

Implementation of a Rule-Based System to Identify Weekly Physical Activity Status in a Web Reporting Platform for Elementary Students

Aslam Dafa Fauzan¹, Purwono Hendradi², Dimas Sasongko³, Endah Ratna Arumi⁴, Emilyya Ully Artha⁵

^{1,2,3,4,5}Department of Informatics Engineering, Universitas Muhammadiyah Magelang, Magelang, Indonesia

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ABSTRACT

Low levels of physical activity and increasing sedentary behavior among elementary school students make it difficult for teachers and parents to monitor children's physical activity when records are still kept manually. This study aims to develop a web-based physical activity reporting system that supports the process of recording, summarizing, and monitoring students' physical activity on a daily and weekly basis. The study used the Waterfall development model, which includes needs analysis through observation and interviews, system design, implementation, and testing. The system was developed using Laravel, PHP, and a MySQL database. To determine students' physical activity status, the system employs a Rule-Based System (RBS) based on World Health Organization (WHO) recommendations, whereby students are categorized as "Active" if their total physical activity duration reaches at least 420 minutes per week and as "Inactive" if it falls below that threshold. System verification was conducted through functional and integration testing, as well as a comparison between the system's classification results and manual calculations using five test data scenarios. The test results showed a 100% level of agreement between the system's output and manual calculations, including in boundary condition testing at 420 minutes per week. The developed system provides a structured mechanism for recording, reporting, and monitoring students' physical activity, thereby supporting teachers and parents in obtaining more documented and systematic information about students' physical activity.

Corresponding Author:

Dimas Sasongko,

Department of Informatics Engineering, Universitas Muhammadiyah Magelang, Magelang, Indonesia.

Jl. Mayjend Bambang Soengeng Km.5 Mertoyudan Magelang 56172

Email: dimassasongko@unimma.ac.id

1. INTRODUCTION

School-age children are at a crucial stage in their physical growth, cognitive, social, and emotional development. However, lifestyle changes that increasingly lead to sedentary behavior are often the cause of decreased physical activity in this age group [1]. Sedentary behavior has become a significant health problem in children and adolescents in various countries. The WHO reports that

sedentary behavior is more common in younger age groups because they tend to spend their free time sitting and engaging in screen time [2], [3]. Loprinzi and Cardinal also explain that children are increasingly spending time watching television, playing games, or using electronic devices for extended periods [4]. These conditions can increase the risk of obesity, reduce physical fitness, reduce sleep quality, and negatively impact social behavior. Furthermore, sedentary behavior tends to persist with age if not balanced with physical activity. In Indonesia, the 2021 National Sport Development Index (SDI) Report released by the Ministry of Youth and Sports shows a national physical literacy index of 0.565, equivalent to 56%, at the lower end of the moderate category [5]. This condition has the potential to impact children's physical fitness. Physical fitness refers to a person's ability to meet the demands of daily activities, both routine and unexpected, without experiencing excessive fatigue.

Physical activity is any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity encompasses a wide range of activities, such as sports, play, active travel (walking or cycling), and household chores [6]. Physical activity plays a crucial role in supporting children's growth and development, including physical, mental, and social aspects. Based on the 2020 World Health Organization (WHO) guidelines, children and adolescents aged 5–17 years are recommended to engage in moderate to vigorous-intensity physical activity for an average of 60 minutes per day, most of which is aerobic. Furthermore, the WHO recommends that children and adolescents engage in muscle-strengthening activities at least three times a week [7].

Various studies have examined the problem of low physical activity in children through literacy approaches, behavioral surveys, and educational interventions. Rosiana et al. developed the physical literacy media "Melifis" (Melifis) in the form of posters, pamphlets, and wall magazines to improve elementary school students' understanding of physical activity. Validation results indicated that the media was suitable for use [8]. Subagyo and Fithroni measured elementary school students' sedentary behavior using the ASAQ instrument and reported that sedentary duration, especially screen-based activities, tended to be high [1]. Ramadhani and Fithroni compared the physical activity of students in urban and rural areas using the PAQ-C and found that the majority of students in both areas fell into the physical activity category [9].

Furthermore, Fitriani et al. implemented practice-based education through counseling, joint physical activities, and school policy assistance and reported an increase in knowledge and physical activity scores after the intervention [10]. Huwaida et al. analyzed the relationship between physical activity and physical fitness in elementary school students and demonstrated a significant relationship, suggesting that the quality and regularity of physical activity are important factors in achieving better fitness [11]. Roswita et al. confirms that excessive screen time contributes to sedentary behavior and decreases children's physical activity [3]. Therefore, education and screen time restrictions are necessary to encourage active lifestyle habits.

Granet et al. developed a web-based physical activity intervention that proved to be feasible and beneficial to users through the use of an online platform to support sustained physical activity [12]. However, that study focused on an adult population and was directed toward exercise interventions, rather than the process of recording and monitoring students' physical activity in a school setting. Meanwhile, Xu et al. demonstrated that most digital physical activity studies utilize gamification elements such as goal-setting, progress tracking, rewards, and feedback to increase user engagement. However, the primary focus of these studies remains on digital health applications and wearable technology, rather than on physical activity reporting systems that support monitoring needs in educational settings [13]. Additionally, a systematic review by Camacho-Sánchez et al. indicates that game-based learning and gamification in physical education have positive effects on students' motivation, academic performance, and health. Nevertheless, the majority of the reviewed studies focused on the implementation of games, exergames, and gamification strategies in the physical education learning process, while research on web-based physical activity reporting systems involving students, teachers, and parents remains very limited [14].

Based on this discussion, there is a research gap in the form of a lack of web-based systems specifically designed to support the structured recording, summarization, and monitoring of elementary school students' physical activity by involving teachers and parents as key stakeholders. Therefore, this study developed a web-based physical activity reporting system that enables the recording of students' daily activities, the generation of weekly activity reports, and the identification of physical activity status

based on World Health Organization (WHO) recommendations as an effort to support more systematic monitoring of students' physical activity.

The application can facilitate daily physical activity recording, provide recommended activity guidelines, and present regular reports. With the support of systematically documented data, teachers can guide physical education (PJOK) learning in a more measurable manner based on students' activity development. Previous research has shown that web-based interventions are effective in increasing physical activity in specific populations [15]. Furthermore, developing web-based physical activity concepts, such as Active Movement for early childhood, has been shown to increase children's participation in physical activity [16]. With the right approach, the application can serve not only as a monitoring tool but also as an educational tool that helps children understand the importance of physical activity and how to perform it correctly.

This study uses the Waterfall development method and implements the system with Laravel, PHP, and a MySQL database. This system employs a Rule-Based System to determine student activity status based on accumulated weekly physical activity duration as recommended by the WHO. With this approach, the application is expected to help physical education teachers and parents monitor students' physical activity habits in a more structured and sustainable manner.

2. METHOD

This research uses the Waterfall method, as seen in Figure 1. The research procedure begins with the requirements analysis stage, when researchers collect data and formulate system specifications based on user needs. Next, researchers develop a system design that includes software architecture, database, and user interface design. After completing the design, researchers implement the system according to the plan. Researchers then conduct system testing to ensure all components function properly and are integrated according to the scenario. The final stage is system maintenance, where researchers fix any bugs found and adapt the system to new needs.

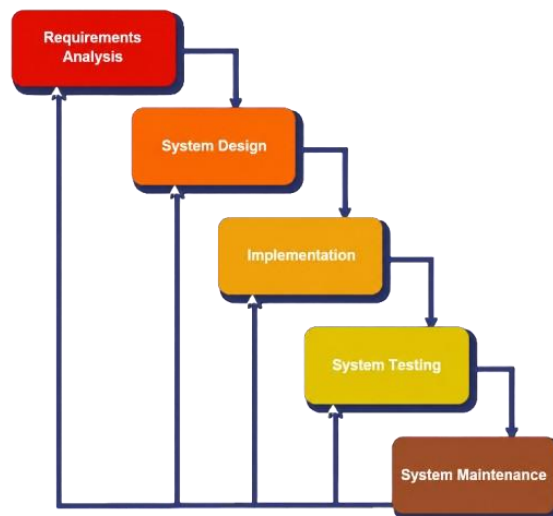


Figure 1. Research Method

In the requirements analysis phase, researchers formulated system requirements based on observations, interviews, and literature review. They found that reporting of ongoing physical activity still focused on manual recording (for example, through the TKJI), resulting in daily physical activity beyond these measurements not being systematically documented. In the system design phase, researchers designed the application flow (as seen Figure 2), features, database, and interface, and created wireframes using Figma for the main page and functional pages (login, dashboard, report input, and reports). The process design also defined user roles: physical education teachers and/or parents as reporters and monitors, while administrators managed school and user data.

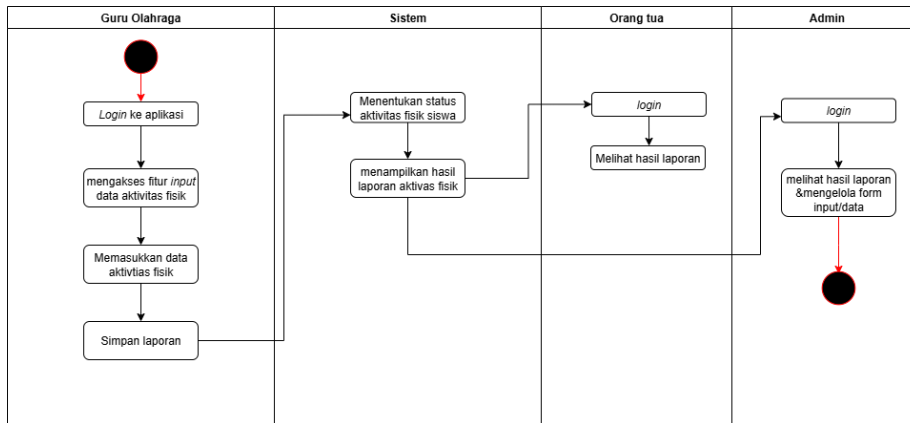


Figure 3. Activity Diagram

Next, in the implementation phase, researchers developed the application using the Laravel (PHP) framework with a MySQL database, utilizing the Model-View-Controller (MVC) pattern to separate application logic, interface, and data processing. In the testing phase, researchers tested features and module integration according to scenarios in a development environment using test (dummy) data to minimize the risk of errors before the system was widely deployed. The maintenance phase is planned for bug fixes, feature adjustments, and performance improvements, but has not been fully implemented because the research focus is on the design, construction, and initial testing of the system.

This study applies a Rule-Based System (RBS) to identify students' activity status based on the accumulated duration of physical activity. The system evaluates the total duration of students' weekly physical activity and outputs "active" if the total duration reaches or exceeds 420 minutes per week, and "less active" if the total duration is less than 420 minutes per week.

Researchers conduct system testing to ensure the system features and flow run according to specifications. Testing includes: (a) Functional testing: researchers test features directly, such as login, report input, daily/weekly report access, and display of activity identification results. (II) Integration testing: researchers test the integration of flows between pages and between modules so that the input-processing-display process runs according to the scenario. Testing is conducted in a development environment using test data to check system stability and ensure system output meets the needs formulated in the analysis stage.

3. RESULT AND DISCUSSION

This section presents the results of the development and implementation of a web-based elementary school student physical activity reporting application, as well as a discussion of the performance and benefits of the resulting system. The researchers present the results of the system implementation based on the Waterfall method stages that have been carried out, from design to testing. In addition, the researchers analyze how the system supports the process of recording, monitoring, and evaluating student physical activity more effectively than manual methods. The discussion also highlights the system's role in helping users, namely physical education teachers and parents, in understanding students' physical activity levels through structured, data-driven reports.

3.1. System Implementation Results

This research resulted in a web-based elementary school student physical activity reporting application that can be used by three types of users: physical education teachers, parents, and administrators. The developed system provides key features such as user authentication, daily physical activity input, report summaries, and visualization of student physical activity results. Users can enter student physical activity data, such as activity type, duration, and intensity. The system then stores this data in a database and displays daily and weekly reports.

The application interface is designed to be simple and user-friendly to meet user needs. The system's main pages include a login page, dashboard, report input, and physical activity reports. Physical education teachers and parents can access student activity reports to regularly monitor physical activity progress, while administrators are responsible for managing user and school data. The database structure consists of several main entities: users, students, schools, and activity reports. This structure allows the system to store and manage data in an integrated manner.

3.2. Rule-Based System (RBS) Implementation

The developed system employs a Rule-Based System (RBS) to identify students' activity levels based on inputted physical activity data. The classification rules used in this study are based on recommendations from the World Health Organization (WHO), which state that children and adolescents are advised to engage in moderate-to-vigorous physical activity for at least 60 minutes every day. Based on these recommendations, the weekly physical activity threshold is set at 420 minutes (60 minutes \times 7 days). Therefore, the system applies a simple rule to identify students' physical activity status as follows: if the total weekly duration of physical activity is \geq 420 minutes, the student is categorized as "Active." Conversely, if the total weekly physical activity duration is $<$ 420 minutes, the student is categorized as "Inactive." This process is performed automatically by the system using if-then logic-based rules, ensuring consistent and easily replicable decisions, as shown in Figure 3.

The application of this simple rule aims to make it easier for teachers and parents to monitor students' physical activity based on available data. Although WHO recommendations consider both the duration and intensity of physical activity, the version of the system developed in this study uses only the accumulated duration of activity as the basis for classification. Therefore, variations in activity intensity have not been taken into account in the decision-making process and represent one of the study's limitations that should be addressed in future system development.

```

91 // -----
92 // RULE-BASED SYSTEM (RBS)
93 // -----
94 $rules = [
95   [
96     'condition' => fn($menit): bool => $menit >= 420,
97     'result' => 'Aktif',
98   ],
99   [
100     'condition' => fn($menit): bool => $menit < 420,
101     'result' => 'Kurang Aktif',
102   ]
103 ];
104
105 $status = 'Tidak Diketahui';
106 foreach ($rules as $rule) {
107   if ($rule['condition']($menit: $totalMenit)) {
108     $status = $rule['result'];
109     break;
110   }
111 }
112
113 return view(view: 'laporan.aktivitas', data: compact(
114   var_name: 'laporans',
115   var_names: 'totalMenit',
116   'startDate',
117   'endDate',
118   'availableStartDates',
119   'selectedStartDate',
120   'status'
121 ));

```

Figure 3. RBS Program Code

3.3. System Testing Results

Researchers conducted system testing to ensure that all features functioned according to the established requirements and specifications. The testing included functional and integration testing. In functional testing, researchers tested each key feature, such as login, activity data input, data storage, and report display, as seen Figure 4. Test results showed that all features functioned properly without significant errors.

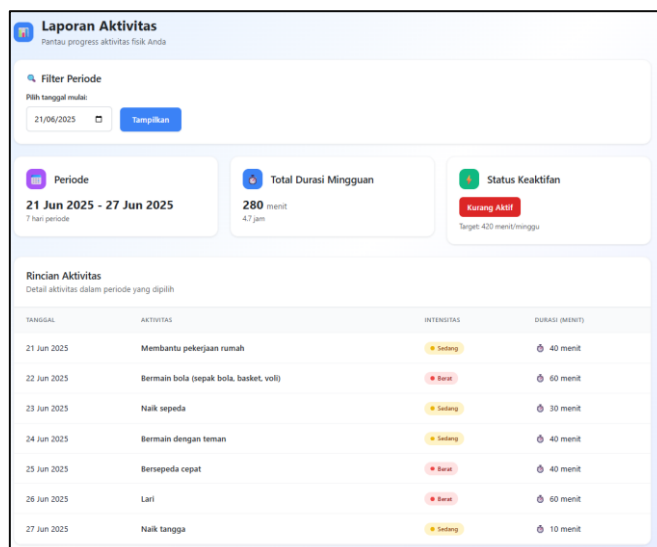


Figure 4. Weekly Report Display

Verification of system results was performed by comparing the system output with manual calculations using Microsoft Excel. The system provides two types of reports: daily and weekly. The daily report displays activity data in tabular form and serves as the basis for calculating the weekly report. The system then calculates the total activity duration for seven days and displays the student's activity status, namely "active" or "less active." Testing focused on calculating the total weekly activity duration and identifying activity levels using a Rule-Based System. Researchers input dummy data into Excel to calculate the total weekly duration and determine categories based on WHO provisions, namely ≥ 420 minutes as "active" and < 420 minutes as "less active." The Excel calculation results were then compared with the system results.

Table 1. comparing the system output with manual (excel)

No.	Total duration (minutes)	Manual results (Excel)	System results	Description
1.	480	Active	Active	consistent
2.	450	Active	Active	consistent
3.	440	Active	Active	consistent
4.	370	Less Active	Less Active	consistent
5.	240	Less Active	Less Active	consistent

System testing was conducted by comparing the classification results generated by the system with manual calculations using spreadsheet formulas, as seen in Table 1. A total of five test data scenarios were used to verify the consistency of classification results between the system and manual calculations. The test results showed that all test data yielded identical classifications between the system and manual calculations, resulting in a 100% consistency rate.

In addition, testing was also conducted under edge cases, specifically when a student's total physical activity duration was exactly 420 minutes per week. The test results showed that the system classified this condition as the "Active" category in accordance with the established rule (≥ 420 minutes). This finding indicates that the classification logic has been implemented in accordance with the designed rules. However, the testing conducted in this study is still limited to functional verification using predefined test data. Therefore, the test results cannot yet be used to draw conclusions regarding the system's usability, user acceptance, or effectiveness under real-world conditions.

3.4. Discussion

The results of the study show that the developed system is capable of providing a structured mechanism for recording, summarizing, and monitoring the physical activity of elementary school students. Through features such as daily activity tracking, weekly activity summaries, and automatic

identification of physical activity status, the system can help teachers and parents obtain information about students' physical activity more efficiently and in a well-documented manner.

These findings align with various studies showing that digital technology can be utilized to support physical activity through web-based platforms and digital applications. Granet et al. demonstrated that web-based platforms can be used to support users' participation in physical activity, while Xu et al. reported that digital features such as goal-setting, progress tracking, and feedback contribute to increased user engagement in physical activity. Furthermore, Camacho-Sánchez et al. concluded that the use of technology and gamification approaches in physical education has a positive impact on students' motivation and engagement. Unlike these studies, this research focuses on developing mechanisms for reporting and monitoring the physical activity of elementary school students, involving teachers and parents as the primary stakeholders in the monitoring process.

This study has several limitations that should be noted. First, the physical activity classification mechanism only considers the cumulative duration of weekly activity and has not yet integrated activity intensity variables as recommended by the WHO. Second, system testing is still limited to functional testing using predefined test data and therefore does not yet reflect real-world usage conditions. Third, this study has not evaluated aspects of usability, user acceptance, or the system's impact on changes in students' physical activity behavior. Therefore, this study cannot yet conclude that using the system increases users' awareness, motivation, or physical activity behavior. Conversely, the results indicate that the system has the potential to support the physical activity monitoring process by providing documented and structured activity data. Future research could involve teachers, parents, and students as direct users to evaluate the system's usability and its impact on physical activity behavior.

4. CONCLUSION

This study successfully developed a web-based physical activity reporting system to support the recording, summarization, and monitoring of elementary school students' physical activity. The system was developed using the Waterfall method, which was selected based on the results of a needs analysis conducted through observation, interviews, and a literature review. This analysis indicated that the users' primary needs were relatively clear and stable, including the recording of physical activity, management of student data, generation of weekly activity reports, and identification of students' physical activity status. The resulting system allows students to record their daily physical activities, while teachers and parents can monitor these activities through reports presented in a structured format. Additionally, the Rule-Based System implemented is capable of classifying students' physical activity status based on the accumulated duration of weekly activities in accordance with World Health Organization (WHO) recommendations.

Test results show that the classification logic implemented in the system produces outputs consistent with manual calculations across all testing scenarios conducted. However, this study has several limitations: physical activity classification is still based solely on the accumulated duration of activity without considering activity intensity, and system testing is limited to functional verification using predefined test data. Therefore, future research could develop a classification mechanism that accounts for physical activity intensity and conduct evaluations of usability, user acceptance, and system implementation among real users to gain a more comprehensive understanding of the system's utilization in a school setting.

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