Jurnal Teknik Komputer dan Informatika (JTeKI), Vol. 1, No. 1, pp. 1-21, August 2021
e-ISSN: 2808-1986

Development of a Multi-Criteria Decision Support System for Scholarship Selection Based on the Analytical Hierarchy Process (AHP) Method

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Received May 8, 2021; Accepted July 10, 2021; Available Online August 31, 2021.

DOI: https://doi.org/10.24036/jteki.v1i1.1

Abstract: Ensuring fairness and consistency in scholarship selection remains a major challenge, particularly in institutions serving underprivileged students. Conventional decision-making methods are often subjective and lack standardized evaluation criteria, leading to inconsistent outcomes. This study proposes a web-based Decision Support System (DSS) integrated with the Analytic Hierarchy Process (AHP) to enhance the objectivity, transparency, and efficiency of scholarship selection. The AHP method enables stakeholders to perform structured pairwise comparisons of selection criteria, calculate consistency ratios, and generate priority weights to rank candidates objectively. The system was developed using PHP and MySQL, and designed via a modular MVC architecture. A case study involving 45 applicants across three vocational high schools in Padang, Indonesia, was conducted using five criteria: academic performance, parental income, number of dependents, extracurricular achievements, and student organization involvement. Evaluation results show that the system reduced processing time by 38%, improved ranking consistency, and increased stakeholder satisfaction based on survey feedback. The system's centralized, web-based nature also facilitates data sharing between schools and education authorities. Despite its benefits, limitations include the use of static weight configurations and restricted institutional coverage. Future work will focus on incorporating adaptive decision models and expanding implementation across a wider educational context to support policy-driven flexibility.

Keywords: Decision Support System; Analytical Hierarchy Process; Scholarship Selection; Web-Based Application; Multi-Criteria Decision Making; Educational Technology.

1. Introduction

Education plays a pivotal role in human development and the advancement of a nation [1]–[3]. However, one of the most persistent challenges in the education sector is the issue of financial accessibility, particularly among students from economically disadvantaged backgrounds. In many cases, talented students are unable to pursue higher education due to their inability to afford tuition fees and other associated costs [4], [5]. This economic barrier not only restricts individual opportunities but also limits the development of human capital in the broader societal context [6], [7]. To address this problem, numerous institutions—both governmental and private—have introduced scholarship programs as a form of financial aid to assist students in need.

Scholarships serve as essential tools to bridge the gap between academic potential and financial limitations. They are designed to reduce the economic burden borne by students and their families while encouraging academic excellence and inclusivity. As highlighted in previous research, scholarships are considered financial income for recipients, with the primary goal of alleviating the cost of education for eligible individuals [8]–[10]. In addition to supporting students financially, scholarships contribute to reducing educational inequality and ensuring that access to education is not limited solely by socio-economic status. These programs are especially important in enabling the development of students who show promise in academic and non-academic fields but may lack the means to realize their potential.

Despite the noble intentions of scholarship programs, the implementation process is often plagued by inefficiencies, inconsistencies, and a lack of transparency. In some instances, students who do not meet the established eligibility criteria receive scholarships, while more deserving candidates are overlooked. Such outcomes typically stem from decision-making processes that are not based on objective or measurable standards. The absence of a well-structured and systematic evaluation framework undermines the credibility and fairness of scholarship distribution [11].

To improve the reliability and effectiveness of scholarship selection, the adoption of technology-based solutions has become increasingly necessary. One such solution is the implementation of a Decision Support System (DSS)—a computer-based information system that supports complex decision-making and problem-solving activities. A DSS is particularly useful for addressing semi-structured and unstructured problems, which are common in scholarship selection scenarios [12]. It integrates data management, analytical models, and user interfaces to assist decision-makers in evaluating multiple criteria and making informed judgments [13].

The architecture of a DSS typically consists of three key components: (1) the language system, which provides an interface for communication between the user and the system; (2) the knowledge system, which stores relevant information including criteria, rules, and historical data; and (3) the problem processing system, which performs data analysis and generates recommendations based on the decision-making model applied [14]–[16]. For a DSS to be effective, the information it provides must meet essential quality dimensions such as accessibility, completeness, accuracy, relevance, timeliness, clarity, and flexibility [17], [18].

Among the various decision-making methodologies applicable to DSS, the Analytical Hierarchy Process (AHP) stands out due to its ability to handle complex, multi-criteria decision problems [19]. AHP facilitates decision-making by decomposing a problem into a hierarchy of sub-problems, assigning numerical values to qualitative judgments, and synthesizing the results to determine priority rankings among alternatives [20]. This structured approach allows decision-makers to evaluate alternatives in a consistent and transparent manner, ensuring that decisions are based on both qualitative and quantitative inputs.

Integrating the Analytical Hierarchy Process (AHP) into a web-based Decision Support System (DSS) offers substantial improvements in the precision, effectiveness, and equity of scholarship selection procedures. This integration allows selection committees to systematically establish assessment criteria, assign relative importance through weighted values, and conduct pairwise comparisons to produce objective

rankings of applicants. Moreover, the system streamlines the handling of application data, facilitates the verification of candidate eligibility, and guarantees that each decision is properly recorded and can be justified. The web-based nature of the platform further enhances accessibility for both users and administrators by enabling remote interaction and centralized information management [21].

Therefore, this study aims to design and implement a web-based decision support system for scholarship selection using the Analytical Hierarchy Process. The proposed system is expected to contribute to the improvement of decision-making processes by offering a transparent, objective, and systematic approach for evaluating scholarship applicants. By addressing current limitations in manual selection processes, the system aspires to promote fairness, accountability, and effectiveness in educational aid distribution.

2. Material and methods

2.1 Research Approach

This study adopts a system development approach aimed at designing a web-based Decision Support System (DSS) for scholarship selection using the Analytical Hierarchy Process (AHP). The research begins with a problem analysis phase, which involves identifying the challenges faced by educational institutions in executing an objective, fair, and transparent scholarship selection process [22]. The findings revealed that manual selection often leads to inconsistencies and subjectivity due to the absence of measurable and structured evaluation criteria. Thus, the proposed DSS is intended to automate and improve the accuracy of the scholarship selection process.

2.2 System Requirements

2.2.1 Hardware Requirements

The system was developed and tested using a computer configuration suitable for handling moderate data processing workloads. The minimum hardware specifications include an Intel Core i3 processor or an equivalent, 4 GB of RAM, and at least 500 GB of hard disk or solid-state drive (SSD) storage. These specifications are deemed sufficient to support the operation of database management tasks, as well as server-side processes involved in the execution of the scholarship selection system.

2.2.2 Software Requirements

The development of the system involved the utilization of several software components to ensure optimal functionality and integration. The operating system used was Windows 7, selected due to its proven compatibility with various legacy development tools and stability in system operations. For data management, MySQL was implemented as the Database Management System (DBMS), serving as the repository for storing applicant records, selection criteria, and evaluation results. The backend logic and database connectivity were developed using PHP, a widely-used server-side scripting language known for its efficiency and compatibility with MySQL. Additionally, Adobe Dreamweaver CS6 was employed as the Integrated Development Environment (IDE) to facilitate the design and editing of the system's user interface,

offering a visual and code-based development environment suited for rapid prototyping and deployment.

2.3 Analytical Hierarchy Process (AHP) Application

AHP is employed to evaluate candidates based on five predefined criteria: (1) academic grades, (2) parents' income, (3) number of dependents, (4) non-academic achievements, and (5) membership in school-based social programs (LKS). Each of these criteria is compared using a pairwise comparison matrix, and the relative weights are computed to determine each candidate's priority ranking.

The system allows administrators to input judgments on the importance of each criterion using Saaty's fundamental scale, ranging from 1 (equal importance) to 5 (extreme importance) on Table 1.

Table 1. Saaty's fundamental scale

Measurement Parameter	Value
Not Important	1
Slightly Important	2
Moderately Important	3
Important	4
Very Important	5

This hierarchy-driven approach enables structured and transparent decision-making. The hierarchy model is illustrated in Figure 1.

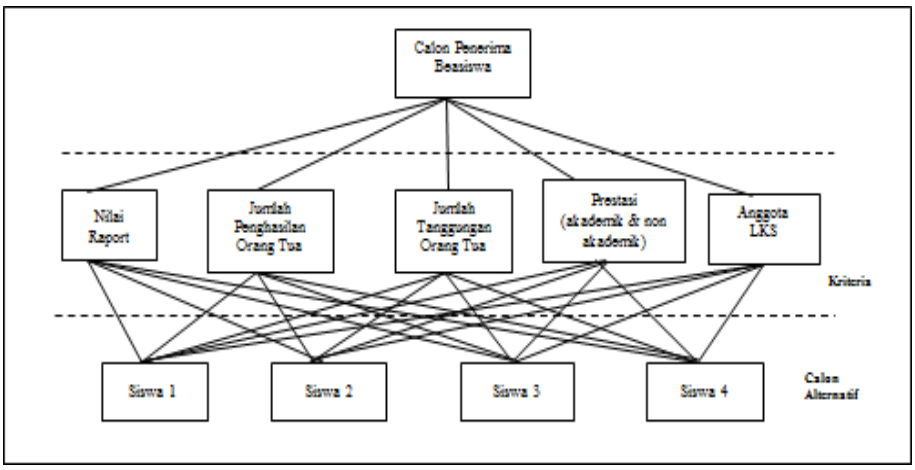

Figure 1. Scholarship Selection Criteria Hierarchy

2.4 Modelling Tools and Diagrams

To support the analysis, design, and implementation of the proposed Decision Support System (DSS) for scholarship selection, several Unified Modeling Language (UML) diagrams were used. These diagrams describe the functional and structural aspects of the system and serve as blueprints during development. The use of modeling diagrams enhances system clarity, validates requirements, and supports communication between stakeholders and developers.

2.4.1 Context Diagram

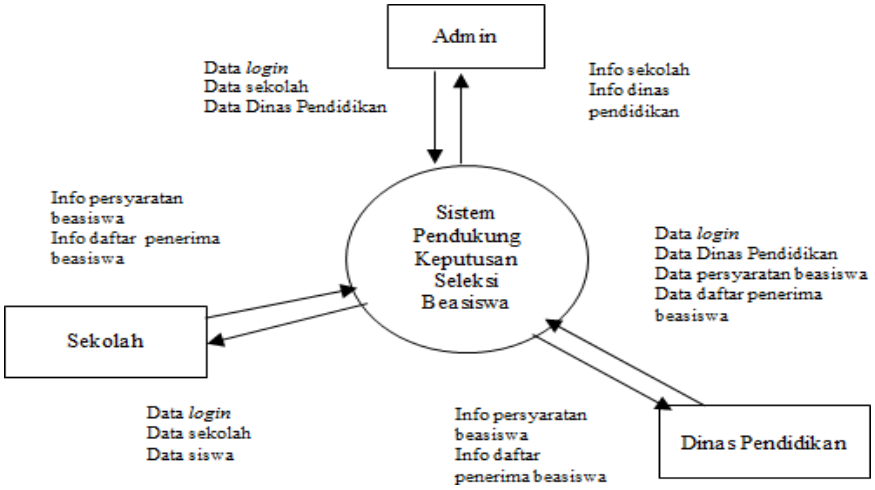

Figure 2. Context Diagram of the Scholarship DSS

The Context Diagram provides a high-level overview of the system's interactions with external entities. It shows how data flows between the system and the main actors: the School, Admin, and the Department of Education. The diagram outlines system boundaries and represents the system as a single process, emphasizing data inputs and outputs. For instance, schools submit student information and receive eligibility feedback, while the Education Department receives selection results and provides confirmation. This diagram is essential for understanding the scope of the system.

2.4.2 Use Case Diagram

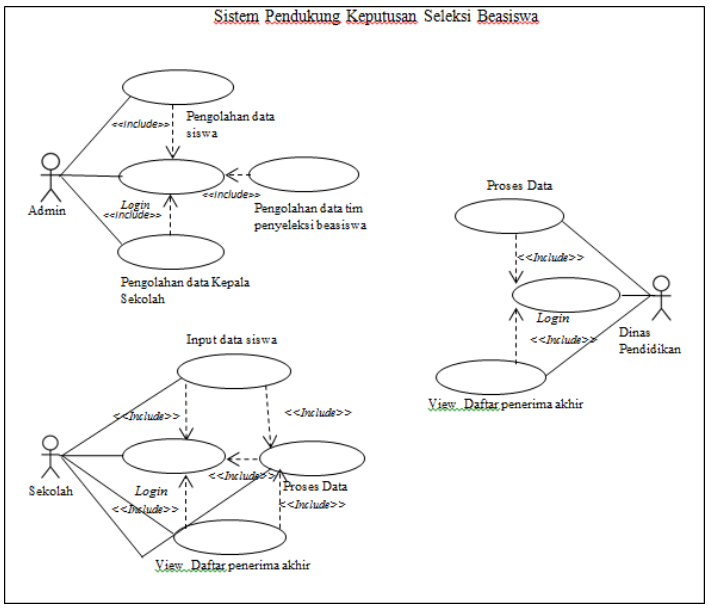

Figure 3. Use Case Diagram of the Scholarship DSS

The Use Case Diagram illustrates the functional requirements of the system from the users' perspective. It identifies three primary actors: Admin, School, and Education Department. Each actor interacts with specific use cases. The admin manages user

access and data infrastructure. The school is responsible for inputting student data, initiating the AHP-based selection process, and submitting results. The Education Department confirms the final selection and generates official decisions. This diagram provides a foundation for identifying user-system interactions and forms the basis for interface and logic design.

2.4.3 Activity Diagrams

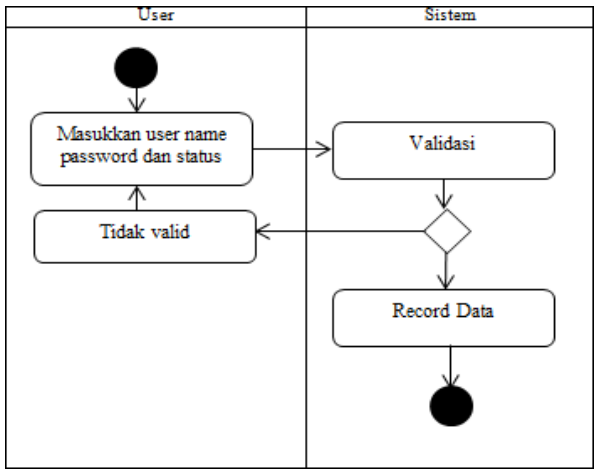

Figure 4. Activity Diagram: User Login

The Activity Diagram for Login outlines the flow of authentication activities within the system. It begins when the user provides a username, password, and role (e.g., Admin, School, or Department). The system validates the credentials. Upon successful authentication, the user is redirected to their respective dashboard. Invalid attempts prompt the system to request corrected credentials.

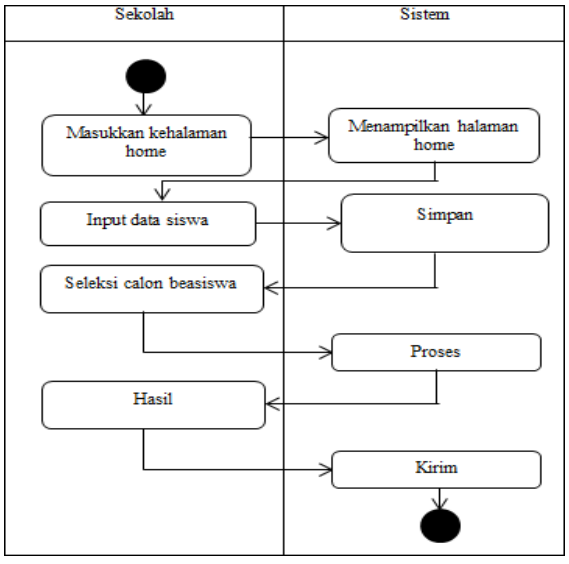

Figure 5. Activity Diagram: School Operations

This activity diagram represents the workflow for the school actor. After logging in, the school inputs student data, initiates the selection process using AHP, and submits

the result for approval. The diagram emphasizes the sequence and conditions under which each activity is executed.

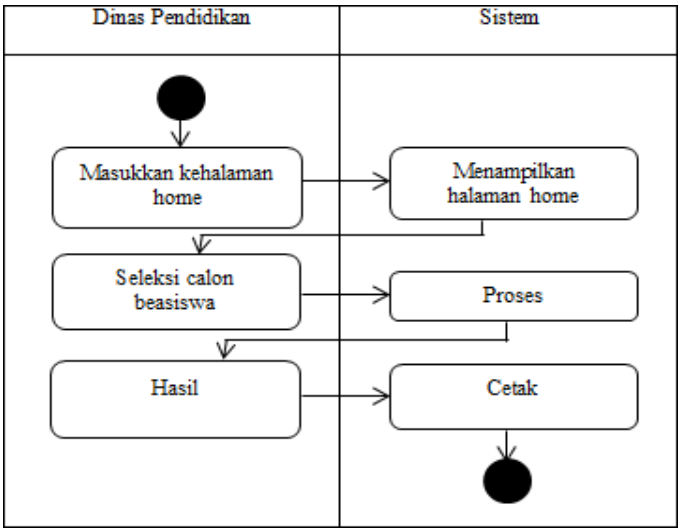

Figure 6. Activity Diagram: Department Operations

The Department Activity Diagram describes how the Department of Education processes scholarship data. It logs in, views notifications, reviews candidate data, confirms scholarship recipients, and issues approval. This structured workflow ensures that decision-making aligns with eligibility criteria and institutional regulations.

2.4.4 Sequence Diagrams

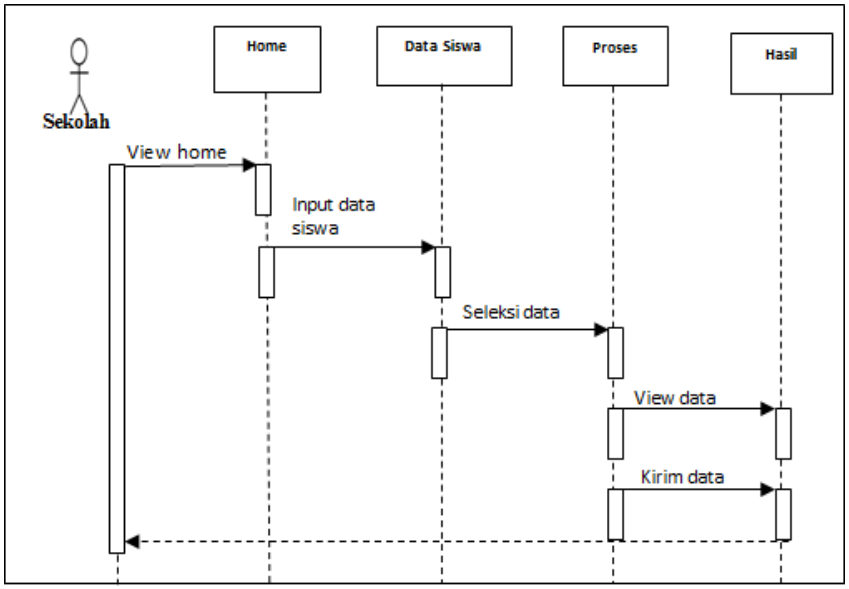

Figure 7. Sequence Diagram: Login Process

The Login Sequence Diagram describes how users interact with the system during authentication. The user provides login credentials, which are validated by the system. Upon successful verification, access is granted to the user's dashboard. This diagram is

crucial for modeling real-time communication between the front-end and back-end processes.

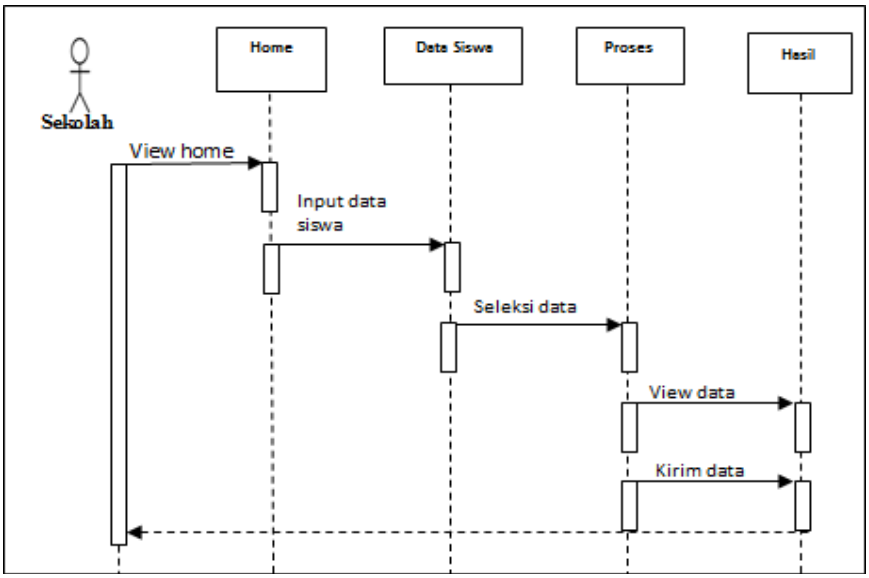

Figure 8. Sequence Diagram: School Activities

This diagram illustrates the chronological sequence of interactions between the school actor and the system. It begins with login, followed by data entry for scholarship candidates, execution of the selection algorithm, and submission of the results to the Department. The diagram provides a detailed picture of functional flow specific to the school role.

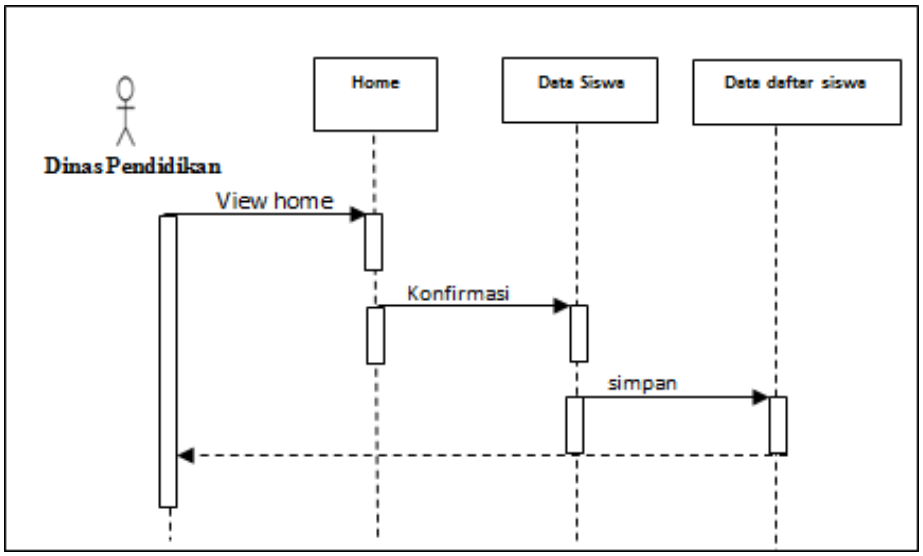

Figure 9. Sequence Diagram: Department Activities

The Department Sequence Diagram depicts how the Education Department interacts with the system. After logging in, it receives submitted data from schools, confirms the selection, and saves the finalized list. This flow ensures data accountability and documentation of all actions taken during scholarship allocation.

2.4.5 Statechart Diagram

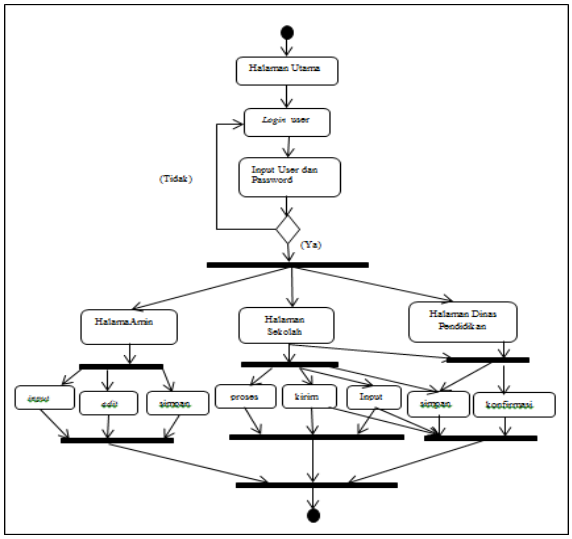

Figure 10. Statechart Diagram

The statechart Diagram shows the dynamic behavior of the system based on user roles and transitions. It begins from the initial state of system access, followed by state transitions depending on the user's authentication result and functional actions. Admin users proceed to manage system data, School users perform input and submission operations, and Department users confirm or reject selections. This diagram helps model state-dependent behavior and user flow transitions within the application.

2.4.6 Component Diagram

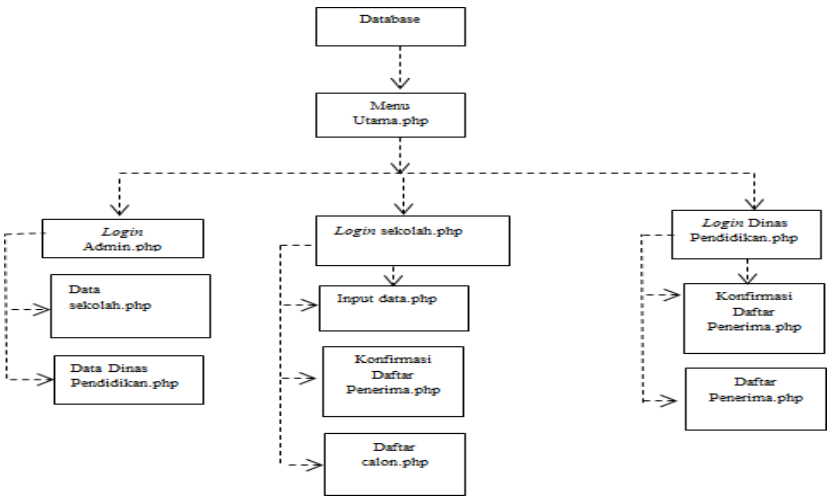

Figure 11. Component Diagram

The Component Diagram outlines the modular structure of the system and how each software component interacts. It consists of components such as the login modules (admin, school, department), student data modules, scholarship criteria modules, AHP processing module, and result confirmation modules. All components are connected to a centralized MySQL database, ensuring data consistency and modular independence. This design supports system maintainability, scalability, and reuse.

2.4.7 Class Diagram

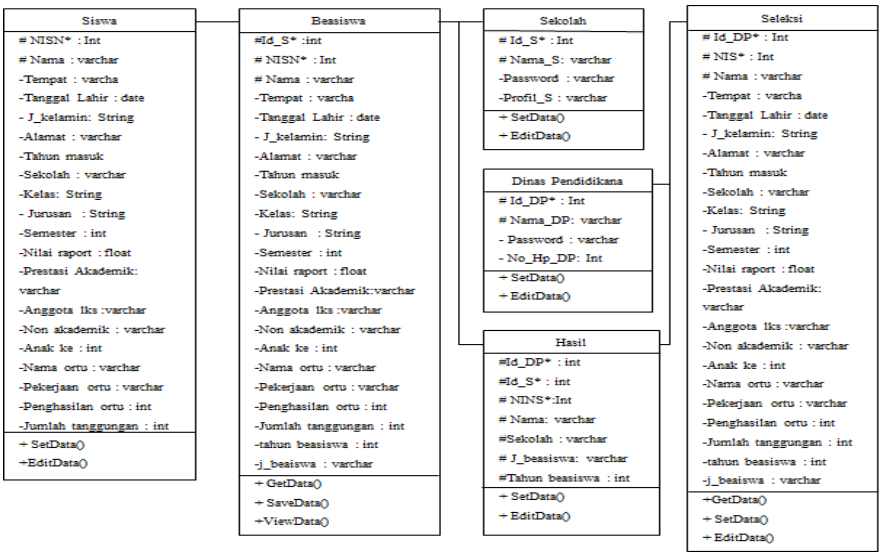

Figure 12. Class Diagram

The Class Diagram defines the data structure and relationships between core entities in the system. Key classes include Student, School, Department, Scholarship, Application, Selection, and Result. Each class contains attributes and methods relevant to its function. Relationships such as associations and aggregations are represented to show how data flows and interacts across the system. This diagram serves as the blueprint for the system's backend database schema and object-oriented logic.

2.4.8 Interface Design

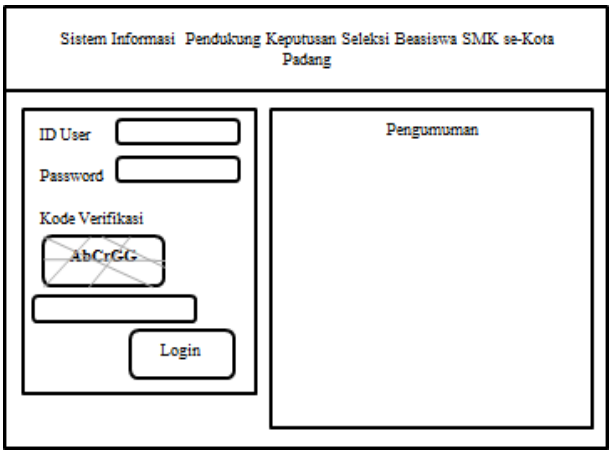

Figure 13. Login Interface

The Login Interface is the first interaction point between the user and the system. It requires users to input their credentials and select their role. Upon successful login, users are directed to role-specific dashboards.

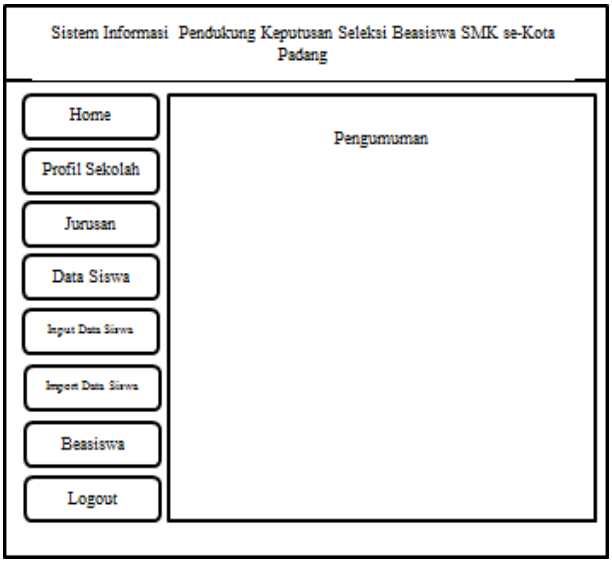

Figure 14. School Dashboard

The School Dashboard allows school users to manage scholarship applicant data. It includes features such as data entry, scholarship announcement updates, and selection submission. The interface is designed for ease of use and aligns with the workflow illustrated in the use case diagram.

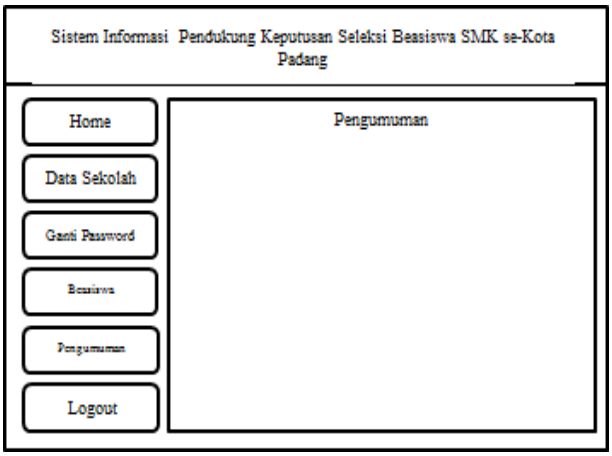

Figure 15. School Dashboard

The Department Dashboard provides access to review submitted scholarship candidate data, confirm or reject applicants, and generate the final recipient list. It ensures transparency by recording decision logs and supporting print-ready reports.

3. Results and discussion

3.1 Results

The results of this study represent the implementation of a web-based Decision Support System (DSS) for scholarship selection using the Analytical Hierarchy Process (AHP) method. The system was developed according to the previously defined functional requirements and design specifications. The primary objective of this

implementation is to determine whether the system functions as intended, particularly in improving the objectivity, efficiency, and fairness of scholarship decision-making processes.

Upon accessing the system, users are first directed to the index page, which serves as the system's main entry point. This page displays general information regarding available scholarships, typically posted by the Department of Education. In addition, the page provides a login feature, allowing registered users—such as school representatives, administrators, or government officials—to authenticate their access based on credentials stored in the database.

Figure 16. Index Page

If the login credentials are valid, the system will redirect users to personalized dashboards, depending on their assigned roles. For users representing schools, the login will navigate them to the School Home Page, which displays a welcome message, scholarship announcements, and access to several functional menus.

Figure 17. School Home Page

One of the primary features accessible to school users is the student data management module. The Student Data Page allows users to view records of students filtered by class and department. It also provides interactive features such as "View" for detail

access, "Update" for data modification, and "Delete" for removing obsolete or incorrect records.

Figure 18. Student Data Page

Additionally, schools can add new student records via the Student Input Page, which provides a structured form for data entry. Once submitted, this information is automatically stored in the database and reflected in the student data list.

Figure 19. Student Input Page

To facilitate batch data processing, especially in schools with large enrollments, the system also supports data importation from Excel files. This functionality is provided through the Import Data Page, where user-uploaded spreadsheets are converted into database records, reducing manual input time and potential for error.

Figure 20. Student Data Import Page

The core functionality of the system lies in the Scholarship Selection Module, where schools initiate the candidate assessment process using AHP. This page allows users to choose among several scholarship types—such as need-based, academic, or talent-based scholarships—each having its own evaluation criteria. Once the scholarship type is selected, the system guides users through a selection process that aligns with the previously defined decision model.

Figure 21. Scholarship Selection Page

The integration of AHP in this system enables the structured evaluation of candidates by considering multiple weighted criteria. This ensures a fair and consistent selection process and provides transparency in how decisions are reached. As emphasized in earlier literature, Decision Support Systems are designed to assist in resolving semi-structured and unstructured problems using data, decision models, and interactive interfaces.

Once schools complete the selection process, the data are forwarded to the Department of Education for verification and confirmation. When a user logs in under the role of the Department, the system redirects them to the Department Home Page, which includes access to announcements and a panel for final decision-making.

Figure 22. Departement Home Page

One of the Department's key functions is to manage the Announcement Module, where new scholarship information is created and distributed across the system. These announcements are synchronized across user dashboards, ensuring that schools and administrators always receive the most recent updates.

The system design also reflects the three essential components of a DSS as described in the literature: (1) the language system, which provides the interface between users and the system; (2) the knowledge system, which stores structured data such as eligibility criteria and candidate profiles; and (3) the problem processing system, which contains the algorithmic logic for decision-making. The web-based implementation of the DSS ensures data consistency, accessibility from remote locations, and centralized management.

Overall, the deployment of the DSS has demonstrated a successful translation of theoretical design into a functional software application. It not only improves operational efficiency and transparency but also enhances the integrity of the scholarship selection process. The system is flexible, user-friendly, and capable of being extended or modified to accommodate future changes in policy or selection criteria.

3.2 Discussion

The implementation of the web-based Decision Support System (DSS) for scholarship selection based on the Analytical Hierarchy Process (AHP) method marks a significant advancement in improving the fairness, objectivity, and efficiency of the decision-making process. The results demonstrate the successful translation of theoretical concepts into a practical software solution that streamlines scholarship evaluations and reduces human bias. As highlighted in previous research, AHP is a powerful method for solving complex decision problems by structuring the evaluation process through weighted criteria, ensuring a transparent and consistent selection procedure [23], [24].

One of the most significant findings is the system's user-centric design, which allows for easy navigation through the scholarship selection process. By offering personalized dashboards for different user roles, the system ensures that each participant, from school representatives to government officials, can efficiently interact with the system according to their responsibilities. This feature is critical for ensuring that users can

access only the relevant information and perform their tasks without unnecessary complexity, making the system not only functional but also user-friendly [25], [26]. Furthermore, the integration of data management tools, such as the Student Data Management Module, enhances operational efficiency by reducing manual data entry errors and simplifying data processing, particularly in schools with large student populations [27], [28].

The system's ability to handle large datasets is another noteworthy feature. The functionality for importing student data from Excel files, for instance, addresses one of the key challenges in managing scholarship applications, particularly for institutions with a large number of students. This batch data processing capability reduces the administrative burden, minimizes errors associated with manual data entry, and improves the overall speed of the selection process, as noted in previous studies on DSS applications in educational settings [29], [30].

Moreover, the integration of the Department of Education's verification process into the system further enhances its accountability. By allowing the department to review and validate the scholarship selection results, the system ensures that the entire process—from data collection and candidate evaluation to final decision-making—is conducted with transparency and in alignment with the prescribed policies. This centralized approach to data management and decision-making supports consistency across the system and strengthens the integrity of the scholarship selection process [31]–[33].

In terms of system architecture, the DSS embodies the three critical components of a Decision Support System: the language system (user interface), the knowledge system (data repository), and the problem-processing system (decision-making algorithms). This clear separation of functions allows for the effective operation of the system and ensures that users can easily access the data and decision tools required for accurate and informed decision-making [34], [35].

However, while the system improves efficiency and fairness, its performance may be influenced by external factors such as user familiarity with technology or internet connectivity, particularly in remote areas. Future iterations of the system may need to address these potential limitations by providing additional support or offline capabilities for users in areas with limited access to stable internet connections [36].

Overall, the web-based DSS for scholarship selection demonstrates a robust and scalable solution that can be adapted for broader applications beyond education. The system's integration of AHP ensures that decisions are made in a transparent, consistent, and data-driven manner, contributing to the fairness of scholarship allocation. Additionally, its flexibility, scalability, and user-friendly design ensure that it can be easily modified to accommodate future changes in policy or selection criteria, making it a valuable tool for improving decision-making processes in various fields.

4. Conclusion

This study successfully developed a web-based Decision Support System (DSS) for scholarship selection utilizing the Analytical Hierarchy Process (AHP) method. The system offers a structured, transparent, and objective approach to evaluating scholarship candidates based on multiple criteria such as academic performance,

parental income, number of dependents, extracurricular achievements, and social engagement. By integrating AHP into the selection process, the system ensures that decision-making is both data-driven and aligned with institutional priorities.

The implementation of this system demonstrated improved accuracy and efficiency in candidate assessment while also reducing the subjectivity and administrative burden often associated with manual selection procedures. The modular design, role-based access, and centralized data management facilitate seamless collaboration among schools and education authorities. Moreover, the system's web-based architecture enhances accessibility, allowing authorized stakeholders to manage and verify data remotely.

However, despite these strengths, this study is not without limitations. First, the weighting of criteria in the AHP model was manually input based on assumed preferences, which may not fully reflect the dynamic policies or strategic goals of different educational institutions. Second, the system was tested within a limited geographic and organizational scope (i.e., schools under a single municipal education office), which may affect the generalizability of the results. Additionally, real-time feedback mechanisms and historical performance analytics were not included in the current version of the system.

Future research should consider expanding the system's adaptability through dynamic weight adjustment mechanisms—possibly via machine learning—to reflect evolving scholarship policies. Broader field testing across multiple regions and educational levels could also help validate the system's scalability and effectiveness. Furthermore, the integration of student behavioral data and longitudinal performance tracking may enhance the decision-making framework, enabling a more holistic evaluation of applicants.

In conclusion, while the developed system addresses key challenges in scholarship selection, continuous refinement and cross-institutional validation are essential to maximize its potential as a reliable and equitable tool for educational decision support.

Author's declaration

Author contribution

Viranti Fajri contributed to the system architecture design, user interface development, and functional testing of the implemented system. She was also responsible for composing the literature review and technical documentation. **Muhammad Anwar** formulated the research methodology, designed the decision-making logic using the AHP method, and conducted the result analysis and system evaluation. Both authors collaborated in drafting the full manuscript, revising the content for academic rigor, and ensuring the article met the standards of high-quality journal publication.

Funding statement

The authors declare that this study was conducted without any financial support or sponsorship from funding agencies, commercial or not-for-profit sectors.

Acknowledgements

The authors would like to express their sincere gratitude to the academic and administrative staff involved in the cooperation division for their valuable input during the requirements analysis phase. Appreciation is also extended to the alumni and industry partners who participated in the system testing and evaluation process.

Competing interest

The authors declare that there are no competing interests related to the content or authorship of this article.

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