

Development of a Robotic Arm Trainer with Color Detection Capabilities for Vocational Schools

Ummiati Rahmah^{1*}, Mahmud Mustapa², Ririn Novita Sari³, Mandeine Resyi⁴

¹⁻³Electrical Engineering Education, Universitas Negeri Makassar, Makassar, Indonesia
⁴Information Systems, Karlsruhe Institute of Technology, Karlsruhe, Germany

Abstract

This study aims to: (1) Analyze the learning conditions of the Robotic System Controller subject at SMK Negeri 4 Soppeng, (2) develop an ARM robotic color detector trainer for use in the Robotic System Controller practicum, (3) evaluate the validity of the trainer as a learning medium, and (4) Assess its practicality in the practicum. The development process followed the Computer-Assisted Instruction (CAI) model. The research subjects consisted of students majoring in Industrial Electronics at Vocational High School (SMKN) 4 Soppeng. Data were collected through validation sheets completed by media experts and response sheets filled out by students. The results showed that the media received a total average score of 93.5% from two media experts, categorizing it as very valid. Additionally, student trials yielded a total average score of 91%, placing it in the very practical category. These findings indicate that the ARM robotic color detector trainer is highly suitable and practical for use as a learning medium for students.

Keywords: Robotic Arm; Color Detection; Trainer; Vocational School; Development

Received: 7 June 2024

Revised: 20 August 2024

Accepted: 30 November 2024

Introduction

In the current era of technological development, it provides various benefits in social aspects (Muzaini, 2014; Bimantoro et al., 2021). Where the process of completing work requires the use of technology (Anshori, 2018; Rizky, 2022). Human Resources must also follow technological developments (Fajriyani et al., 2023; Maeda, 2024). Current technology and future technological developments must be able to be utilized by humans (Danuri, 2019). Education is one of the human processes to become more familiar with technological developments (Achyandia & others, 2016; Nurkholis, 2013; Ajizah & Munawir, 2021; Buddhist, 2017). To assist the development and improvement of Human Resources (HR) (Gudanescu, 2010; Haddad & Draxler, 2002; Prastyaningtyas et al., 2023; Swanson, 2022; Thomson & Mabey, 1994). Education is the most effective means. Education is very important in determining the progress of a nation to obtain quality human resources (Hanushek & Wößmann, 2007; Karim, 2002; Pandey, 2003). So that the generation is not left behind in facing current technological developments, schools are one of the places where students' abilities and potential can be developed (Agbedahin, 2019; Blossfeld & Von Maurice, 2019; Madani, 2019).

Robotics learning in vocational schools often faces challenges, such as limited adequate facilities and infrastructure (Apatya et al., 2023; Putra et al., 2023; Siswanto & Sigit, 2019). One of the important components in learning robotics is a trainer or educational prop that supports understanding of concepts as well as practical applications (Aristawati & Budiyanto, 2018; Asri, 2018; Basit et al., 2022). The right trainer can improve the effectiveness of learning, especially in the subject of Robotic System Controllers which requires an understanding of technological components such as ARM (Advanced RISC Machines) microcontrollers. The use of technology such as ARM Robotic Color Detector as a trainer is very relevant to helping students understand the concept of interactive color-based robotic control.

Learning media in the form of a trainer in the robotic system control practicum is a medium that can be used to learn more about technological developments (Adisantoso, 2021; Alamsyah, 2023; Alamsyah et al., 2022; Farisi et al., 2022; Hendra, 2021; Permata et al., 2021; Rozy & Fijratullah, 2024). One example of robotics that is really needed in vocational schools is ARM Robotic, which is also a miniature industrial robot machine.(Lee, 2020; Reinkensmeyer et al., 2004; Wilson, 2014; (Ery Eka, 2018). Observations conducted at SMK Negeri 4 Soppeng during the Robotic System

*Corresponding author.

E-mail address: ummiatirahmah@gmail.com (Ummiati Rahmah)



Control practicum revealed that students created ARM robotic systems using basic components. While the use of these basic trainers has facilitated the teaching and learning process, advancements in learning media are necessary to align with current technological demands. This enhancement aims to support more effective learning outcomes and equip students with greater competency in the field.

To address these challenges, the author proposes a study titled "Development of an ARM Robotic Color Detector Trainer in the Subject of Robotic System Control for Class XI ELID at SMK Negeri 4 Soppeng." This research aims to: (1) analyze the current learning conditions of the Robotic System Control subject, (2) develop an ARM robotic color detector trainer, (3) assess the validity of the ARM robotic color detector trainer as a learning medium, and (4) evaluate the practicality of the trainer in the learning process.

Method

The learning conditions for the Robotic System Controller subject at Vocational High School (SMKN) 4 Soppeng, based on the experience of the subject teacher, indicate that the teaching process still relies on a very basic ARM robotic trainer without practical guidelines. This limitation affects the effectiveness of the learning process. This study aims to: (1) analyze the learning conditions of the Robotic System Controller subject, (2) develop an ARM robotic color detector trainer, (3) evaluate the validity of the trainer as a learning medium, and (4) measure the practicality of the trainer in the learning process. The development procedure in this study follows the CAI (Computer Assisted Instruction) model. The CAI model is supported by various references (Darmawan, 2018; Janardhan, 2019; Kaye et al., 2021; Kustandi, 2014; Muliawan, 2014). Consists of four main stages in the development process of this model, namely needs assessment, design, development and implementation, evaluation and revision (BA, 2012; Guthrie, 1991; Majer, 1973; Nyunt, 2019; Wulansari et al., 2023), More details can be seen in Figure 1.

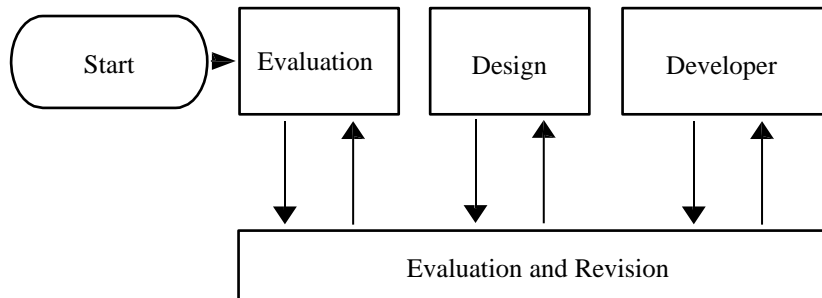


Figure 1. CAI design model adopted from the Hannafin and Peck model

The subjects of this study were Class XI students majoring in Industrial Electronics at SMK Negeri 4 Soppeng. The study involved individual trials with 6 students, group trials with 15 students, and expanded field trials with one class consisting of 21 students.

Results and Discussion

Results

Researchers have developed learning media using the CAI (Computer-Assisted Instruction) model. The CAI model, as adopted from Hannafin, consists of four stages: Needs Assessment, Design, Development and Implementation, and Evaluation and Revision. The structured approach ensured that the learning media addressed the identified challenges and met the educational needs effectively. The stages of development and their outcomes are detailed in Table 1.

Table 1. Development stages

Research stages	Method	Results
Needs analysis	Live interview	Identified that the existing learning trainer is manual and lacks supporting learning modules.

Research stages	Method	Results
Design	Designing	Created the initial design of the trainer media and practical modules.
Development and implementation	Trial and questionnaire	Developed hardware for the trainer and created practical modules.
Evaluation and revision	Analysis of comments and suggestions	Conducted improvements based on feedback from trials and evaluations.

Each stage contributed to refining the ARM robotic color detector trainer and ensuring its effectiveness as a learning tool.

Needs Analysis: The initial needs analysis revealed that the existing learning trainer was overly simplistic, relying on manual operation without proper learning modules. Interviews with teachers and students highlighted the necessity of developing a more advanced trainer with comprehensive instructional materials to support effective teaching and learning.

Design: In the design phase, the research team focused on creating a prototype for the ARM robotic color detector trainer. This included designing both the physical trainer and a practical module to guide students through its use. The design prioritized user-friendliness and alignment with the curriculum objectives.

Development and Implementation: The development phase involved assembling the hardware components of the trainer and creating detailed practical modules. Implementation included trial sessions with small groups of students to test the functionality and effectiveness of the trainer. Feedback was gathered through questionnaires to identify areas needing improvement.

Evaluation and Revision: The evaluation process involved analyzing comments and suggestions from media experts and students. This feedback guided the revisions, ensuring that the final product was optimized for classroom use. The trainer was refined to enhance its usability, practicality, and alignment with learning outcomes. The results demonstrate that the developed ARM robotic color detector trainer effectively addresses the limitations of the previous learning media and provides a practical, modern solution for teaching Robotic System Control to students. More details can be seen in Figure 1.



Figure 2. ARM robotic color detector trainer

The validation of the learning media was conducted by educational media experts, focusing on four key aspects: device, display, material, and language. The device aspect received an average score of 95%, indicating excellent functionality and compatibility of the components, while the display aspect scored 94%, reflecting a visually appealing and user-friendly interface. The material aspect, which evaluates content relevance and alignment with learning objectives, achieved a score of 88%, with minor suggestions for improvement. The language aspect attained the highest score of 97%, highlighting the clarity and ease of understanding of the instructions and descriptions. With an overall average

score of 93.5%, the ARM robotic color detector trainer was categorized as very valid, demonstrating its suitability and effectiveness for use in teaching Robotic System Controller subjects.

The data on the practicality of the media were obtained from student responses collected during the implementation stage. Based on the recapitulation of results from individual trials, the practicality score was 91%, while the linguistic aspect received a score of 93.16%. The overall average score across all assessment aspects was 91%, categorizing the media as very practical. Based on the recapitulation of results from small group trials, the device aspect scored an average of 88%, the display aspect also scored 88%, the content aspect achieved 90%, and the language aspect received 92%. This resulted in an overall average score of 89.5%, placing the media in the very practical category, as seen in Figure 3.

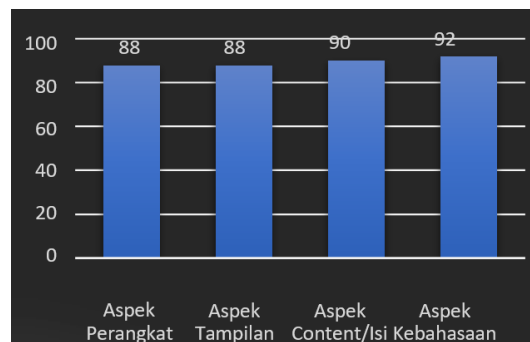


Figure 3. Recapitulation results graph

Based on the results of the recapitulation of the large group trial, the average value of the device aspect was 91%, the display aspect was 91%, the content aspect was 95% and the language aspect was 98%, so the total average value of all assessment aspects was 93.75%, which is included in the very practical category, as seen in Figure 4.

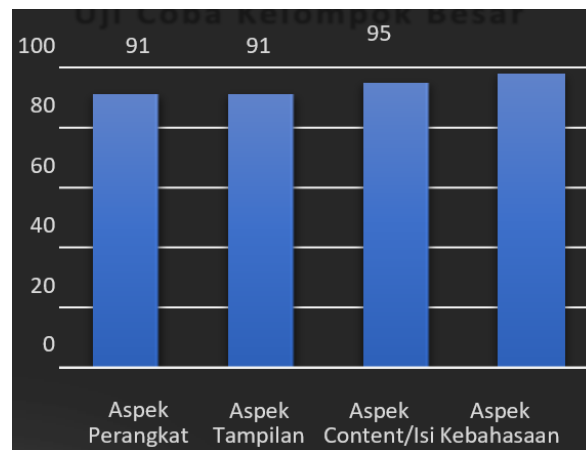


Figure 4. Graph of the results of the large group test recapitulation

Discussion

The learning conditions at Vocational High School (SMKN) 4 Soppeng, particularly in the Robotic System Control subject, highlight significant challenges based on the teacher's experience. Students rely on a basic ARM robotic trainer without practical guidelines, limiting the effectiveness of the learning process. Similarly, a study by (Agrawal et al., 2020; Anand et al., 2024) on the design of a robotic arm with manual control revealed limitations in the robot's functionality due to its manual operation. According to (Bhuttah et al., 2024), the integration of innovative teaching tools significantly enhances student engagement and learning outcomes, emphasizing the importance of addressing these challenges through technological advancements.

To address these challenges, this study developed an ARM robotic color detector trainer along with a practical guidebook to enhance the learning process. This trainer aims to improve the efficiency of learning, increase student engagement, and align with the demands of modern technology. As stated by (Dzaiy & Abdullah, 2024), well-designed learning media support active learning and provide a hands-on approach that fosters deeper understanding. The development employed a Research and Development (R&D) approach using the CAI (Computer-Assisted Instruction) model, which includes four stages: needs assessment, design, development and implementation, and evaluation and revision (Calzada et al., 2023).

The process began with direct interviews involving teachers responsible for the Robotic System Control subject and students who had completed the course. These interviews helped identify the specific needs for improvement, aligning with Borg and Gall's (Ross et al., 2008) framework for educational research, which emphasizes the importance of identifying practical needs in instructional design. A literature review was conducted to determine the material to be included in the trainer. Once the material was finalized, the hardware design process for the ARM robotic color detector trainer commenced using the Diptrace application to create schematics and PCB layouts, following the principles outlined by (Ross et al., 2008) for designing effective educational technology.

In the development stage, components were soldered onto the PCB, and the hardware trainer was housed in a protective box. Additionally, a practical module was developed to complement the trainer. Before implementation, the trainer underwent validation by two media experts to assess its feasibility. The results showed high validity: 95% for the device aspect, 94% for the display aspect, 88% for the material aspect, and 97% for the linguistic aspect, with an overall average of 93.5%, categorizing it as very valid. These results align with the findings of (Penuel & Gallagher, 2009), who states that high-quality validation ensures the effectiveness and reliability of instructional materials.

After the validation process and subsequent revisions, the trainer was ready for implementation. The practicality of the product was assessed through three types of trials: individual, small group, and large group. Individual trials involved six students, yielding an average score of 91% (very practical). Small group trials with 15 students resulted in an average score of 89.5% (very practical). Large group trials, conducted with 21 students, achieved an average score of 93.75% (very practical). The overall average score from all trials was 91.42%, confirming the trainer's practicality for classroom use. These findings are supported by (Mutlu-Bayraktar et al., 2019) cognitive theory of multimedia learning, which highlights the importance of practical and interactive media in improving learning outcomes.

The ARM robotic color detector trainer effectively addresses the limitations of the existing learning media by providing a modern, practical solution. Its high validity and practicality demonstrate its potential to enhance student learning outcomes and engagement in the Robotic System Control subject. This development aligns with educational goals to integrate innovative learning tools and prepare students for future technological advancements (Riddel & Zulfikar, 2024).

Conclusions and Suggestions

Conclusions

Based on the research findings regarding the development of the ARM robotic color detector trainer for the class XI robotic system controller practicum at Vocational High School (SMKN) 4 Soppeng, it can be concluded that the existing learning conditions utilized a basic ARM robotic trainer during practicum sessions. However, this trainer was still very simple, as its operation relied on manual controls, and no practicum module was available, resulting in limitations in the learning process for students. The development of the ARM robotic color detector trainer followed four stages: (1) Needs assessment, which identified the necessity of using modules and practicum tools, including trainers and modules, to support learning; (2) Design, involving the creation of trainer media and the practicum module design; (3) Development and implementation, focusing on the construction of the ARM robotic color detector trainer hardware and the practicum module; and (4) Evaluation and revision, which included reviewing and improving the product to ensure its validity and practicality. The ARM robotic color detector trainer was deemed highly valid by expert validators, as evidenced by validation results: a device aspect score of 95%, a display aspect score of 94%, a material aspect score of 88%, and a language aspect score of 97%, resulting in an overall average score of 93.5%, which falls into the "very valid" category. Following revisions, the trainer was also determined to be highly practical for use by students, as shown

by the results of individual trials with an average score of 91%, small group trials with an average score of 89.5%, and large group trials with an average score of 93.75%, categorizing it as "very practical." Therefore, the ARM robotic color detector trainer is concluded to be both valid and practical for student use in the robotic system controller subject.

Suggestions

For future research, the development of ARM robotic trainers can be expanded and refined based on the following suggestions:

1. Future studies can focus on integrating advanced automatic control systems for ARM robotic trainers by utilizing technologies such as the Internet of Things (IoT) or Artificial Intelligence (AI) to enhance automation and adaptability.
2. In addition to the color detection functionality, further development could incorporate additional sensors, such as proximity, temperature, or pressure sensors, to expand the range of linear functions and provide a more comprehensive learning experience.
3. Future research can also explore the creation of interactive, digital-based learning modules, such as applications or e-learning platforms, directly linked to ARM robotic trainers. This approach would enable students to understand theoretical concepts more effectively and conduct virtual simulations, fostering an engaging and innovative learning environment.

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