Line follower robot module design for increasing student comprehension in robotics

N E Budiyanta¹, I A Darmawan²*, A Sarah¹, M Mulyadi¹, H Tanudjaja¹ and S O B Widiarto¹
¹ Department of Electrical Engineering, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia
² Department of Electrical Engineering Vocational Education, Faculty of Teacher Training, Sultan Ageng Tirtayasa University, Banten, Indonesia

*ilham.ad@untirta.ac.id

Abstract. The use of instructional media is a very important aspect to consider in teaching practice. This study aims to design an effective robotics learning media among adolescents as an effort to socialize robotics technology. This study used a research development model of learning media that can be used to make effective and fun robotic learning. The development of learning media is carried out based on several stages, namely Analysis, Design, Development Implementation and Evaluation (ADDIE). The results of this study indicate that the designs made in general are in the excellent category with an average value of 86.3%. The application of learning media can also be said to be effective with an increment value of 36.83% compared to the learning activities previously carried out. Therefore, robotic learning media in the form of a line follower robot module is one of the learning media that can be used to improve student understanding in robotic learning.

1. Introduction
Technological advances have now penetrated all aspects of human life. The history of the use of technology in society also shows the existence of increasingly strong connections. In addition, these advances also make humans very dependent on technology in living life [1]. In response to this, the community must have the ability to be involved in technological development. However, involvement in technological advancements requires learners' confidence to become accustomed to applying their expertise [2].

In academic studies, technological developments always attract the attention of researchers. Nowadays, there is increasing access to gain any technical skills such as microcontrollers along with the development of education, one of them is vocational education and training [3-5]. Vocational education has a role to produce people who are skilled with and have the ability to interact with tasks in workplace organizations properly and correctly [6]. However, vocational education must pay attention to the skills of its teachers. The implementation of vocational education must be supported by adequate infrastructure to create skills formation. Concretely, vocational education requires a conducive and effective learning climate [7-9].

The field of Robotics and Microcontroller is still a very interesting topic to study Vocational learning, especially regarding the teaching techniques such as various studies conducted by [10-13]. Based on the
Research findings, it is known that the learning media and techniques used are very influential on learning outcomes. In addition, teaching research by paying attention to various elements such as interaction in class, grouping, discussion, competition is known to increase students' understanding of the material being studied [14-16]. However, in most studies that have been carried out, various aspects such as the characteristics of materials with techniques and the structure of teaching and media are often ignored.

This study was conducted as one step to create a robotic learning media and also a learning model that can optimally explore students' potential and creativity [17]. The learning media created in this study have a coherence between the characteristics of the material, teaching techniques and also the learning media used. As a contribution to improving the quality of learning or lean vocational, this study also provides a form of comprehensive learning design for vocational students to be able to optimize their full potential in robotic and microcontroller learning.

2. Method

Vocational Education and Training in the Field of Microcontrollers is a training model created to facilitate students in learning robotics. The procedure in this study was adopted from the ADDIE development model with context adjustment. The equipment designed in this study is adjusted to the training needs based on an initial analysis of the students. The results of the tools designed in this study are expected to facilitate the teaching of microcontrollers to students. The illustration from this study can be seen as shown in Figure 1.

![Figure 1. Research methodology.](image)

Based on Figure 1, it is known that in general there are 5 stages carried out in making robotic learning media, namely Analysis, Design, Development, Implementation, and Evaluation. In the first stage, information about the subject that will be targeted as learning is collected. These things are done by conducting surveys or observations, the results of these observations are then used as a basis for designing and developing a robot that will be used as a learning media. In the next stage, the designed media will be evaluated after its implementation in learning. The results of the next evaluation will be used as input for developing tools so that their functions can be better.

The data collection techniques in this study used test sheets and also questionnaires that were analyzed with a Likert scale with the criteria of "very poor", "poor", "good", "very good".
Table 1. Score conversion.

| Percentage (%) | Criteria       |
|----------------|---------------|
| 0% - 25%       | Very Poor     |
| 26% - 50%      | Poor          |
| 51% - 75%      | Good          |
| 76% - 100%     | Very Good     |

Based on these criteria, Robot Line Follower can be called good and can help facilitate robotic learning if it has a percentage above 75 percent.

\[ \text{Percentage (\%)} = \frac{\text{Total Actual Score}}{\text{Total Ideal Score}} \times 100\% \]

3. Result and discussion

3.1. Analysis

Analysis is the initial stage of conducting an assessment to formulate the fundamental foundation of the robotics course. Based on observations of students involved in robotic learning, not all of them can absorb the lesson well.

![Problem Observation](image)

Figure 2. Observation results regarding problems in class.

Figure 2 shows that the dominant problem faced based on the results of initial observations is weak cooperation between students and the delivery of material that is too vague in the classroom. The problems in learning are caused by differences in comprehension as expressed by Halsal et al [17]. Therefore, more effective robotics courses are needed so that students' skills can grow evenly and optimally.

3.2. Design and development

The learning media design as an instrument to facilitate learning is the most appropriate concrete step. A robot media created is a robot that contains learning objectives, namely the achievement of minimal competence in each student. This robot is designed for used in learning an automatic line follower concept with a block diagram which can be seen in Figure 3.
The robot design is equipped with Liquid Crystal Display (LCD) and push buttons to assist the operational process. These features are parts that can trigger the ability of students in learning projects that are carried out as implemented by Project-Based learning (PBL) referred to by Fernandes [7].

The sensor used in the line follower feature is the light sensor. The sensors used in this robot are 8 photodiodes where each sensor is given a distance of about 1-2 cm. The schematic of the robot sensor can be seen in Figure 4 and an illustration of the photodiode performance can be seen in Figure 5.

The purpose of this sensor reading is to detect black or white lines contained under the robot. In this section, students will also find out how sensors work. "Scan Sensor" feature works by passing the robot on the line without lifting the robot and then taking the highest input reading value as high input and the lowest input reading value as low input. The results of 8 sensors reading will be used to determine the location of the robot against the line so that the robot can move until the location of the line can be right in the middle position of the robot, namely the sensors 4 and 5.

The controller device used in this robot is Arduino Nano. In general, this robot is designed as a portable system on several components such as Arduino Nano, LCD and IC shift register. The main control schematic design in this study can be seen in Figure 6.
3.3. Evaluate
Evaluation is the last phase to reflect all phases that have been designed. The aspects of concern at this stage are in terms of ease (usability) of the implementation of training and also the effectiveness of training with each measurement technique.

3.4. Usability
In this phase, implementation is measured by analyzing responses from trainees with questionnaires that have been distributed to participants. At the end of this activity, an evaluation questionnaire was circulated consisting of 5 (five) Likert model statements with 4 (four) alternative answers. The results of data collection can be shown in table 2.

Table 2. Evaluation of participant satisfaction.

| Aspect                              | Mean Score | Category     |
|-------------------------------------|------------|--------------|
| Ease of Information Absorption      | 90,5%      | Very good    |
| Operationality of robot module      | 89%        | Very good    |
| The learning sequence of each material | 85%        | Very good    |
| The reliability of the robot module | 75%        | Good         |
| Interestingly the robot module for learning | 92%        | Very Good    |

Table 2 shows that the usability of the programs that have been carried out is very good and reach the average mean score by 86,3%. Indirectly, this also shows that the robot module that has been developed is very suitable for the learning needs of students. Thus, as expressed by Catlin [11] about robotic learning media, this media is quite appropriate to be implemented in learning.
3.5. Effectivity
The effectiveness of the application of robot modules designed in learning is the most important part of this study. The effectiveness of this training shows that there is a contribution to produce a robotic learning media design. The results of measurement of effectiveness based on tests given to students can be seen in Figure 7.

Figure 7. The effectiveness testing result of the teaching model.

Figure 7 shows that there is a very striking difference between the learning outcomes of participants before and after using the learning media in the form of robotic modules according to the average pre-test point in 50.53 to the average post-test point in 69.15. This difference shows that the media and learning design applied that contribute to student competence in learning by 36.83% as well as the improvements in studies conducted by Nur et al [10].

4. Conclusion
Learning media is a very important aspect to be considered in robotics learning activities. The Robot Module as a learning medium is proven to be used as a media that can boost student competence in robotic learning. This is seen based on students' responses to the robot module that has been designed and is considered to be very helpful in learning activities with an average percentage of 86.3%. In addition, based on test results shown a significant change in student learning outcomes with an average of 36.83%. Thus, the design of instructional media in the form of a line follower robot module is very appropriate to be applied in robotics learning.

Acknowledgment
This Research was supported by Universitas Katholik Indonesia Atma Jaya funded by LPPM Unika Atma Jaya.

References
[1] Mackenzie D and Wajcman J 2012 Introductory essay : the social shaping of technology Book section in The social shaping of technology (Buckingham: Open University Press) pp 1–49
[2] Marini C K 2015 Strategi Training Within Industry Sebagai Upaya Peningkatan Kepercayaan Diri Siswa pada Mata Pelajaran Pengolahan Makanan Kontinental J. Technol. Vocat. Educ. 22 4 pp 410–423
[3] Nurmaini S, Tutuko B, Dewi K, Yuliza V and Dewi T 2017 Improving Posture Accuracy of Non-Holonomic Mobile Robot System with Variable Universe of Discourse TELKOMNIKA 15 3 pp 1265–1279
[4] Karna N, Supriana I and Maulidevi N 2018 A Survey on Knowledge Transfer between Knowledge- based Systems TELKOMNIKA 16 1 pp 265–273
[5] Budiyanta N E, Tanudjaja H and Mulyadi M 2018 Rancang Bangun Robot Line Follower Portable Sebagai Upaya Minimalisasi Sampah Elektronik di Ranah Robotika TESLA J. Tek. Elektro 20 2 pp 148–156

[6] Hadi M Y A, Hassan R, Razzaq A R A and Mustafa M Z 2015 Application of Thinking Skills in Career: A Survey on Technical and Vocational Education Training (TVET) Qualification Semi-professional Job Duties Procedia - Soc. Behav. Sci. 211 pp 1163–1170

[7] Fernandes M A C 2015 Project-Based Learning Laboratory for Teaching Embedded Systems Math. Probl. Eng.

[8] Choi M H and Lee W W 2003 Quantitative Evaluation of an Intuitive Teaching Method for Industrial Robot Using a Force / Moment Direction Sensor Int. J. Control 13 pp 395–400

[9] Depešová J, Noga H and Migo P 2018 In Search of Modern Teaching Methods - Humanoid Nao Robot, as Help in the Realization of it Subjects TEM J. 7 2 pp 250–254

[10] Nur M, Susanti I, Arianto R and Siregar R R A 2018 Embedded System Practicum Module for Increase Student Comprehension of Microcontroller TELKOMNIKA 16 1 pp 53–60

[11] Catlin D 2017 29 Effective Ways You Can Use Robots in the Classroom An Explanation of ERA Pedagogical Principle Educ. Robot. Makers Era pp 135–148

[12] Nicolescu M N and Matari M J 2002 Natural Methods for Robot Task Learning: Instructive Demonstrations Generalization and Practice c

[13] Chevalier M, Riedo F and Mondada F 2014 How do teachers perceive educational robots in formal education? A study based on the Thymio robot (Thymio BeeBot Finch)

[14] Hiryanto H 2017 Pedagogi, Andragogi dan Heutagogi Serta Implikasinya Dalam Pemberdayaan Masyarakat Din. Pendidik. 22 1 pp 65–71

[15] Saglam-Arslan A and Deveciogle Y 2010 Student Teachers’ Levels of Understanding and Model of Understanding about Newton’s Laws of Motion Asia-pacific Forum Sci. Learn. Teach. 11 1 pp 1–20

[16] Zairoslawanee Z and Hairuddin H 2014 Leadership in Technical and Vocational Education: Towards Excellence Human Capital J. Educ. Pract. 5 23 pp 132–136

[17] Halsall J P, Powell J L and Snowden M 2016 Determined learning approach: Implications of heutagogy society based learning Cogent Soc. Sci. 37 pp 1–11