UNDERGRADUATE THESIS

DESIGN AND CONSTRUCTION OF AN MULTIFUNCTIONAL EDUCATIONAL MOBILE ROBOT FOR STEM LEARNING BASED ON VISUAL PROGRAMMING USING ESP32

MOCHAMAD FARID FADLULLOH
NPM 19081010148

THESIS ADVISORS
Dr. I Gede Susrama Mas Diyasa, ST., MT.IPU
Prof. Dr. Basuki Rahmat, MT

MINISTRY OF HIGHER EDUCATION, SCIENCE, AND TECHNOLOGY
UNIVERSITAS PEMBANGUNAN NASIONAL VETERAN JAWA TIMUR
FACULTY OF COMPUTER SCIENCE
INFORMATICS STUDY PROGRAM
SURABAYA
2026

APPROVAL SHEET

DESIGN AND CONSTRUCTION OF AN MULTIFUNCTIONAL EDUCATIONAL MOBILE ROBOT FOR STEM LEARNING BASED ON VISUAL PROGRAMMING USING ESP32

By :
MOCHAMAD FARID FADHLULLOH
NPM. 19081010148

Has been defended before and accepted by the Thesis Examination Committee of the Informatics Study Program, Faculty of Computer Science, Universitas Pembangunan Nasional Veteran Jawa Timur, on June 17, 2026:

Approved,

Dr. I Gede Susrama Mas Diyasa, ST., MT.
IPU
NIP. 19700619 2021211 009 ..... **(Advisor I)**

Prof. Dr. Basuki Rahmat, MT
NIP. 19690723 2021211 002 ..... **(Advisor II)**

Dr. Ir. Mohammad Idhom, S.P., S.Kom., MT
NIP. 19830310 2121211 006 ..... **(Assessor 1)**

Ardhom Rakhmadi, S.Tr.T., M.Kom
NIP. 19910805 2024061 002 ..... **(Assessor 2)**

Acknowledged by,

Dean of Faculty of Computer Science

Prof. Dr. Ir. Novirina Hendrasarie, MT
NIP. 19681126 199403 2 001

APPROVAL SHEET

DESIGN AND CONSTRUCTION OF AN MULTIFUNCTIONAL EDUCATIONAL MOBILE ROBOT FOR STEM LEARNING BASED ON VISUAL PROGRAMMING USING ESP32

By :
MOCHAMAD FARID FADHLULLOH
NPM. 19081010148

Approved to proceed to the Thesis Examination

Approved by,

Coordinator of Informatics Study Program
Faculty of Computer Science

Dr. Intan Yuniar Purbasari, S.Kom. M.Sc
NIP. 198006022 025212 029

STATEMENT OF ORIGINALITY

I am the undersigned:

Student Name	: Mochamad Farid Fadhlulloh
NPM	: 19081010148
Degree Program	: Bachelor (S1)
Study Program	: Informatics
Faculty	: Faculty of Computer Science

Hereby declares that this undergraduate thesis contains no part of any other scientific work that has been submitted to obtain an academic degree at any higher education institution. Furthermore, it does not contain any work or opinions previously written or published by others, except for those which are explicitly cited in this thesis and listed completely in references.

And I declare that this scientific document is free from elements of plagiarism. If in the future indications of plagiarism are found in this Thesis, I am willing to accept sanctions in accordance with the applicable laws and regulations.

Thus, I made this statement without any coercion from anyone and to be used as it should.

Surabaya, June 26 2026
Declarant,

MOCHAMAD FARID FADHLULLOH
NPM. 19081010148

ABSTRACT

Student Name / NPM	:	Mochamad Farid Fadhlulloh / 19081010148
Thesis Title	:	Design And Construction Of An Multifunctional Educational Mobile Robot For Stem Learning Based On Visual Programming Using ESP32
Advisor	:	1. Dr. I Gede Susrama Mas Diyasa, ST., MT.IPU 2. Prof. Dr. Basuki Rahmat, MT

STEM-based learning (Science, Technology, Engineering, and Mathematics) requires interactive and applicable media to enhance 21st-century skills such as critical thinking, creativity, and problem solving. However, currently available STEM learning media are still lacking in interactivity, the price of commercial robotics platforms is relatively expensive, and the use of text-based programming languages poses a barrier for students who do not yet have a programming background. This research aims to design and build a multifunctional educational mobile robot based on the ESP32 microcontroller by applying the Finite State Machine (FSM) method as a decision-making mechanism for each operating mode, as well as implementing Scratch/PictoBlox-based visual programming. The research method used is Research and Development (R&D) with the Prototyping Model as the product development framework and the V-Model as the system verification and validation framework. A Moore Machine type FSM was applied to model the robot's behavior across three operating modes, namely line follower (4 states), obstacle avoidance (4 states), and smartphone control (9 states). The test results show that the HC-SR04 ultrasonic sensor has an average error of 1.48%, the TCRT5000 line sensor achieves a detection success rate of 96.7%, and Bluetooth communication remains stable up to a distance of 8 meters. The line follower and obstacle avoidance modes each achieved a 90% success rate with 90% FSM conformity, while the smartphone control mode achieved 100% with a response time under 100 ms. The application of FSM successfully modeled the robot's behavior in a structured, deterministic, and well-documented manner, and could be translated directly into PictoBlox visual programming blocks. Thus, this robot is effective as an interactive, flexible STEM learning medium that is easy to use across various levels of education.

Keywords: ESP32, Finite State Machine, Mobile Robot, PictoBlox, Visual Programming, STEM.

ACKNOWLEDGEMENT

All praise and gratitude are devoted to Allah SWT for His abundant grace and blessings bestowed upon the author, enabling the completion of the undergraduate thesis entitled **"Design And Construction Of An Multifunctional Educational Mobile Robot For Stem Learning Based On Visual Programming Using ESP32***"*.

On this occasion, the author would also like to express sincere appreciation and gratitude to all parties who have provided their support, thereby facilitating the completion of this thesis, in particular to:

1. Mr. Prof. Dr. Ir. Akhmad Fauzi, M.MT., IPU., as the Rector of National Development University "Veteran" East Java,
2. Mrs. Prof. Dr. Ir. Novirina Hendrasarie, MT., as the Dean of the Faculty of Computer Science, National Development University "Veteran" East Java,
3. Mrs. Dr. Intan Yuniar Purbasari, S.Kom., MSc., as the Coordinator of Informatics Study Program, Faculty of Computer Science, National Development University of East Java,
4. Mr. Dr. I Gede Susrama Mas Diyasa, ST. MT. IPU, as the first advisor of the author,
5. Mr. Prof. Dr. Basuki Rahmat, MT., as the second advisor of the author,
6. Mr. Dr. Ir. Mohammad Idhom, S.P., S.Kom., MT., and Mr. Ardhon Rakhmadi, S.Tr.T, M.Kom., as the assessor,
7. Mr. Andreas Nugroho Sihananto, S.Kom., M.Kom as the thesis coordinator who organized the entire thesis process to ensure its smooth progression,
8. Lecturers of the Informatics Departement, National Development University of East Java Veterans for their guidance during the author's education.
9. The parents of the author, who have continuously provided prayers, support, and motivation for the completion of this thesis,
10. Fellow students of the Informatics Study Program, Class of 2019, who have strived together toward graduation,

11. All parties who have assisted the author in completing this thesis and cannot be mentioned individually.

The author realizes that in the preparation of the following thesis there are many shortcomings. For this reason, constructive criticism and suggestions from all parties are highly expected for the perfection of writing the following thesis. Finally, with all the limitations that the author has, hopefully the following report can be useful for all parties in general and the author in particular.

Surabaya, June 26 2026

Mochamad Farid Fadhlulloh

TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLE