P-ISSN: 2776-7329, E-ISSN: 2776-7310
Proceedings
5th Vocational Education International Conference
Semarang, 13 July 2023

Microcontroller Trainer Simulation in Basic Programming Courses

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ABSTRACT
The purpose of this study was to (1) develop microcontroller programming simulations in basic programming courses (2) find out how to use microcontroller learning simulations in basic programming courses. In designing this learning simulation, researchers used the ADDIE development model. To be precise, in the Informatics Engineering department, the test subjects were class A students class of 2022. The trials in this study were carried out three times, namely one-to-one trials, small group trials and field trials. Data collection techniques are questionnaires and tests. The instruments used in collecting data are observation, documentation, and tests.
Keywords:

Keywords: *Development, Microcontroller, Programming.*

1. INTRODUCTION

Education in English means Education is a conscious, real, and planned effort that is applied in a learning process in order to improve the quality and abilities of students who have a desire to always develop their potential. Advances in information and communication technology have made the challenges faced by academics increasingly competitive. In its development, the term "education" or "pedagogic" describes the intentional guidance process carried out by adults to help individuals achieve maturity [1]. The Government Regulations and Regulations of the Minister of Health that will be formed are also part of the type of legislation so that their formation must also use definite, standard, and standard methods and methods. It is feared that the effects of this global pandemic will have an unfavorable impact and hamper the activities of the world community for the next few years. The impact of all the instability caused by this epidemic is very influential on the quality of the output of students (students) because the implementation of the educational process is different from before around the world.

In Indonesia, learning strategies that prioritize student skills to be more active certainly require more in-depth development and renewal, according to what has been regulated in [2] The National Education System Law No. 20 of 2003, specifically in CHAPTER II Article 3, states that the primary purpose of national education is to foster the development of individuals' abilities and cultivate their character and civilization, ultimately contributing to the well-being and progress of the nation. The education system aims to unlock the potential of students, enabling them to become individuals who possess strong faith and reverence for the Almighty, exhibit noble character, enjoy good health, acquire knowledge, demonstrate competence, express creativity, embrace independence, and actively participate as democratic and responsible citizens. In essence, this law emphasizes several key aspects:

1. Capability development: National education endeavors to enhance students' potential and skills, equipping them with the knowledge and competencies necessary for personal growth and future success.
2. Character and civilization formation: Education plays a vital role in shaping the moral character and advancing the civilization of the nation. Its objective is to instill essential values, ethics, and moral principles in students, promoting virtues such as honesty, integrity, respect, and tolerance.
3. Cultivating a national identity: Education is an integral part of national life, contributing to the nation's progress by nurturing individuals who are well-prepared to make positive contributions to society and the country.
4. Faith and devotion to the Almighty: Recognizing the significance of religious beliefs and spirituality in

education, the law highlights the importance of strengthening faith and fostering reverence for the Almighty in students.

5. Noble character development: Education aims to foster noble character traits in students, including humility, compassion, honesty, and empathy. These virtues are crucial for individuals to become responsible and ethical members of society.
6. Promotion of health: National education places importance on promoting the health and well-being of students. It encourages the adoption of healthy lifestyles, physical fitness, and a balanced approach to life.
7. Encouragement of knowledge acquisition: Education serves as a pathway for acquiring knowledge and fostering intellectual growth. Its goal is to provide students with diverse knowledge and stimulate their love for learning, critical thinking, and problem-solving abilities.
8. Nurturing creativity: National education seeks to nurture creativity and innovation in students, fostering an environment that encourages thinking beyond conventional boundaries and exploring new ideas.

In summary, the National Education System Law underscores the objectives of national education, including the development of students' potential, the cultivation of their character and civilization, and the preparation of responsible individuals who contribute to the nation's progress.

Especially in Bone Bolango Regency itself Universitas Negeri Gorontalo is one of the leading universities, so it is always required and challenged to follow the development of science, especially in the field of informatics and computer competence, especially in the informatics management study program which is expected to always make a positive contribution to the realm of skills development.

This study aims to describe the learning outcomes of interactive multimedia microcontroller and simulation. describe learning outcomes using virtual media in computer assembly practicum, develop microcontroller programming simulations in basic programming courses in computer assembly practicum.

The Programming Virtual course is a very interesting scientific tool and even has the potential to be studied in depth. Learning media in the form of a Personal Computer/Notebook assembly simulation can be one of the potentials that can be used by students in order to face the demands of increasing knowledge and competence in facing the practicum learning process. Simulation-based learning media like this will also make students more interested in improving learning outcomes and eliminating the limitations of time and learning space. Arduino is an electronics prototyping platform that utilizes both software and hardware components. Its primary purpose is to simplify the development of electronic projects that involve various components and sensors. With Arduino, users can create their own electronic devices without the need for an extensive background in electronics engineering.

1.1. Microcontroller

A microcontroller is a compact electronic device that combines a processor, memory, and input/output components on a single chip. It serves as the control center for electronic systems, managing operations and coordinating various elements. Microcontrollers find wide applications in consumer electronics, automation, robotics, and IoT devices. They are programmed for specific tasks, interact with sensors, communicate with other devices, and execute commands. Microcontrollers are known for their efficiency, come in different types, and offer development tools for programming and customization. They play a crucial role in powering electronic devices and systems of all sizes and complexities. [3] A microcontroller is a single chip device that typically consists of a CPU, RAM, ROM, and I/O, used in control systems. That's mean microcontroller is a compact integrated circuit that combines a CPU, RAM, ROM, and I/O components to perform control functions in embedded systems. It is a versatile chip used in automation, robotics, consumer electronics, automotive systems, and industrial control. The CPU executes instructions, while RAM provides temporary storage, and ROM holds pre-programmed data. I/O peripherals enable interaction with external devices. Microcontrollers offer a cost-effective and programmable solution for device control, making them essential in modern technology applications.

1.2. Arduino

[4] Control refers to the management and regulation of a system process to align with human intentions when performing various activities. Arduino was originally developed in 2005 by a team led by Massimo Banzi in Italy. Initially, it was designed as an affordable and rapid prototyping platform for electronic devices. However, it has since gained widespread popularity and is now widely used across the globe.

The programming language used in Arduino is C++, which is a commonly employed language among software and hardware developers. Additionally, Arduino offers an accessible and free Integrated Development Environment (IDE) that can be used on Windows, Mac, and Linux operating systems.

[5] One advantage of the Arduino microcontroller is its ease of controlling and managing digital and analog inputs and outputs, making it applicable to a wide range of projects such as control systems, monitoring systems, automation, and various other projects. Additionally, the Arduino microcontroller can also serve as a learning tool for understanding the fundamentals of electronics and

programming.

One of the key advantages of Arduino is its user-friendliness. Even individuals without prior knowledge of electronics can quickly grasp the fundamentals of Arduino. Moreover, Arduino's open-source nature has resulted in the availability of numerous free online resources and tutorials, contributed by a wide community of users.

Arduino is versatile and applicable to a broad range of projects, ranging from simple to complex and sophisticated. Examples of projects that can be accomplished with Arduino include robotics, temperature and humidity sensing, automated lighting control, and more.

When it comes to components and accessories, Arduino offers abundant options and flexibility. Various Arduino boards with diverse features and specifications are available. Additionally, a wide array of compatible sensors and components, such as temperature sensors, light sensors, and servo motors, can be integrated with Arduino.

To sum up, Arduino is a highly flexible and user-friendly electronics platform suitable for beginners and experienced electronic developers alike. If you're interested in embarking on an Arduino journey, there is a wealth of online resources and tutorials readily accessible to help you kickstart your learning process.

1.3. Programming

Basic programming covers fundamental concepts like syntax, variables, control structures, functions, input/output handling, error management, and problem-solving skills. Practical exercises aid skill development and create a foundation for further programming. [6] The acquisition of programming expertise cannot be uniformly taught to individuals. This is due to the presence of different proficiency levels in programming, ranging from logical reasoning skills to mastery of a chosen programming language, advanced programming frameworks, and the ability to develop real-world computer-based systems. Before individuals can become proficient in creating computer programs, it is essential to establish a strong foundation in logic and basic programming concepts.

Table 1. Knowledge and Understanding of Basic Programming Concepts

Concept	Description
Syntax	Rules and structure of a programming language
Variables	Containers for storing and manipulating data
Control Structures	Constructs for controlling the flow of program execution
Functions	Blocks of code that perform specific tasks
Input/Output Handling	Interacting with users and displaying information
Error Management	Handling and responding to errors and exceptions
Problem-Solving Skills	Analyzing problems and devising solutions
Practical Exercises	Hands-on activities to apply and reinforce programming concepts
Foundation	Building a base for further learning and development in programming

1.4. Microcontroller Programming Simulation

There are several online simulators available that allow you to simulate Arduino and ESP32 development without physical hardware. These simulators provide a virtual environment where you can design circuits, write code, and test the behavior of your Arduino or ESP32 projects. Some popular options include Tinkercad, Autodesk EAGLE, EasyEDA, Circuito.io, and Wokwi Arduino Simulator. These simulators enable you to simulate circuits, write and test code, and interact with virtual components. However, it's important to keep in mind that while these simulators provide a convenient way to prototype and test projects, real-world hardware testing is still recommended for accurate results and performance evaluation, example of a simple Arduino project using the Wokwi Arduino Simulator:

```
// Blink an LED on pin 13

void setup() {
  pinMode(13, OUTPUT); // Set pin 13 as output
}

void loop() {
  digitalWrite(13, HIGH); // Turn on the LED
  delay(1000); // Wait for 1 second
  digitalWrite(13, LOW); // Turn off the LED
  delay(1000); // Wait for 1 second
}
```

Figure 1 Simple Arduino project using the Wokwi Arduino Simulator.

According this scrip the wokwi connection between an Arduino Uno and an LED using pin 13. A 220-ohm resistor is incorporated to safeguard the LED from high currents. This project results in the LED blinking at regular intervals of 1 second. [7] The ArduinoWOKWISimulator is a recently launched online

simulator developed by CodeMagicLTD, designed specifically for Arduino and other microcontroller modules.

In conclusion, the Arduino WOKWI Simulator is a helpful online tool for Arduino and microcontroller enthusiasts. It allows users to learn, experiment, and test Arduino projects without physical hardware. The simulator has an easy-to-use interface and lets users write, test, and fix code efficiently. It's great for beginners learning programming and experienced users prototyping ideas. Overall, the Arduino WOKWI Simulator simplifies microcontroller development, making it accessible to everyone.

2. METHOD

This research use R&D (Research and Development) process involves simplified steps to develop new knowledge, technology, or products. These steps include identifying the problem, formulating a hypothesis, designing the research, implementing it, analyzing the data, interpreting the results, and drawing conclusions with implications for theory and practice. The process is iterative and aims to address challenges and achieve research objectives effectively.

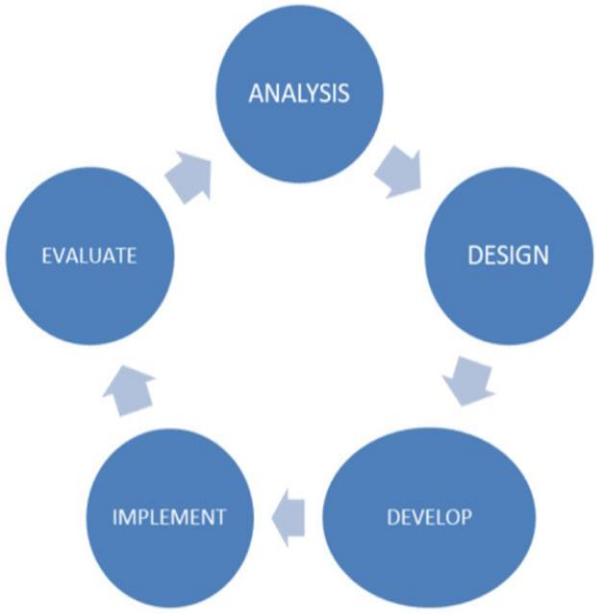

Figure 2 ADDIE Model.

Source : Penelitian Pengembangan Model Addie dan R2d2 Teori & Praktek (2020)

The Research and Development (R&D) process for creating the Arduino Microcontroller Trainer involves the following steps:

1. Analysis Stage: This initial stage focuses on analyzing the microcontroller and interface course. It includes:
   a. Assessing the required competencies of the learners.
   b. Evaluating the characteristics of the learners.
2. Design Stage: In this phase, a plan is developed based on observations to achieve the desired learning outcomes. The steps involved are:
   a. Selecting appropriate course materials based on learner characteristics and competencies.
   b. Defining clear learning objectives for the students.
3. Development Stage: This stage involves creating the learning resources and conducting validation. The steps include:
   a. Developing the Semester Learning Plan (RPS).
   b. Creating the Arduino microcontroller trainer, including all learning materials.
4. Implementation Stage: The developed trainer is implemented in the learning process to assess its effectiveness. This stage involves:
   a. Deploying the Arduino microcontroller trainer during actual teaching and learning sessions.
5. Evaluation Stage: Evaluation is an ongoing process conducted at each stage of the development.

3. RESULTS AND DISCUSSION

Furthermore, it is important to note that the overall assessment of the components validated by experts indicated their usability. All validators provided positive evaluations, affirming that the components were suitable for practical application.

Field trials were conducted to simulate actual learning conditions, involving a sample of 15 students. The results of the trial stages indicated a significant increase in student responses. During the one-to-one trial stage, the average percentage of student responses was 81.10%, demonstrating a favorable reception of the Arduino Microcontroller Trainer. This percentage further increased to 84.00% during the small group trial stage, indicating growing satisfaction and acceptance. Finally, in the field trial stage, an average percentage of 88.80% was achieved, affirming the practicality and effectiveness of the trainer in enhancing the learning experience for students.

Lecturer responses were collected by involving instructors who taught microcontroller and interface courses. To assess learning outcomes, multiple-choice questions were administered at the beginning and end of each session. The analysis of the learning outcome data revealed a substantial difference of 0.72 between the pretest and posttest values, which falls within the high category on the gain test. These positive changes demonstrate the significant positive influence of the Arduino Microcontroller Trainer in improving student learning outcomes.

In conclusion, the validation analysis, including expert assessments, student feedback, and learning outcome evaluations, provides strong evidence for the high validity, practicality, and effectiveness of the Arduino Microcontroller Trainer. The trainer has been well-received by both instructors and students, and it has demonstrated its ability to enhance the learning

experience and improve learning outcomes in microcontroller and interface courses.

4. CONCLUSION

Based on the results of research and development, it can be concluded several things as follows:

1. The Programming Virtual course development process was developed using the ADDIE development model which consists of 5 stages, namely, (1) Analyze; needs analysis to determine the right problems and solutions and determine student competencies in the Basic Programming class of 2022 class students (2) Design; determine the special competencies, methods, teaching materials, and learning strategies for class A students of class 2022 Informatics Engineering UNG. (3) Development; developed the Microcontroller Trainer. (4) Implementation; carry out a learning program by applying the Simuation Trainer in class 2022 student courses (5) Evaluation; This evaluation stage is carried out at all stages, especially at the design stage and the development stage.
2. The resulting product is in the form of microcontroller simulation media which has been declared valid, practical, and effective to be used as learning media for 2022 students.

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