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Analyzing the Performance of a Gizduino-Based Modular Microcontroller Training System

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Abstract: ***When experimenting in the microcontroller laboratory, most students spend much time debugging the circuit connections on their breadboard rather than focusing more on the program code to be uploaded to their microcontroller. Thus, this study sought to design and fabricate a Gizduino-based microcontroller training board and use it as an educational tool for technological design activities. Circuit designs for every learning module are created using the NI Multisim software, and NI Ultiboard software was used to design the PCB layout of the entire training board. This development training board consists of fifteen (15) on-board embedded modules, including the mainboard. Using the created laboratory activities, the board was utilized to teach and learn microcontrollers using only one development training board. The selected students at Mindanao State University-Naawan, Naawan, Misamis Oriental, Philippines, characterized the training board as instrumental in enhancing their knowledge of microcontroller programming and interfacing. Moreover, the development board offers faster and more effective prototyping for Gizduino-based microcontroller projects.***

Keywords: ***Arduino-based microcontroller, Gizduino-based microcontroller, microcontroller, Multisim, Ultiboard, development training board, training modules, Arduino-based projects***

I. INTRODUCTION

Microcontrollers are versatile electronic chips that play a crucial role in controlling and monitoring various devices in the real world. Typically embedded in a wide range of electronic devices, a microcontroller functions as a compact, single-chip computer [1]. Its most significant feature is its ability to store and execute programs, distinguishing it from other components [2]. An integrated chip, a microcontroller, encompasses essential features found in microprocessors, including ROM, RAM, I/O ports, timers, counters, ADC, and a clock circuit [3]. Its affordability, compact size, low power consumption, and re-programmability make it a preferred choice for specialized applications, from simple household appliances to complex industrial systems.

The importance of studying a microcontroller system nowadays is increasing globally in various science and engineering branches. The utilization of microcontroller chips for embedded system functions is growing exponentially in most technological design activities in colleges and technological research institutes [1]. Educational institutions are responsible for providing students with appropriate skills and knowledge, and they need to be aware of the industry's needs and practices [4]. On the other hand, the industry is also responsible for identifying the needs and requirements.

Among the various microcontrollers available, the Arduino-based microcontroller stands out for its popularity and ease of use. As an open-source platform, Arduino simplifies coding and interfacing through readily accessible online libraries [5]. Its flexibility extends across a range of applications, including sensors and serial devices, and it boasts broad compatibility with multiple operating systems, including Windows XP, Vista, 7, 8, and 10, as well as Mac OSX and Linux [5]. This project, however, takes a unique approach by using the

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Gizduino microcontroller as the central microcontroller platform. We chose this type of microcontroller because it can be easily docked to our designed development board. The Gizduino MCU, developed here in the Philippines, offers functionality similar to the Arduino but at a lower cost, making it more accessible in certain regions. Its unique features and cost-effectiveness make it a valuable and innovative choice for our project.

This paper developed a laboratory manual for utilizing a Gizduino-based microcontroller training board. The microcontroller training board was also specifically designed and developed. The manual showcases the actual interface of the hardware, provides detailed sample codes, and includes step-by-step instructions for various experiments. Our students assessed and evaluated the effectiveness and usability of the training board through hands-on sessions and feedback surveys. The results indicate a significant improvement in the student's understanding and practical skills in microcontroller programming and applications.

II. METHODOLOGY

The Design

The design of the Gizduino-based microcontroller training module board was implemented using the simulation software called NI (National Instruments) MultiSim Capture and using the Gizduino MCU (Microcontroller Unit) ATmega324 as the main microcontroller. Designed circuits were laid out and simulated using the NI Multisim 13.0 to ensure the functionality of the designed circuits for the training board. Then, the PCB (Printed Circuit Board) layout of the entire board was created and rendered using NI Ultiboard 13.0.

Fig. 1 shows the placement of different training modules inside the development board. The microcontroller unit was mounted in the development board through the docking port.

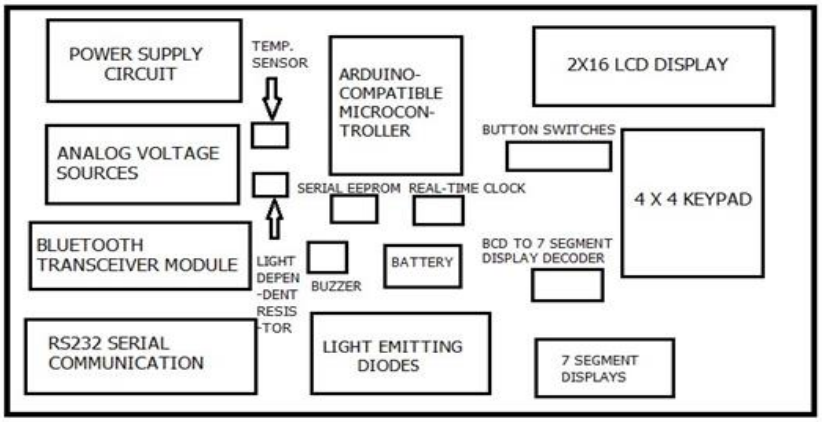

Fig. 1 The Set-up for the Training Module

The Gizduino MCU, as depicted in Fig. 2, is distinguishable by its male connectors, a feature absent in the Arduino MCU shown in Fig. 3. This unique feature of the Gizduino MCU allows for easy mounting to our development board, making it a more valuable choice for our project.

Fig. 2 The Gizduino MCU ATmega324 (Implying the Male Connectors)

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Fig. 3 The Arduino Uno MCU

The IDE (Integrated Development Environment) of NI Multisim 13.0 is shown in Fig. 4, where all the circuit modules of the development board were designed and simulated to ensure that the designed circuits in the development board would work when implemented. Fig. 5 shows the NI Ultiboard 13.0 environment where the PCB layout of the entire board was created.

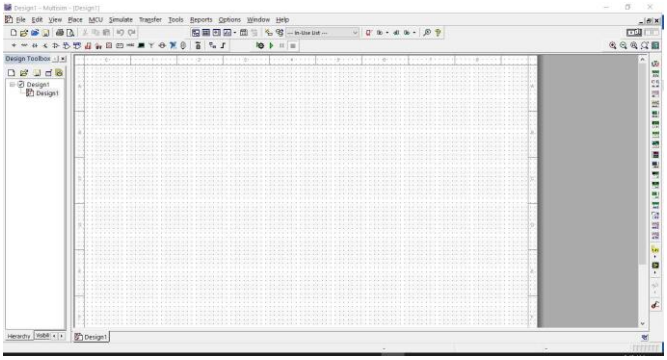

Fig. 4 The NI Multisim 13.0 Environment

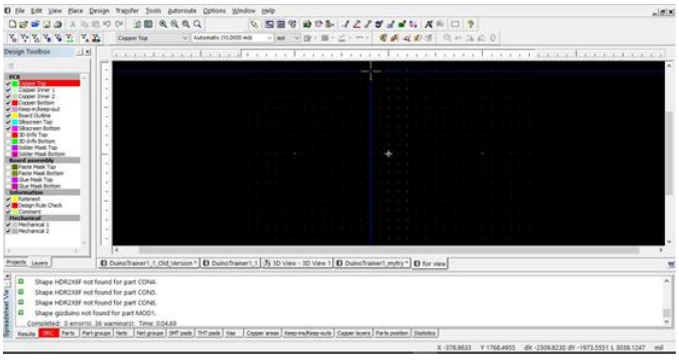

Fig. 5 The NI Ultiboard 13.0 Environment

The Development and Implementation

With the final design from the Ultiboard, the entire PCB was fabricated by a reputable company from another country. The electronic parts of the development board were procured through various suppliers and were soldered properly into the training board. The Arduino Sketch IDE, as shown in Fig. 6, was used to test the board components through different sample codes to verify their functionality and reliability.

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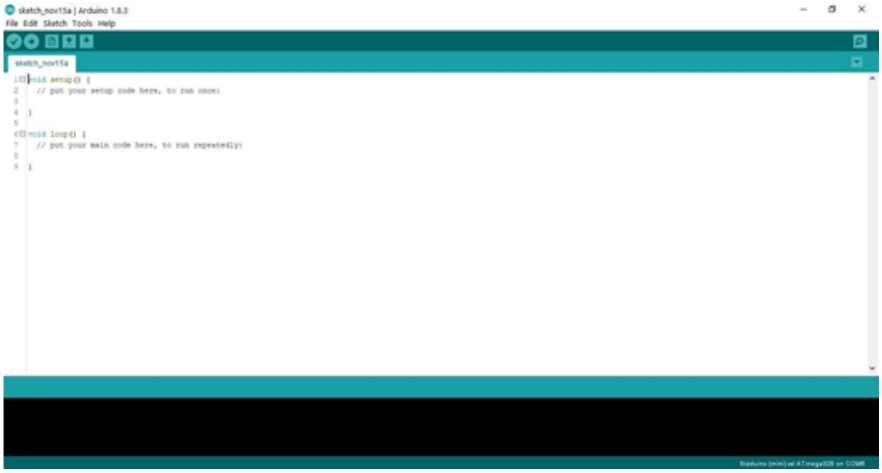

Fig. 6 The Arduino Sketch IDE 1.8.3 Environment

The Evaluation

The laboratory manual for the Gizduino-based training module board was developed and utilized to assess its effectiveness and usability. With a tested board and sample codes running, a comprehensive laboratory manual suitable for seminar workshops was developed. This manual contains clear learning objectives for each lesson and detailed activities, exercises, and practical applications to enhance learning. The correspondents were the BS Information Technology students. Questionnaires were presented to the correspondents to rate several aspects of the training board using the five-point rating scale descriptive statistics.

The laboratory manual includes a variety of activities designed to facilitate microcontroller learning. It targets students, hobbyists, or individuals interested in learning and building electronic projects using the Gizduino microcontroller. The manual covers nine (9) essential topics, each structured to build foundation knowledge and practical skills, namely (a) Basic Arduino Programming and Interfacing, (b) Analog Interfacing with LCD, (c) Serial Communication, (d) Keypad, (e) DS1307 RTC (Real-time Chip), (f) Multitasking, (g) Seven-Segment Display, (h) Bluetooth, and (i) Drivers and Shields.

Each topic is designed to be comprehensive, providing step-by-step instructions, illustrative diagrams, and example codes. This structured approach ensures that users can effectively learn and apply the concepts in practical scenarios.

III. RESULTS AND FINDINGS

The Design and Development

The final design was achieved using Multisim 13.0 and Ultiboard 13.0. Fig. 7 below indicates the various components and details of the Gizduino-based microcontroller training board.

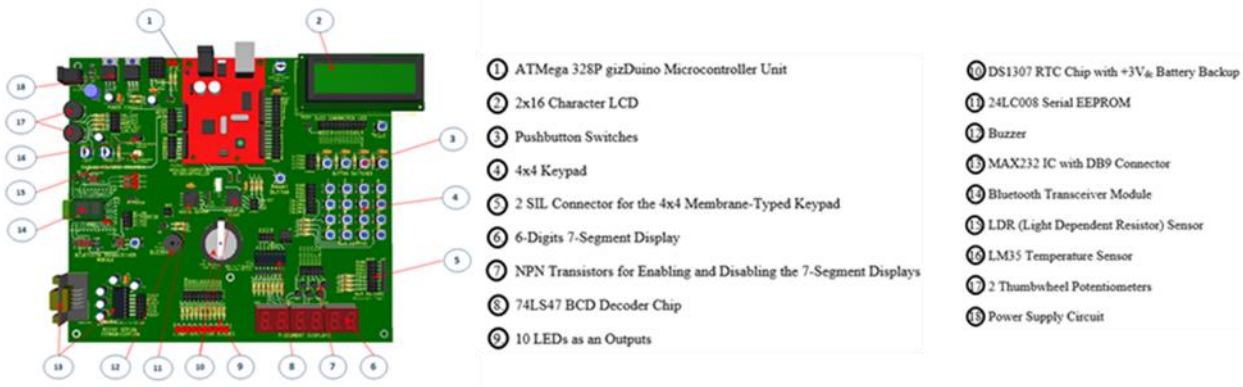

Fig. 7 The Final Design of the Trainer Board with Detailed Parts

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The Gerber files were sent to the PCB manufacturer in another country. Upon delivery of the PCB here in the Philippines, electronics parts were soldered to the specific locations of the PCB. The electronics parts were purchased from several electronics shops, including online shops. The entire board, then, was placed and screwed in a solid plastic casing. The actual development board is shown in Fig. 8, and Fig. 9 shows the board's accessories.

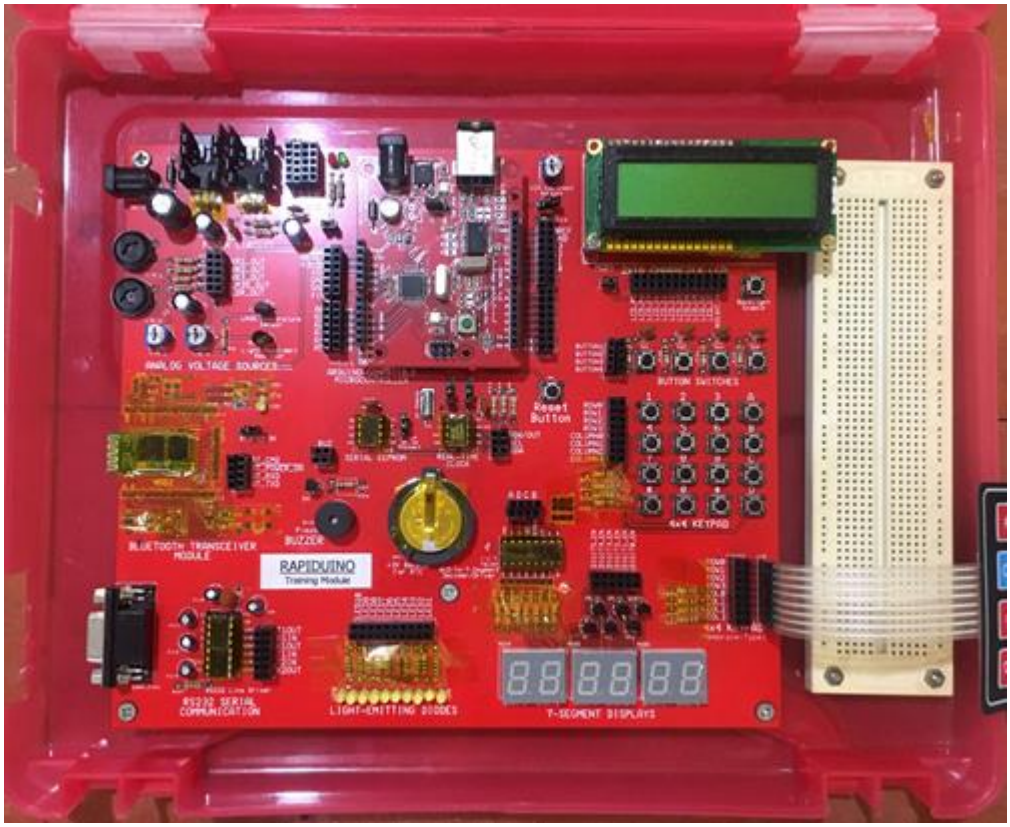

Fig. 8 The Gizduino-Based Modular Microcontroller Trainer with ATmega328 MCU

Fig. 9 The Accessories of the Training Board

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The board components were successfully tested using the sample codes uploaded to the Gizduino MCU by the Arduino Sketch software installed in the Intel Core i5 processor laptop with 8 GB memory and Windows 10 operating system.

The Evaluation

The training board was evaluated through a two-day training workshop about the basic programming and interfacing of Gizduino in one of the computer laboratories of Mindanao State University at Naawan (MSUN), Naawan, Misamis Oriental. Every computer desktop in the laboratory has an Intel Core i3 processor with 4 GB memory and a Windows 10 OS. Eight (8) fourth-year BS Information Technology (BSIT) students participated in the training workshop. The evaluation process involved a series of practical sessions where students interacted with the Gizduino-based microcontroller training module board. They followed the laboratory manual, executed the sample codes, and completed the activities and exercises provided. The assessment focused on the board's usability, the clarity of the manual, and the overall learning experience. Fig. 10 shows the workshop's location, and Figs. 11 and 12 show students interfacing with the development board.

Fig. 10 The Venue of the Workshop

Fig. 11 Students Interfacing with the Trainer Board

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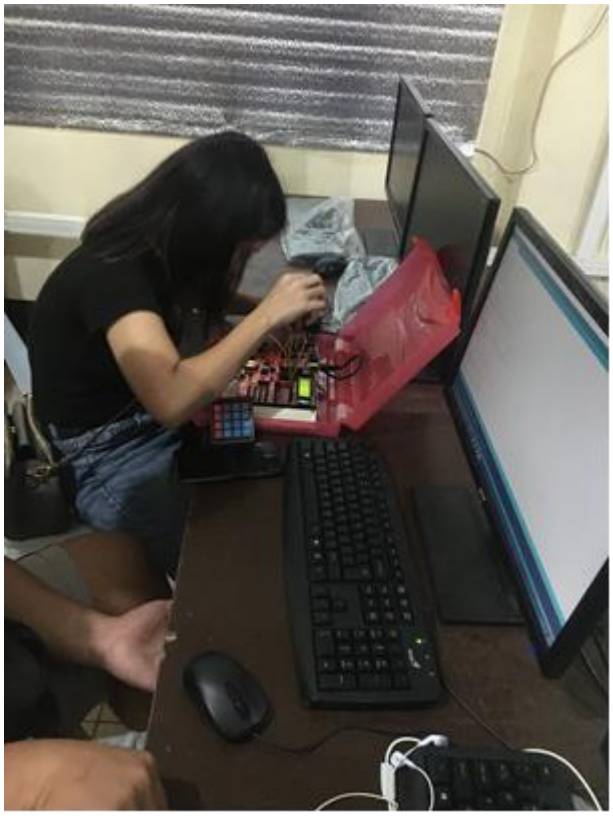

Fig. 12 A Student Connecting the Wires in the Trainer Board

Fig. 13 shows the title page of the created laboratory manual for the development board. Figs. 14 and 15 show the contents of the lab manual.

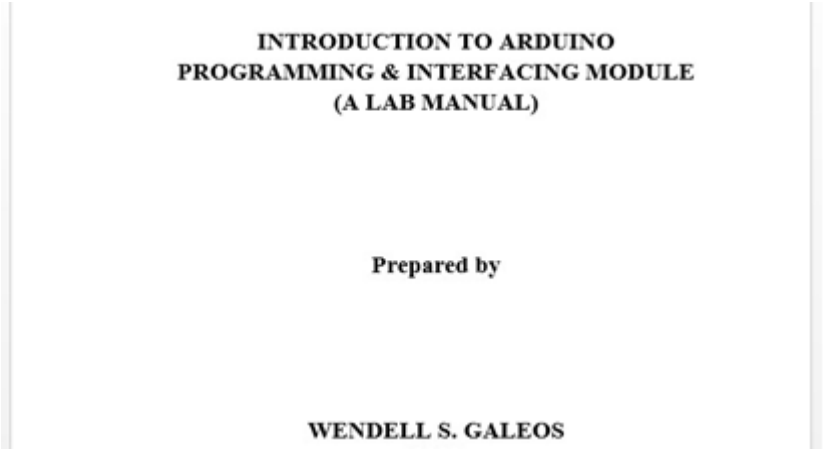

Fig. 13 Title Page of the Lab Manual

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TABLE OF CONTENTS

Fig. 14 Table of Contents of the Lab Manual

1 BASIC ARDUINO PROGRAMMING AND INTERFACING

Objectives:

After performing these activities, you will be able to:

1. Implement essential structure routines needed to work properly with Arduino and its compatible micro-controller such as gizDuino for Arduino sketch.
2. Get acquainted with some basic digital I/O functions in the Arduino IDE.
3. Write a simple program to control one or more LEDs.
4. Use tactile switch.
5. Utilize digital level readings on gizDuino pins.
6. Use a buzzer.
7. Control the buzzer's sound using gizDuino.

Activity # 1: LED INTERFACING

Discussion:

What is an LED? LED means Light-Emitting Diode. It emits visible light when activated. This is commonly used as status indicators. Series resistor is connected to it in order to protect it from over-current.

Fig. 15 The First Activity of the Lab Manual

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The eight (8) BSIT students were each provided with a laboratory manual. There were five (5) Gizduino-based training boards available for evaluation. Three (3) pairs of participants shared one (1) training board, while the remaining two (2) participants had a one-on-one experience with the training board. Twenty percent (20%) of the participants needed more knowledge about microcontrollers, while the others had none.

The evaluation process involved several key activities to ensure comprehensive hands-on experience. The participants prepared the training boards, installed the Arduino IDE and the Prolific USB Driver in their computer desktop, and interfaced with the LCD and the 7-segment display of the trainer board. They also experimented with Bluetooth communication between the training board and Android phones. Additionally, they practiced DC Motor Control, which included connecting the motor wires to the driver controller and demonstrating stepper motor control. Lastly, they work with the SD/MMC shield.

After the workshop, attendees were surveyed to evaluate the effectiveness of the training board and gather feedback for future improvements. The survey aimed to determine the workshop's impact on the student's knowledge and the potential usefulness of such seminars in the future.

Overall, the students found the workshop helpful in enhancing their programming and interfacing skills, as shown in Table I. They were delighted with the workshop content and the topics discussed. Attendees reported increased awareness, knowledge gains, and new ideas for collaboration and implementation using the Gizduino.

Participants provided specific recommendations for improving the workshop and the training kit, including (a) allowing more time to inform the public about the seminar-workshop, (b) increasing the number of training kits to accommodate more participants, (c) upgrading the microcontroller used in the training kit, (d) adding more activities and exercises; and (e) including additional modules in the training kit.

TABLE I
Workshop And Training Kit Outcomes (n=8)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The workshop helped me how to program the Arduino microcontroller and to understand how to interface it with different input and output devices using the training kit module.	7 (87.8%)	1 (12.50%)			
The Arduino training kit module helped me a lot in learning the programming and interfacing of the Arduino microcontroller in a faster way.	7 (87.8%)	1 (12.50%)			
The workshop showcased examples of how to interface all the components in the training kit.	7 (87.8%)	1 (12.50%)			
After this workshop, I have a better understanding of programming and interfacing of the Arduino microcontroller.	7 (87.8%)	1 (12.50%)			
Interactions and discussions with the lecturer and with my peers gave me ideas for implementing a possible Arduino project to solve or improve a certain problem.	7 (87.8%)	1 (12.50%)			
I expect to use the information gained from this workshop to initiate implementation plans for a Capstone project or Thesis.	6 (75.0%)	2 (25.00%)			
After the workshop, I plan to contact the lecturer to further discuss and share ideas for a possible Arduino project.	6 (75.0%)	2 (25.00%)			

In their open-ended responses about the workshop and training kit, participants stated that the experience was precious. It provided a unique opportunity to program the Gizduino MCU and interface it with various modules in the training kit. Participants appreciated discussing potential Gizduino projects with their peers and the lecturer. Some mentioned contacting the lecturer for further guidance on Gizduino MCU projects.

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For the overall feedback to the workshop, as shown in Table II, participants highlighted that the content presented was excellent. They appreciated the thorough coverage of topics and found the hands-on sessions particularly beneficial for reinforcing their learning. The interactive format was praised for fostering a collaborative environment, allowing them to engage in meaningful discussions and exchange ideas with peers and the lecturer.

TABLE II
Overall Workshop Feedback (n=8)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The content presented and discussed was informative and relevant to challenges for learning Arduino programming and interfacing.	7 (87.8%)	1 (12.50%)			
The workshop enhanced my knowledge.	6 (75.0%)	2 (25.00%)			
The workshop was well organized.	7 (87.8%)	1 (12.50%)			
The workshop format encouraged interaction, discussion and learning.	7 (87.8%)	1 (12.50%)			

For their satisfaction with the workshop, as shown in Table III, participants reiterated their level of satisfaction with the quality content of the workshop and the training kit. Many students noted that the pacing of the lecture was appropriate and that outlining the day's topics helped them manage time effectively. Other valued features of the workshop included knowledge sharing, small-group discussions on specific program codes, and the opportunity to share and hear about effective strategies and lessons in Gizduino programming and interfacing.

TABLE III
Workshop Satisfaction (n=8)

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Overall quality of the workshop and the experience.	7 (87.8%)	1 (12.50%)			
Quality of lecturer/presenter.	7 (87.8%)	1 (12.50%)			
Networking and knowledge sharing opportunities.	7 (87.8%)	1 (12.50%)			
Workshop materials and training kit.	7 (87.8%)	1 (12.50%)			
Pace and time management.	7 (87.8%)	1 (12.50%)			
Outreach and communication about the workshop.	7 (87.8%)	1 (12.50%)			
Workshop facilities.	7 (87.8%)	1 (12.50%)			
Location of the workshop	7 (87.8%)	1 (12.50%)			

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The overall evaluation of the training workshop received positive feedback. Participants praised the content, organization, and hands-on experience, noting significant improvements in their Arduino programming and interfacing skills. The constructive suggestions will help refine the training board's functions and ensure a better learning experience.

IV. CONCLUSIONS

In conclusion, the Gizduino-based development board was successfully designed and fabricated into a fully functional training tool. This training board showcases the potential for creating embedded system trainers with diverse functional modules. Accompanied by a detailed lab manual, this board is a practical educational resource for teaching and learning microcontroller applications. It provides engineering and technical education students with valuable hands-on experience in programming and implementing the Gizduino microcontroller across various embedded systems.

The trainer features fifteen (15) on-board embedded modules, including the main board, enabling comprehensive learning opportunities. Future enhancements should consider incorporating additional modules such as GPS, GSM, Ethernet for LAN networks, RFID, and a fingerprint module. Integrating motor drivers, SD/MMC, and Wi-Fi interface circuitry on the board will further expand its capabilities. Upgrading to the Gizduino ATmega1281 as the main microcontroller will ensure compatibility with newer technologies in embedded systems.

Overall, this development board and its accompanying resources offer a robust platform for advancing students' knowledge and skills in embedded system applications.

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