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Workshop on STM32 Board Utilization to Elevate the Expertise of Electrical Vocational High School (SMK) Teachers in the Greater Bandung Region

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ABSTRACT

The STM32 microcontroller technology workshop, held in the Greater Bandung region, was a pioneering initiative aimed at enhancing the skills of vocational high school educators. It provided in-depth knowledge and practical experience in advanced STM32 features like GPIO, ADC, PWM, and UART communication. The workshop employed an active, participant-focused approach, ensuring impactful learning. Feedback was overwhelmingly positive, with high satisfaction rates in content quality (83.5%), delivery method (81.75%), and hands-on activities (79.25%). However, suggestions for improvement included better preparatory materials and post-workshop support. Overall, the workshop marked a significant step in advancing the professional development of educators and elevating the quality of technical and vocational education in the region.

Keywords: *Teacher Training, STM32, Microcontroller, Engineering Education*

1. INTRODUCTION

With an increasing number of students showing interest in electronics and cutting-edge technology, there is an urgent need for educators proficient in this field, capable of delivering content that aligns with technological advancements **(Isti'anah, 2020)**. Technical and vocational education plays a pivotal role in preparing the younger generation for the workforce, especially in the ever-evolving technology sector. A crucial element of this education is the understanding and application of microcontroller technology, which has become an industry standard in various technical and industrial applications **(Fedorov et al., 2022).**

According to official information from **(STMicroelectronics, 2022)**, the STM32 is a microcontroller designed by the company. This microcontroller operates on the Cortex-M architecture developed by ARM and is supported by compilers provided by STMicroelectronics. The STM32 offers a range of types and variants tailored for diverse applications, from control systems, measurement systems, communication, to multimedia systems. It also comes

equipped with various peripherals such as ADC, DAC, UART, SPI, I2C, among others, facilitating the development of a wide range of applications. The STM32's strengths lie in its low power consumption, high performance, affordability, and the abundance of available software.

The STM32 is now integrated into the electronics and technology curriculum at Vocational High Schools (SMK) and universities **(Rizqulloh et al, 2021)**, emphasizing its use as a primary microcontroller in application development. This curriculum spans basic STM32 programming to complex applications, including control, measurement, communication, and multimedia systems. The STM32 also features prominently in the Student Competency Competition (LKS) in electronics. However, challenges arise due to many teachers' limited STM32 proficiency, outdated curricula, and constraints in accessing the necessary resources. Addressing these, community service efforts, such as specialized STM32 workshops for SMK teachers in the Greater Bandung area, are imperative.

According to a study by **(Hofmeister and Pilz, 2020)**, training teachers in new and emerging technologies can enhance teaching effectiveness and student learning outcomes. Additionally, research by **(Vilppola et al, 2022)** indicates that the use of information and communication technology (ICT) in technical and vocational education can enhance students' understanding of technical concepts and their real-world applications.

Therefore, this workshop aims to enhance teacher competency in the use and instruction of STM32 technology, hoping to positively impact the quality of technical and vocational education in the Greater Bandung area.

This workshop, tailored for teachers in the Greater Bandung region, aims to boost their competencies in addressing educational challenges, particularly in managing STM32 devices. The goal is to enhance their STM32 proficiency, benefiting the school learning process and stimulating student interest in electronics. Ultimately, this aims to better prepare students for the Student Competency Competition (LKS) and elevate electronics education standards in Vocational High Schools (SMK) across Greater Bandung.

2. IMPLEMENTATION METHOD

Methodology refers to the sequence of procedures or steps applied in this community service and training activity. Fundamentally, training is a learning process. The utility of training lies in its role as an instrument used by organizations to maintain, hone, and enrich the skills of workers within the organization, ultimately enhancing their efficiency **(Saputra, 2019).** Efficient training must be conducted systematically and continuously. A training system comprises elements of input, process, output, and outcomes. Every training model encompasses three categories: a) planning function; b) implementation function; and c) evaluation function **(Isti'anah, 2020).**

2.1 Methods used in training

In this training, the method employed is the ADDIE Training Method. This training model ilustrate in Figure 1 consists of five stages, which are as follows:

a. Training needs analysis;
b. Design of training approach;
c. Development of training materials;
d. Implementation of training;

e. Evaluation and updating of training.

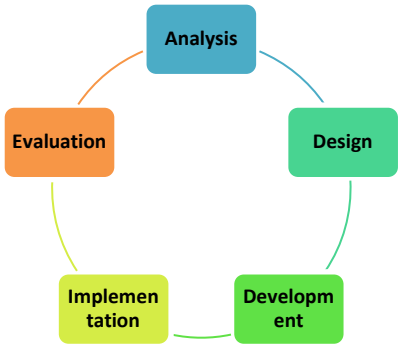

Figure 1. Illustration of the ADDIE Method

2.2 Goals and Targets

This community service and training aims to bolster the STM32 microcontroller expertise of SMK teachers in the Greater Bandung area, enhancing the quality of regional technical education. It promotes knowledge exchange among teachers and the adoption of innovative technology in education, prepping students for digital-era careers. While primarily targeting electrical-field SMK teachers, the activity welcomes teachers from other disciplines interested in STM32 technology, ensuring diverse insights for all attendees..

2.3 Preparation Stage

Workshop preparation is paramount for the activity's success. The process begins with planning, which entails setting the workshop's objectives, targets, topics, materials, date, and duration, as well as determining the teaching methods like presentations, group discussions, or hands-on practices. Next, STM32 experts are selected as speakers and tasked with readying their presentations, often with the organizing team's support. Concurrently, participants are identified, invited, and informed about the workshop's specifics, and in some cases, given pre-reading materials or assignments. The venue is then chosen and readied, ensuring its suitability for the planned activities and participant count, and essential equipment like computers, projectors, and STM32 devices are set up. Logistical arrangements cover catering and potentially transportation. Lastly, a dry run is performed to ascertain the readiness of equipment, materials, and all logistical elements, ensuring the workshop's seamless execution.

2.4 Training Implementation Plan

The workshop will take place offline at FPTK UPI's Industrial Electronics Laboratory, a venue optimized for immersive microcontroller interaction. Designed for hands-on learning, the event kicks off by distributing STM32 boards to all 20 participants, ensuring firsthand engagement with the technology. The speaker will introduce the STM32 microcontroller, detailing its operations and diverse applications, before delving into the General Purpose Input Output (GPIO) concept. Participants will grasp how to configure and control GPIO pins, utilize them with other devices, and further explore the Analog to Digital Converter (ADC) and Pulse Width Modulation (PWM) features for signal processing. The course will also touch on UART communication, emphasizing serial data transmission and reception. Integral to the workshop's design is the immediate application of each lesson; after each segment, participants will experiment with their STM32 boards, assisted by the speaker and helpers. This structure ensures participants leave not just with theoretical insights but also the practical skills essential for harnessing and instructing on STM32 technology.

2.5 Training Evaluation

The workshop's evaluation process, integral for assessing its effectiveness and identifying improvement areas, incorporates two key methods. Firstly, a summative evaluation is conducted through a post-workshop questionnaire, where participants reflect on the material quality, teaching methods, and relevance to their professional needs. This offers insights into the participants' perceptions and pinpoints potential areas for enhancement. Secondly, peer-to-peer evaluations are utilized, enabling participants to share their learning experiences and provide diverse perspectives. This method helps uncover aspects potentially overlooked in the questionnaire, thus enriching the overall feedback.

3. RESULT AND DISCUSSION

The 'Results and Discussion' section is dedicated to discussing and elucidating the findings and deliberations from the Community Service Activities (PKM). This section will provide a comprehensive overview of the PKM activities' implementation, encompassing the evaluations of the training conducted and the insights gained from those evaluations.

3.1 Preliminary Preparation

The preparation phase is an initial and crucial step in the execution of the STM32 Board Workshop program for teachers. This preparatory phase encompasses various activities, ranging from planning and designing the training program, creating training flyers, identifying and recruiting participants, determining the curriculum, and organizing the training schedule. The details are elaborated as follows:

a. Firstly, we conducted a series of meetings and discussions to plan and design the training program. In this phase, we identified the objectives and targets of the training, determined the format and methods to be used, and formulated strategies to ensure the effectiveness and impact of the training.
b. In the subsequent phase, we will be orchestrating the formulation of an invitation letter directed towards Vocational High Schools (SMK) specializing in Electronics within the Greater Bandung area. The list of targeted SMKs can be referenced in Table 1. The primary rationale behind selecting these SMKs is the alignment of their specialized programs with the training content to be delivered. Additionally, during the preparatory stage, we have also readied a request letter to utilize the Industrial Electronics Laboratory affiliated with the respective Faculty and Study Program.
c. The next step was the socialization of the training activities and the distribution of invitation letters to the Electronics-focused Vocational High Schools (SMK) throughout Bandung Raya, where the dates of the invitation letter issuance and their receipt by the schools are indicated in Table 1.

Table 1. Date of Giving the Invitation Letter

No	1 Oct 2023	2 Oct 2023
1	SMKN 6 Bandung	SMKN 8 Bandung
2	SMKN 1 Cimahi	SMKN 2 Cimahi
3	SMKN 1 Cimahi	SMKN 7 Baleendah
4	SMKN 4 Bandung	SMKN 1 Majalaya

d. The subsequent step involves formulating the training curriculum. The curriculum is designed to impart comprehensive knowledge and skills about STM32 microcontroller technology to the participants. This curriculum encompasses various topics, ranging

from a basic introduction to the STM32 to the utilization of features such as GPIO, ADC, PWM, and UART communication. Table 2 shows the detailed components of this training curriculum.

Table 2. STM32 Training Curriculum

Session	Topic	Description	Durasi
1	Introduction to STM32	A basic introduction to the STM32 microcontroller, including an explanation of how the microcontroller operates and the applications of STM32 across various fields.	1 Hour
2	STM32 Laboratory: Introduction	Participants will be provided with an STM32 board and taught how to set up and utilize the board.	1 Hour
3	General Purpose Input Output (GPIO)	Participants will learn how to configure and control the GPIO pins on the STM32, as well as how to use these pins to interact with other devices.	2 Hour
4	STM32 Laboratory: GPIO	Participants will engage in hands-on exercises using the GPIO pins on their STM32 boards.	2 Hour
5	Analog to Digital Converter (ADC) and Pulse Width Modulation (PWM)	Participants will learn how to use the ADC and PWM features on the STM32 to process analog and digital signals.	2 Hour
6	STM32 Laboratory: ADC and PWM	Participants will engage in hands-on exercises using the ADC and PWM features on their STM32 boards.	2 Hour
7	UART Communication	Participants will learn how to transmit and receive data through serial communication using the STM32.	2 Hour

3.2 Implementation of Training

This workshop was held on Wednesday, October 4th, 2023, commencing with an opening by the Head of Community Service. In his address, the Head provided an overview of the objectives and significance of this workshop, as well as his aspirations for the outcomes to be achieved by the participants. Following that, the Head handed over the proceedings to the speaker to begin the training session as showed in figure 2.

Figure 2. PKM Chairman Gives speech and Opens the Workshop Event

The first training session began with a basic introduction to the STM32 microcontroller (figure 4). The speaker explained how the microcontroller operates and the applications of STM32 across various fields. After the presentation, participants were given the opportunity to ask questions and discuss the material that had been presented.

Figure 3. STM32F4 Discovery board used during training

Subsequently, each participant was provided with an STM32 board (figure 3) and taught how to set up and utilize it. This marked the first hands-on session of the workshop, where participants could learn and experiment with the technology directly.

Figure 4. Presentation of ARM STM32 Theory

The workshop then proceeded with a session on General Purpose Input Output (GPIO). Participants learned how to configure and control the GPIO pins on the STM32, as well as how to use these pins to interact with other devices. This session was followed by the second hands-on exercise, where participants were tasked with completing assignments using the GPIO pins on their STM32 boards (figure 5).

Figure 5. Workshop participants doing practice

The subsequent session covered the Analog to Digital Converter (ADC) and Pulse Width Modulation (PWM). Participants learned how to utilize these features on the STM32 to process analog and digital signals. This session was also accompanied by a hands-on exercise, where participants were tasked with completing assignments using the ADC and PWM features on their STM32 boards.

The workshop continued with a session on UART communication. Participants learned how to transmit and receive data through serial communication. This session was followed by the final hands-on exercise, where participants were tasked with transmitting and receiving data through serial communication using their STM32 boards.

Figure 6. Group Photo Session

After all the training sessions and hands-on exercises were completed, the workshop concluded with a closing session (figure 6). In this segment, the Head of Community Service provided an assessment and feedback on the workshop and expressed gratitude to all participants and speakers. Participants were also given the opportunity to provide their feedback on the workshop and share their experiences through a questionnaire.

3.3 Evaluation

As part of the training evaluation, participants were instructed to complete satisfaction and program success surveys. The success criteria for this training activity were determined by the positive responses from the participants, gauged through the survey results. The survey, designed to gather quantitative data, consisted of 12 questions. Participants were prompted to respond using a Likert scale ranging from 1 to 4, which reflected their level of agreement or satisfaction with various training aspects: 1 being 'Strongly Disagree', 2 'Disagree', 3 'Agree', and 4 'Strongly Agree'. This scale resulted in four interval classes as depicted in Table 3.

Table 3. Range of Training Participant Satisfaction

No	Percentage (%)	Information
1	81,26 – 100,00	Very satisfied
2	62,51 – 81,25	Satisfied
3	43,76 – 62,50	Not satisfied
4	25,00 – 43,75	Very dissatisfied

Table 3 indicates that participants are considered satisfied if their responses fall within the range of 62.51% to 81.25%, and very satisfied if their responses exceed 81.26%. There were 20 participants in the STM32 training, so if all participants gave a score of 4, the maximum achievable score would be 80. Conversely, if all participants gave a score of 1, the minimum achievable score would be 20.

Three primary aspects were assessed in this survey: content material, material delivery, and practical demonstration activities. Based on these criteria, the survey results are as follows.:

1. In terms of satisfaction with the substance and material taught, several questions were posed. For instance, one of the questions was, "Was this training sufficiently engaging for the participants?" From the responses received, 84% indicated a very high level of satisfaction. For other questions, the details can be seen in Table 4. Overall, the satisfaction level regarding the content aspect reached 83.5%, indicating that participants were highly satisfied with the content and substance of the material presented.

Tabel 4. Material Aspects Questionnaire

	Material Aspect	Percentage
1	"The Training Theme is Appealing to Me"	84 %
2	"The Training Material is Relevant to My Needs"	80 %
3	"The Training Material is Well-Organized"	87 %
4	"The Material is Presented Clearly and Provides Understanding for Me"	83 %
Average		83,5 %

2. In Table 5, the results for the aspect of material delivery are displayed, where the questionnaire posed several questions about the satisfaction level related to the method of material presentation, including the instructor's understanding of the material, the time allocation conducted by the instructor, and more. A figure of 81.75% was obtained from the responses regarding the material delivery aspect, indicating that participants were highly pleased with the material presentation techniques implemented by the instructor.

Table 5. Material Delivery Aspects Questionnaire

	Delivery Aspect	Percentage
5	The instructor has a deep understanding of the material presented.	85 %
6	The instructor's time allocation for delivering the material is sufficient.	82 %
7	The instructor conveys the content of the material well and is easily understood.	83 %
8	The instructor facilitates discussions and provides feedback.	77 %
Average		81,75 %

3. The final evaluation aspect pertains to the practical activities, where several questions were posed concerning the implementation of practical exercises, including the ease of operating the practical modules, the quality standards of the modules, and other issues related to the laboratory work. A score of 79.25% was obtained from the responses regarding the practical aspect, indicating that participants were quite satisfied with the practical activity segment associated with the STM32 microcontroller material (table 6).

Table 6. Questionnaire Aspects of practical activities

	Aspects of practical activities	Percentage
9	The modules provided are of good quality	79 %
10	The modules provided are easy to understand	82 %
11	The assistant instructor has facilitated practical activities well	83 %
12	The time allocated for practical implementation is sufficient	73 %
Average		79,25 %

3.4 Discussion

This training is expected to provide valuable insights into the use and teaching of STM32 microcontroller technology. We will attempt to analyze and understand this experience within the broader context of educational theory.

Firstly, this training can be viewed as an example of the constructivist approach in education. According to constructivist theory, learning occurs when students are active in the learning process and construct their own knowledge based on experience **(Piaget, 1950).** In this training, participants not only receive information from the instructor but are also given the opportunity to experiment with the technology directly and build their own understanding of how it works.

Secondly, this training also reflects the principles of adult learning proposed by **(Knowles, 1984)**. According to Knowles, adults learn most effectively when they see the direct relevance of what they are learning to their life or work, and when they can actively participate in the learning process. In this training, participants are given the opportunity to learn about technology relevant to their roles as technical educators, and they are also given the chance to actively participate in labs and discussions.

Thirdly, this training also highlights the importance of lifelong learning. In an ever-changing world, especially in the realm of technology, it's crucial for educators to continually update their knowledge and skills. This training offers participants the chance to do just that, thereby supporting the concept of lifelong learning **(Field, 2000)**.

Overall, this training has provided a valuable learning experience for participants and has showcased how educational theories can be applied in practice. However, there's always room for improvement and innovation, and we should continually seek ways to make such training more effective and impactful.

4. CONCLUSION

The training on the use and teaching of STM32 microcontroller technology has been successfully conducted, bringing numerous benefits to the participants, especially the vocational high school (SMK) teachers in the Greater Bandung area. Through this training, participants have acquired new knowledge and skills that they can apply in their teaching, thereby enhancing the quality of technical and vocational education in the region. This training also underscores the importance of an active, participant-centered learning approach. By providing participants with hands-on experience with the technology and allowing them to apply the concepts they've learned in practical sessions, the training has facilitated deeper and more meaningful learning. However, the training also highlighted areas for improvement and innovation. While participants generally expressed satisfaction with the training, there are aspects that could be enhanced, such as providing pre-reading materials to prepare participants ahead of the training and improving post-training support to assist participants in applying what they've learned. Overall, this training has made a positive contribution to the professional development of teachers and the enhancement of education quality in the Greater Bandung area.

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