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Need Analysis for Enhanced Teaching Aids in Embedded Robotics Courses: Addressing Challenges in Programming and Electronic Circuits Comprehension

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Abstract: *This study investigates the necessity for enhanced teaching aids in the Embedded Robotics course at Politeknik Ungku Omar, with a particular focus on addressing the challenges students face in mastering programming and electronic circuits comprehension. Embedded Robotics, which combines the intricacies of software coding and hardware integration, demands a strong understanding of both programming logic and electronic circuit design. However, the complexity of these subjects often poses significant learning barriers to students, leading to a demand for more effective instructional tools. A quantitative survey was conducted with 68 students enrolled in the course to assess their satisfaction with the current teaching aids and to identify specific areas where improvements are needed. The findings indicate that while students are generally satisfied with the existing teaching resources, there is a pronounced need for more interactive, AI-integrated, and digitally accessible teaching aids that can facilitate a deeper understanding of programming and circuit design. Additionally, the study highlights the importance of incorporating practical, industry-aligned features into teaching aids to better prepare students for real-world applications. These insights underscore the critical role of advanced technological tools in enhancing students' comprehension and application of complex concepts in Embedded Robotics, ultimately contributing to improved educational outcomes and industry readiness.*

Keywords: Embedded Robotics, Teaching Aids, Programming, Electronic Circuits

1. Introduction

In the rapidly advancing field of robotics, understanding the intricacies of programming and electronic circuits is paramount for students. These core components are the backbone of any robotics system, and the ability to comprehend and apply these concepts effectively is crucial for success in the industry. Robotics programming fosters creative design, computational thinking, and problem-solving skills, while also promoting positive attitudes and success in learning tasks through its user-friendly hardware and block-based programming (Çalişkan, 2020). Programming and robotics, vital elements of informatics, have been integrated into education as essential tools for equipping students with the skills needed to meet the evolving technological demands of society (Seckel et al., 2022). However, traditional teaching methods and aids may not sufficiently address the challenges students face in these areas, particularly in courses like Embedded Robotics. Programming language education often fails to capture students' attention, leading many to view it as difficult and suitable only for professionals,

highlighting the need for strategies that simplify and engage students in learning (Çam & Kiyici, 2022). A common difficulty highlighted in the literature is that students often find electronic circuits also challenging to understand. This is due to their lack of familiarity with real-life electronic components, making the abstract concepts in circuit analysis harder to grasp (Fayyaz & Trueman, 2022).

This study aims to assess the current state of teaching aids used in the Embedded Robotics course at Politeknik Ungku Omar, with a particular focus on programming and electronic circuits. By exploring students' perceptions of the effectiveness of these aids, the study seeks to provide insights into the specific enhancements needed to improve learning outcomes in these challenging areas.

Objectives:

a. To evaluate students' satisfaction with the current teaching aids related to programming and electronic circuits.
b. To identify the key features students believe are necessary in new teaching aids for these areas.
c. To explore the importance of integrating advanced technologies, such as AI, into teaching aids to enhance comprehension of programming and electronic circuits.

2. Methodology

A quantitative survey was conducted among 68 students currently enrolled in the Embedded Robotics course, which is part of the Department of Electrical Engineering at Politeknik Ungku Omar. These students were selected as respondents because they are directly involved in the coursework and have firsthand experience with the teaching aids used in the subject. Their insights are crucial for providing accurate data that will inform the development of more effective teaching aids tailored to their specific needs.

The survey was designed to capture students' perceptions of the current teaching aids, with a particular focus on their effectiveness in facilitating the understanding of programming and electronic circuits—two core components of the Embedded Robotics curriculum. To this end, the survey included a series of statements related to these topics. Students were asked to rate their level of agreement with each statement using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Descriptive statistics, including mean scores and standard deviations, were used to analyze the survey data. Descriptive statistics is the most fundamental form of statistical analysis, serving as a tool to organize and summarize the inherent variability present in collections of observational data or scores (Dong, 2023). Descriptive statistics also aids in assessing missing data and bias, ensuring that data presentation reflects accurate collection, analysis, and interpretation by the researcher (Bulanov et al., 2021). This analysis aimed to identify trends and pinpoint areas where there is a significant demand for enhancement in teaching aids. The focus was on determining the extent to which the current aids meet the learning needs of students, particularly in the context of programming and electronic circuits, and where there might be opportunities for improvement. The findings from this analysis provide critical insights that will guide the development of new teaching aids designed to address the specific challenges faced by students in this course.

3. Result

The results of the survey reveal that students generally hold a positive perception of the current teaching aids used in the Embedded Robotics course at Politeknik Ungku Omar. The mean scores for most of the survey statements were above 4.0, indicating a consensus among students that the teaching aids are somewhat effective in supporting their learning. However, the standard deviations, which measure the spread of responses around the mean, suggest some variability in how students perceive these aids.

The mean scores represent the average level of agreement among students for each statement. A mean score above 4.0 indicates that students generally agree that the teaching aids are beneficial. For instance, the highest mean score of 4.31 suggests a strong consensus that integrating AI technology into teaching aids would significantly enhance understanding of programming logic and circuit behavior. This high mean score underscores the perceived importance of modern, interactive, and AI-driven tools in improving the learning experience in complex subjects like programming and circuits.

Standard deviations in this survey range from 0.589 to 0.889, indicating the degree of agreement or disagreement among students. A lower standard deviation, such as 0.589 for the statement "I agree that teaching aids should come with step-by-step guides to facilitate teaching and learning in programming and circuits," suggests that most students consistently agree with this statement, reflecting a shared need for structured, easy-to-follow teaching aids. Conversely, a higher standard deviation, such as 0.889 for the statement "I feel that the current teaching aids are not fully sufficient to help me understand the basics of programming and electronic circuits in Embedded Robotics," suggests more diverse opinions among students. This indicates that while many students see the need for improvement, others may feel differently, pointing to varied experiences or needs within the course. For a comprehensive overview of student perceptions and the variability in responses, refer to Table 1.

Table 1: Student Perceptions of Teaching Aids for Embedded Robotics

Statement	Mean	Std. Deviation
I believe that the current teaching aids could still be improved to better support my learning needs.	4.15	0.851
I feel that the current teaching aids are not fully sufficient to help me understand the basic concepts of Programming and Electronic Circuits in Embedded Robotics.	4.01	0.889
I am somewhat satisfied with the quality of the teaching aids used in the Embedded Robotics course, but there is room for improvement, especially in terms of references.	4.1	0.775
I find the current teaching aids effective, but there are still aspects that could be improved in the delivery of information.	4.1	0.794
I believe that new, more interactive teaching aids are highly needed in the Embedded Robotics course, particularly for Programming and Electronic Circuits.	4.16	0.822
I agree that new teaching aids should integrate AI technology.	4.31	0.718
I feel it is important for new teaching aids to focus on practical training for Programming and Electronic Circuits.	4.22	0.709
I agree that new teaching aids should come with comprehensive guides or modules.	4.22	0.73
I believe that teaching aids that can be accessed digitally are highly necessary.	4.22	0.643
I agree that new teaching aids should have futuristic features aligned with current technology trends.	4.19	0.675

I feel that teaching aids should be easy to understand and suitable for all skill levels.	4.29	0.692
I agree that new teaching aids that integrate industry case studies are important.	4.18	0.711
I believe that new teaching aids should focus more on practical aspects rather than theory in Programming and Electronic Circuits.	4.25	0.699
I agree that new teaching aids should come with more comprehensive trainers and training kits to facilitate understanding.	4.22	0.643
I believe that new teaching aids should be aligned with the latest technological advancements in robotics.	4.26	0.683
I feel it is important for new teaching aids to contain project-based learning elements to reinforce understanding.	4.22	0.643
I agree that teaching aids should come with step-by-step guides to facilitate teaching and learning.	4.26	0.589
Overall, I require up-to-date teaching aids that are improved from the existing ones.	4.28	0.688

4. Discussion

The survey provides valuable insights into the effectiveness of current teaching aids and the specific needs for enhancement in Embedded Robotics courses. The analysis of the data aligns closely with the objectives of the study: evaluating student satisfaction, identifying necessary features for new teaching aids, and exploring the role of advanced technologies such as AI. Overall, students express a positive outlook on the current teaching aids, with mean scores ranging from 4.01 to 4.31. This suggests that while the existing aids are valued, there is widespread recognition that improvements are needed. The variation in responses, as indicated by the standard deviations, reveals a spectrum of opinions on the adequacy of current resources. For instance, a higher standard deviation for some statements points to diverse experiences among students, indicating that the current aids may not uniformly address all learning needs.

Evaluation of Student Satisfaction

The survey results reveal a generally positive view of the current teaching aids, with mean scores ranging from 4.01 to 4.31. This indicates that while students find the existing aids useful, there is a consensus on the need for improvements. The variation in standard deviations, from 0.589 to 0.889, underscores the diversity in student opinions regarding the sufficiency of current resources. Specifically, the higher standard deviation for the statement on the sufficiency of current aids (0.889) suggests a significant variation in experiences, which could be attributed to different levels of prior knowledge or engagement with the material.

Teaching and learning are influenced by students' skills, attitudes, and research orientation, with negative physical and social conditions potentially impacting effectiveness. An enabling environment and well-trained teachers are crucial for using teaching aids effectively and imparting accurate knowledge (Ordu, 2021). The findings suggest that while current teaching aids meet some needs, there is considerable room for enhancement to better address students' understanding of programming and electronic circuits. The use of teaching aids in the classroom enhances students' critical thinking and active engagement by stimulating psychomotor activities, allowing students to experience concepts directly (Jamil, 2024). This aligns with Objective i, highlighting the need to reassess and refine the existing resources to improve overall student satisfaction and learning outcomes.

Key Features for New Teaching Aids

The survey identifies several key features that students believe are crucial for new teaching aids. High mean scores for statements related to practical training (4.22), project-based learning

(4.22), and comprehensive guides (4.22) reflect a strong preference for resources that provide hands-on experience, structured support, and practical applications of theoretical concepts. These preferences indicate that students seek teaching aids that not only explain concepts but also offer opportunities to apply and test their knowledge in realistic scenarios.

Additionally, the high mean score for AI integration (4.31) highlights its critical role in enhancing learning experiences by offering personalized feedback and adaptive learning, which are crucial for improving comprehension of complex subjects. The integration of AI technology significantly streamlines the creation and management of teaching materials. Teachers no longer need extensive technical knowledge, as numerous applications and platforms are available to select from based on their needs. AI also simplifies assessment processes; assignments can be automatically evaluated, and item analysis is conducted without manual intervention. This automation not only provides students with immediate feedback but also frees up teachers to concentrate more on the teaching and learning process(Fitria, 2021). Research indicates that integrating AI into robots and cobots as instructional tools enhances learning, with studies showing improvements in teaching methods and the development of better educational tools(Nguyen, 2023).

Addressing Challenges in Comprehension

The survey highlights specific challenges that students face in comprehending programming and electronic circuits. These challenges are significant, given the complexity of the subjects involved, which often require both theoretical understanding and practical application. The results indicate a clear demand for teaching aids that focus on practical aspects, project-based learning, and interactive elements. These approaches are crucial for addressing the difficulties students encounter.

Teaching aids that emphasize practical aspects and project-based learning are particularly effective in tackling these comprehension challenges. Project-based teaching, especially when integrated with educational robots, has been shown to positively impact the development of key competencies, particularly in problem-solving. This method encourages students to engage directly with the material, apply theoretical knowledge in real-world contexts, and develop practical skills essential for mastering complex topics in programming and electronic circuits (Coufal, 2022). By utilizing educational robots in project-based learning, students can work on hands-on projects that simulate real-world scenarios, thus deepening their understanding of programming concepts and circuit design. This practical engagement helps bridge the gap between abstract theoretical concepts and their practical applications, making the learning process more effective and engaging.

The emphasis on comprehensive guides and step-by-step instructions further supports the need to address these comprehension challenges. Detailed instructional materials are essential for helping students navigate complex topics effectively. These guides provide structured support, allowing students to progress through intricate concepts in a logical and manageable way. For subjects like programming and electronic circuits, where understanding builds progressively from fundamental principles to more advanced topics, having clear and detailed resources is crucial. Comprehensive guides and step-by-step instructions can help students break down complex tasks into smaller, more manageable steps, making it easier for them to grasp and apply new concepts. This structured approach not only aids in overcoming difficulties but also enhances overall learning effectiveness.

In summary, integrating practical aspects, project-based learning, and interactive elements into teaching aids addresses the specific challenges related to programming and electronic circuits comprehension. Furthermore, providing detailed instructional resources supports students in navigating these complex subjects more effectively, ultimately leading to a more comprehensive and effective learning experience.

Addressing Challenges in Comprehension

In summary, the survey data provides a clear understanding of the current limitations and needs for teaching aids in Embedded Robotics courses. The findings emphasize the need for practical, interactive, and technologically advanced resources to enhance students' comprehension of programming and electronic circuits. By addressing these needs and incorporating AI technology, educational institutions can develop teaching aids that significantly improve student learning outcomes and align with current educational trends. This approach not only addresses the challenges identified in the study but also supports the overarching goal of developing effective and engaging teaching resources for Embedded Robotics.

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