The Design of a Badminton Score Board Based on IoT Using ESP32 at Aviation Polytechnic of Surabaya

Sari Nastiti Nalurita[1,*] , Ade Irfansyah[2] , Gunawan Sakti[3]

[1&2] *Politeknik Penerbangan Surabaya, Air Navigation Engineering*
[3] *Politeknik Penerbangan Surabaya, Aircraft Engineering*
[*]*Corresponding author. Email: sarinastitinlrt107@gmail.com*

ABSTRACT

The development of Internet of Things (IoT) technology open sup opportunities for innovation in various fields, including sports. This research aims to design and implement a badminton scoreboard system using IoT technology with an ESP32 microcontroller connected to the Blynk Application. The system enables wireless score recording via a smartphone and displays the results directly on a P10 LED panel. Currently, the manual scoreboard still used at the Civil Aviation Polytechnic of Surabaya is inefficient and prone to errors during score recording in matches. To address this, the research adopts the 4D development method there are Define, Design, Develop, and Disseminate. The define stage involves needs analysis, including data collection and interviews. The design stage focuses on planning the system, covering both hardware and software components. The develop stage implements the design, including component selection, software development, and system validation to ensure feasibility and functionality. And the last one is the Disseminate stage involves distributing the tested product to users and relevant stakeholders. The results of this study indicate that the IoT-based badminton match scoreboard is able to meet the needs of an interactive digital scoreboard for badminton matches at the Surabaya Aviation Polytechnic with validation results by sports experts showing that this product is very feasible to use based on assessment aspects including technical, economic, legal, operational, and scheduling (TELOS) aspects of 95% and validation results by users with an assessment of 85%. This research contributes significantly to the institution by supporting the development of campus infrastructure and enhancing the quality of sports facilities. For the wider community, the system serves as a model for implementing accessible and affordable IoT-based technology to modernize local sports environments.

Keywords: *ESP32, IoT, Badminton, Blynk, P10 Led Panel, Score Board*

1. INTRODUCTION

The advancement of the Internet of Things (IoT) has significantly influenced various sectors, including sports technology. IoT enables physical devices to communicate through the internet, creating more dynamic, responsive, and user-friendly systems. In the context of educational institutions, integrating IoT-based systems not only supports digital transformation but also can improve the efficiency of score recording and enhances the quality of supporting facilities, including sports infrastructures such as scoreboards [1]. Badminton, a widely practiced sport in Indonesia, particularly in vocational campuses like the Aviation Polytechnic of Surabaya, requires accurate and efficient scoring systems to support fair and professional matches.

However, current scoring methods at the Surabaya Aviation Polytechnic are still performed manually, using whiteboards or paper scorecards, which have low readability and are prone to human error. Observations and interviews conducted in the field showed that the existing manual scoreboard is difficult to see from a distance, lacks real-time control, and disrupts the flow of the game. Literature also reveals limited implementation of low-cost, real-time IoT-based scoreboards, especially in badminton-specific applications [2]. Most existing technologies focus on football or basketball, and fewer systems explore seamless mobile integration using platforms like Blynk with ESP32 microcontrollers [3].

This gap highlights the scientific and practical urgency of developing an IoT-based scoreboard for badminton that is affordable, easy to use, and capable of displaying scores in real-time through wireless connectivity. From a scientific perspective, this initiative contributes to the growing domain of embedded systems and wireless communication, while from a practical perspective, it enhances the quality of sporting events and digital facilities in vocational education environments [4]. The need for accurate, efficient, and remote-controlled scoring mechanisms is essential in promoting fairness and professionalism in match settings.

The primary aim of this research is to design and build a prototype IoT-based badminton scoreboard using the ESP32 microcontroller and the Blynk application. The system is designed to display scores via P10 LED panels and receive input wirelessly from smartphones. The development process follows the 4D method (Define, Design, Develop, Disseminate) and evaluates system feasibility using the TELOS (Technical, Economic, Legal, Operational, and Schedule) analysis framework [5].

This article contributes to the scientific field by presenting a practical application of IoT in sport score tracking with real-time control and wireless communication. It serves as a reference for further research on smart facility development in educational settings and offers a low-cost, replicable model for digital transformation in sports infrastructure. By bridging the gap between theory and practice, this research supports the advancement of smart campus environments and applied electronics education.

2. METHODS

This research adopts the 4D development model, which consists of four sequential stages: Define, Design, Develop, and Disseminate. The 4D model, originally proposed by Thiagarajan (1974) and later adapted in technological and educational product development is particularly effective for building systems that require iterative refinement and stakeholder validation. In this study, the model was used to guide the process of developing an IoT-based scoreboard system—from identifying user needs and designing the technical framework to system development and implementation testing in a real environment.

1. Define

In the Define stage, the research began by identifying the core problems associated with the manual scoreboard system used at Surabaya Aviation Polytechnic. Through field observations and user interviews, the study found that the current method using paper suffers from limited readability, lack of accuracy, and slow updates during matches. The data collected during this stage served as the basis for defining system requirements and user expectations.

2. Design

The Design stage focused on planning both hardware and software components of the system. This included designing the electronic circuit using an ESP32 microcontroller, selecting the P10 LED display modules, and designing the smartphone interface via the Blynk platform. Flowcharts and block diagrams were developed to map out the data flow and control structure. The design phase also incorporated the layout of the printed circuit board (PCB) and schematic configurations for stable power supply and component routing.

3. Develop

During the Develop phase, the actual prototype was constructed. All components were assembled, and the system was programmed using Arduino IDE with supporting libraries for Blynk and LED matrices [6]. The system was tested using component testing to ensure each function worked as expected. Additionally, feasibility was evaluated using the TELOS analysis framework, which assessed the system from Technical, Economic, Legal, Operational, and Schedule perspectives. The validation results demonstrated that the system met predefined user needs and technical standards.

4. Disseminate

In the final stage, Disseminate, the completed prototype was implemented in the badminton court environment at the campus. Demonstrations and trials were conducted with real users, including referees and players. Evaluation was done using questionnaires and expert feedback to measure the system's usability, readability, and reliability. The outcomes indicated a high acceptance rate and confirmed the potential of the system for broader application within similar institutions.

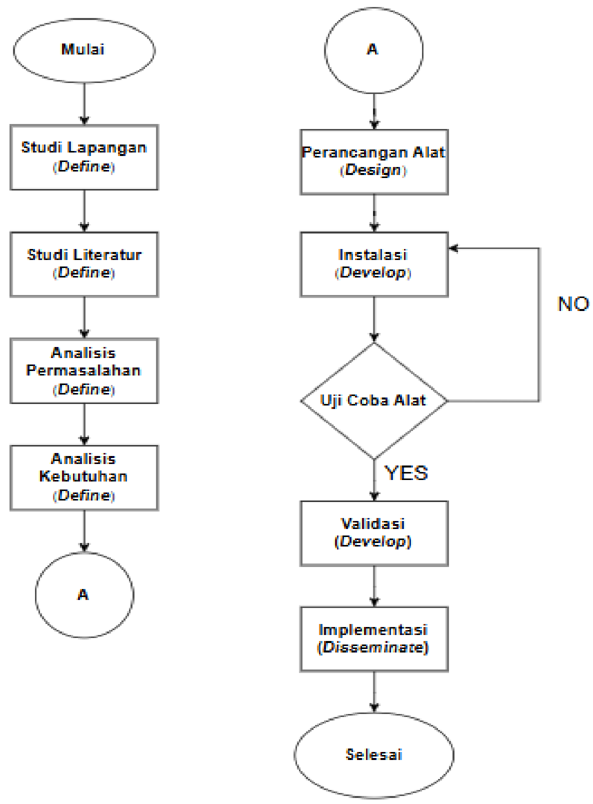

Figure 1 Research Flowchart

3. RESULTS AND DISCUSSION

The Results and Discussion chapter is a critical component of a scientific article, as it presents the main findings of the research and provides interpretation, comparison, and significance of those findings. The purpose of this section is to demonstrate what was achieved during the research process, why the results matter, and how they relate to existing theories or prior studies. In this study, the results and discussions are organized according to the 4D development model (Define, Design, Develop, Disseminate), with each phase contributing significantly to the overall objectives and conclusions.

1. Define

The initial stage of this study involved identifying real-world problems in the current badminton scoring system at the Surabaya Aviation Polytechnic's multipurpose hall (GSG). Through informal interviews and a questionnaire distributed to referees and players, it was found that the existing scoreboard relied on manual flipboards not specifically designed for badminton. This method led to visibility issues, scoring delays, and disrupted match flow. A survey of 17 respondents revealed that 58.8% had difficulty viewing the scores during matches, and an inventory check confirmed the absence of a dedicated digital scoreboard for badminton in the venue. Moreover, the scoreboard was used interchangeably for other sports and public events, as evidenced by rental documentation and promotional flyers.

These findings reflect a critical infrastructure gap and highlight the need for a real-time, sport-specific scoring solution. The collected data validated the urgency of developing an IoT-based system that enables remote input, better visibility, and faster updates features that align with the principles of modern Human-Computer Interaction and smart facility development. The Define stage successfully laid the foundation for a technology-driven approach, confirming both the user need and institutional relevance of the proposed system [7].

2. Design

In response to the identified problems, the system design was formulated with an emphasis on usability, scalability, and cost-effectiveness. The core hardware architecture consisted of the ESP32 microcontroller, selected for its built-in Wi-Fi and processing efficiency. Three rows of P10 LED display panels were configured to display scores and a service indicator, while the Blynk mobile application was used as a wireless interface for referees [8]. Block diagrams and wiring schematics were created to ensure reliable interconnections, and PCB layouts were drafted to integrate all components within a compact and stable circuit system.

The design addressed all user requirements defined in the initial phase. The selection of P10 LED ensured clear visibility from various angles and distances, meeting the physical demands of indoor badminton matches. Meanwhile, the Blynk interface allowed for intuitive, real-time input using a smartphone, reducing dependence on physical scoreboards. This integration of hardware and software design demonstrates the applicability of embedded IoT systems for localized, context-specific problems. Overall, the Design stage ensured technical feasibility, functionality, and user-centric operation.

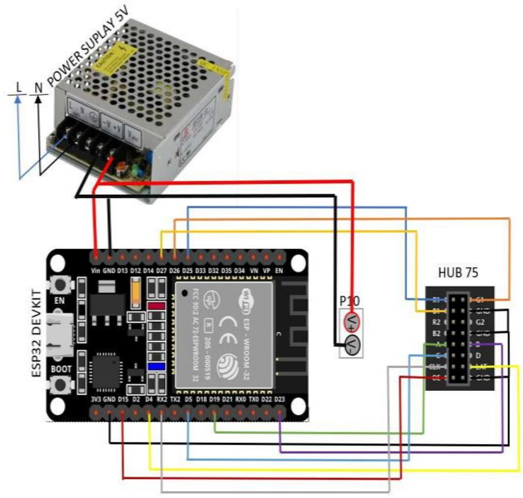

Figure 2 Integration of Components in Tool

3. Develop

The development process involved assembling the prototype and programming the ESP32 using Arduino IDE. The system was designed to respond to commands from the Blynk app [9] such as incrementing scores, resetting the game, and switching service with corresponding outputs displayed on the LED panels. Black-box testing was applied to evaluate system behavior without delving into internal code logic. The prototype operated effectively, with score updates appearing instantly and accurately on the display. The LED panels-maintained visibility up to 25 meters and within a 225° viewing angle, satisfying performance expectations.

The successful development of the system confirmed its operational reliability under real-use conditions. Functional testing validated that the input from the mobile interface accurately translated into real-time display outputs. The system's responsiveness, visibility, and ease of use indicated that the core technological components ESP32, P10 LEDs, and Blynk were appropriately chosen. This stage also underscored the advantage of modular, IoT-based solutions in improving institutional infrastructure without requiring complex setup or high operational costs [10].

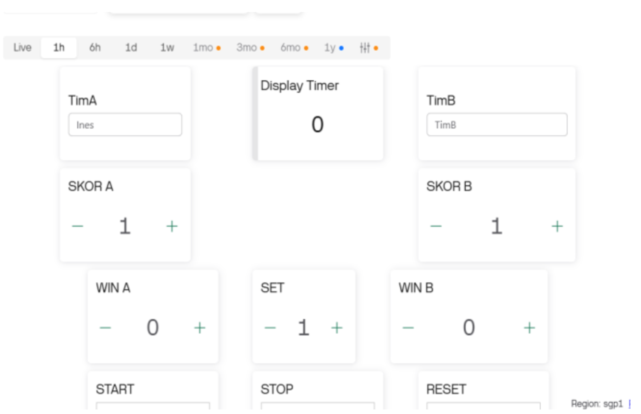

Figure 3 Display Score in Blynk

Figure 4 Display Score in Tool

Table 1 Tool Testing Results

No	Information Aspects	Tested Indicator	Test Result	Remarks	Notes
1.	Team Name	Characters are displayed clearly	Characters are are clearly legible	Matches expectation	Max. 5 characters
2.	Team Score	Increases and decreases according to accurate real-time input	Real-time scores sync with input and are accurate.	Matches expectation	Max. 2 numbers
3.	Set Winner	Appears automatically/according to accurate input and is not mixed up	The winning set indicator appears automatically.	Matches expectation	Green arrow
4.	Active Set Indicator	Active sets are clearly and correctly marked	The active set is clearly and correctly marked.	Matches expectation	White score
5.	Ball Position	The service indicator changes according to the status, clearly visible	The serve indicator changes according to the status and is clearly visible.	Matches expectation	Green arrow
6.	Max Distance Viewing	Effective distance between 20-30 meters	Clearly readable from the furthest distance of 24.6 meters.	Matches expectation	Max. 30 meters
7.	Display Contrast	Clearly readable in both bright and dim conditions	Clearly readable in various conditions.	Matches expectation	Brightness set to 60
8.	Point of View	Seen from a 45-degree angle.	Clearly visible from various directions.	Matches expectation	Variable viewing angle 45°-315°

On the Table 1, the functional testing of the IoT-based badminton scoreboard prototype demonstrated that all key features performed as expected. The scoreboard successfully displayed team names and scores with clear visibility, allowing real-time updates through the Blynk mobile app. Indicators for the winning set, active set, and ball position (serve) operated accurately and automatically, improving match monitoring for referees and players. The display was clearly readable up to a distance of 24.6 meters and maintained visibility under both bright and dim lighting conditions with a brightness setting of 60.

In addition, the scoreboard could be viewed from a wide angle, ranging from 45° to 315°, ensuring accessibility for spectators from various positions. These results confirm that the system is not only functionally reliable but also user-friendly and suitable for real match conditions. The successful implementation of real-time display and mobile control proves the effectiveness of IoT integration in enhancing sports equipment within educational environments.

$$percentage\ of\ eligibility = \frac{34}{40}\ x\ 100\%$$

= 85%

The feasibility test was taken from the validation by Mr. Catur Erik Widodo as a sports expert. The data calculated using the above formula was obtained from the validator with a score of 38 out of a maximum score of 40. Thus, the feasibility score percentage was 95%. This percentage falls into the highly feasible category. This means that the scoreboard system has passed all instrument validations. The feasibility results of expert assessment using the TELOS framework, which evaluates the project based on Technical, Economical, Legal, Operational, and Schedule aspects. The scoreboard system was rated as irrelevant to very relevant in all indicators. Technically, the system's hardware and software were found to be compatible and stable during matches. Economically, the prototype was considered low-cost and energy-efficient. From a legal standpoint, the system complied with institutional policies and caused no interference to other equipment. Operationally, it was easy to use and readable from a distance, making it suitable for referees and players. In terms of schedule, the project was completed on time, with researchers following the planned timeline effectively. These results confirm the overall feasibility and practicality of the scoreboard system for real-world use.

4. Disseminate

This stage involves disseminating the research results to the community and relevant stakeholders. In this study, the research results will be disseminated in the form of a report published in the Aviation Polytechnic of Surabaya library and disseminated at the final project examination. Furthermore, the research results will be published in the form of scientific articles.

4. CONCLUSION

Based on the results of the analysis, design, implementation, and testing of the system, it can be concluded that:

1. The internet of things IoT-based badminton scoreboard system using esp32 has been successfully developed and meets the needs of an interactive digital scoreboard through a p10 led panel at the Aviation Polytechnic of Surabaya. Through the 4D development method (define, design, develop, disseminate), the system has been developed systematically, starting from needs analysis to product validation.
2. The feasibility results obtained from instrument validation tests by sports experts and users indicate that the system falls into the "highly feasible" category, with validation scores for sports experts and user feasibility validation scores based on the telos aspects (technical, economic, legal, operational, and scheduling).

REFERENCES

[1] A. Irfansyah, Y. Thiro, K. Yunior, and B. B. Harianto, "Internet of Things (IoT) Based Trash Can Monitoring System Using Web Services with the CodeIgniter Framework in the Surabaya Aviation Polytechnic Environment," pp. 1050–1053.

[2] **[2]** K. Amali, Y. Kurniawati, and Z. Zulhiddah, "Pengembangan lembar kerja peserta didik berbasis sains teknologi masyarakat pada mata pelajaran IPA di sekolah dasar," *Journal of Natural Science and Integration*, vol. 2, no. 2, pp. 70, 2019.

[3] F. Supegina and T. Elektro, "Jurnal Teknologi Elektro , Universitas Mercu Buana Rancang Bangun Iot Temperature Controller Untuk Enclosure Bts Berbasis Microcontroller Wemos Dan Android ISSN : 2086 - 9479," vol. 8, no. 2, pp. 145–150, 2017.

[4] M. Lestari, E. Haryani, and T. Wahyono, "Analisis Kelayakan Sistem Informasi Akademik Universitas Menggunakan PIECES dan TELOS," *Jurnal Teknik Informatika dan Sistem Informasi*, vol. 7, no. 2, pp. 373–380, 2021, doi: 10.28932/jutisi.v7i2.3612.

[5] A. Harjanto, A. Rustandi, and J. A. Caroline, "Implementasi Model Pengembangan 4D Dalam Mengembangkan Media Pembelajaran Berbasi Online Pada Mata Pelajaran Pemrograman Web di SMK Negeri 7 Samarinda," *Jurnal SIMADA (Sistem Informasi dan Manajemen Basis Data)*, vol. 5, no. 2, pp. 1–12, 2023, doi: 10.30873/simada.v5i2.3412.

[6] K. Kamal, U. M. Tyas, A. A. Buckhari, and P. Pattasang, "Implementasi Aplikasi Arduino Ide Pada Mata Kuliah Sistem Digital," *Jurnal Pendidikan dan Teknologi (TEKNOS)*, vol. 1, no. 1, pp. 1–10, 2023.

[7] H. P. B. dan E. F. Utsman Syah Amrullah, Satworo Adiwidodo, Riyanto Heri Nugroho, "Pengadaan Fasilitas Olahraga Badminton Bagi Taman Pendidikan," *Jurnal Kajian Pendidikan Teknik Bangunan*, vol. 7, no. 1, pp. 67–73, 2019.

[8] N. L. Mauliddiyah, "Papan Skor Berbasis Led P10," no. November, p. 6, 2021.

[9] M. S. R. H. y S. J. H. Sigurdsson Houghton B. and F. M. Wedge, "Teori Komponen Utama Blynk," *Encyclopedia of volcanoes.*, vol. 3, p. 662, 2000.

[10] H. Hikmarika, U. Sriwijaya, and O. Ilir, "Design of Digital Scoreboard for Badminton Match Based on Desktop Computer," vol. 14, no. 1, pp. 10–15, 2025.