, but have yet to consider the fundamental reasons why a smart energy system needs to be developed and how to optimize it. On the other hand, from a technopreneurial perspective, participants have not yet considered the potential to venture into entrepreneurship based on their expertise in microcontrollers, especially in smart energy applications.

### 3.1.2 Curriculum Training Development

Additionally, we determined the training curriculum. The curriculum was designed to cover various relevant topics and skills essential for IoT-based technopreneurship, ranging from technical knowledge about IoT and smart energy to entrepreneurial skills such as opportunity identification, idea development, and risk assessment. The curriculum was developed while considering the participants' needs and interests, as well as the latest trends and developments in the field of technopreneurship and IoT. The following Table 1 presents the rundown of the event and the curriculum for the Technopreneur Training through IoT-based Smart Energy System Application.

**Table 1. Event Rundown and Curriculum for Technopreneur Training through IoT-based Smart Energy System Application.**

| Time | First Day | Second Day |
|---|---|---|
| 07:30 - 08:00 | Registration and Opening | - |
| 08:00 - 10:00 | Introduction of IoT and Smart Energy | Technopreneurship in the Context of IoT and Smart Energy |
| 10:00 - 12:00 | Introduction to Hardware and Software | Project-Based Learning |
| 12:00 - 13:00 | Lunch Break | Lunch Break |
| 13:00 - 15:00 | Arduino Basic Programming and Blynk | Project Presentation and Evaluation |
| 15:00 - 17:00 | Implementation of Smart Energy System | Training Evaluation and Closing |

### 3.2 Result of Implementation Stage

The implementation stage begins with an opening session and the delivery of theoretical materials. In this stage, participants are introduced to the concepts of IoT and Smart Energy. The materials are presented by experienced trainers in the field of IoT and Smart Energy. The objective of this session is to equip participants with the fundamental knowledge needed to apply these concepts in the development of their businesses or ventures. Figure 3 shows opening activity of community service.

**Figure 3. Opening of Community Service Program by the Head of Community Service Program.**



Table 10. Cortex®-M4 performance comparison HW SP FPU vs. SW implementation FPU with MDK-ARM™ tool-chain V5.17

| Frame | Zoom | Duration with HW FPU [ms] | Duration with SW implementation FPU [ms] | Ratio |
|---|---|---|---|---|
| 0 | 120 | 195 | 2426 | 12,44 |
| 1 | 110 | 170 | 2097 | 12,34 |
| 2 | 100 | 146 | 1782 | 12,21 |
| 3 | 150 | 262 | 3323 | 12,68 |
| 4 | 200 | 275 | 3494 | 12,71 |
| 5 | 275 | 261 | 3307 | 12,67 |
| 6 | 350 | 250 | 3165 | 12,66 |
| 7 | 450 | 254 | 3221 | 12,68 |
| 8 | 600 | 240 | 3038 | 12,66 |
| 9 | 800 | 235 | 2965 | 12,62 |
| 10 | 1000 | 230 | 2896 | 12,59 |

**Figure 4. Theoretical Material Session by the Speaker.**

In addition, participants are also introduced to the hardware and software that will be used in the training, including Arduino and the Blynk platform as shown in figure 4. This introduction is designed to prepare participants for the upcoming practical sessions.

After the theoretical session, participants are directed to the practical session. In this session, participants are given the opportunity to apply the knowledge and skills they have learned in the theoretical session. They are taught how to program Arduino and use the Blynk platform to implement the Smart Energy System.

During these practical sessions, the trainers provide guidance to ensure that participants can follow instructions and understand the taught concepts. This guidance also aims to assist participants in resolving any issues or challenges they encounter during the practical sessions as shown in figure 5.

**Figure 5. Practical Activities in the Community Service Program.**

At the end of the training, participants are given the opportunity to present and evaluate the projects they have worked on during the practical sessions. This provides an opportunity for participants to share what they have learned and receive feedback from trainers and other participants.

Furthermore, in this session, participants are also mandated to present entrepreneurial ideas they intend to implement, with a particular emphasis on the smart energy system domain as shown in figure 6. This presentation is not merely a formality; it serves as a platform for them to articulate and refine their concepts, receive feedback, and engage in constructive discussions with peers and experts. The objective is to ensure that by the end of the session, participants not only possess a theoretical understanding of smart energy systems but also have a clear and actionable entrepreneurial roadmap. This initiative underscores the training's commitment to fostering innovation and driving real-world applications in the realm of smart energy.

**Figure 6. Project Presentation by Training Participants.**

Overall, this implementation stage is designed to ensure that participants acquire the knowledge and skills they need to become technopreneurs in the field of IoT and Smart Energy. The practical experience and guidance provided during this training process are also crucial in helping participants apply what they have learned and prepare them for potential challenges they may encounter in the future.

### 3.3 Result of Post Implementation Stage

One of the evaluation methods we used was distributing opinion and satisfaction questionnaires to the participants. These questionnaires were designed to gather feedback from participants about various aspects of the training, ranging from the quality of materials and teaching methods used to their overall satisfaction with the training. The data generated from these questionnaires was then processed and analyzed to provide an objective overview of the effectiveness and impact of the training.

Table 2 below shows the results of the satisfaction and opinion questionnaire, where we presented 10 questions regarding the training and assessed them using a Likert scale, where a score of 1 represents strongly disagree, a score of 2 represents disagree, a score of 3 represents neutral, a score of 4 represents agree, and a score of 5 represents strongly agree.

**Table 2 Results of The Satisfaction and Opinion Questionnaire**

| No | Question | Scale | Mean |
|---|---|---|---|
| 1 | The content delivered in this training is relevant to the training topic. | 1-5 | 4.4 |
| 2 | The training material is presented clearly and is easy to understand. | 1-5 | 4.2 |

| | | | |
|---|---|---|---|
| 3 | The instructor has a deep understanding of the topic being taught. | 1-5 | 4.5 |
| 4 | The instructor is able to explain concepts and applications effectively. | 1-5 | 4.3 |
| 5 | The practical activities in this training have helped me understand the material. | 1-5 | 4.2 |
| 6 | I feel that I have gained new and useful knowledge from this training. | 1-5 | 4.3 |
| 7 | I feel more confident in applying the knowledge I have gained from this training. | 1-5 | 3.8 |
| 8 | The facilities and equipment used in this training are adequate. | 1-5 | 4.0 |
| 9 | I am satisfied with the service and support provided during the training. | 1-5 | 4.1 |
| 10 | I would recommend this training to others. | 1-5 | 4.5 |

This evaluation stage is important as it allows us to measure the success of the training and identify areas for improvement. By conducting systematic and comprehensive evaluations, we can ensure that our training program continues to evolve and adapt to the needs and expectations of participants, while providing maximum benefit to them.

### 4.4 Discussion

Based on the satisfaction and opinion questionnaire results presented in Table 1, it can be observed that the training participants overall expressed satisfaction and found value in the training. The questions with the highest average scores were "The instructor has a deep understanding of the topic being taught" and "I would recommend this training to others" with a score of 4.5. This indicates that participants highly appreciate the expertise of the instructor and believe the training would be beneficial to others. On the other hand, the question with the lowest average score was "I feel more confident in applying the knowledge I have gained from this training" with a score of 3.8, suggesting that while participants feel they have acquired new knowledge, they may need more time and practice to feel confident in applying that knowledge. Overall, the questionnaire results indicate that the training has been successful in providing relevant knowledge and skills to the participants.

In addition to using the questionnaire, we also conducted direct evaluation discussions with the participants. These discussions provided an opportunity for participants to share their experiences, provide direct feedback, and offer suggestions or recommendations for improving future trainings. These discussions also allowed us to evaluate and understand the extent to which the training objectives were achieved.

Through this training, participants built their own knowledge about IoT and smart energy through direct learning experiences, both from theoretical materials and practical exercises. This aligns with Piaget's constructivism theory **(Piaget, 1972)**which suggests that learning is a process in which individuals construct their own knowledge from experiences. Piaget argued that humans generate knowledge and shape meaning based on their experiences. Additionally, in this training, the learning process involved group work and discussions, where participants could share knowledge and learn from each other's experiences. This aligns with Vygotsky's sociocultural theory **(Vygotsky, 1978)** which suggests that the learning process is most effective when students work in groups and learn from one another.

## 5. CONCLUSION

The technopreneurship training through the Internet of Things-based Smart Energy System application has been successfully conducted smoothly and effectively, from the preparation stage to the implementation. The preparation phase was well executed, including planning, creating flyers and banners, participant recruitment, and the development of a comprehensive training curriculum. During the implementation, the activities ran smoothly and efficiently with active participation from all participants. The training evaluation results obtained through the distribution of questionnaires to the participants indicated highly positive assessments, reflecting the success and effectiveness of this training. Therefore, this training has successfully achieved its objectives and provided added value to the participants in preparing competent technopreneurs in the field of technology.

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