Information System Development of Master's and Doctoral Study Task Recommendation Using Fuzzy AHP

N Ni'mah, Y Anang

Politenik Statistika STIS

*Corresponding author's e-mail: 221709926@stis.ac.id, anang@stis.ac.id

Abstract. In improving quality of employees through education, Statistics Indonesia is assisted by Education and Training Centre, one of them through the Study Task program at Master's and Doctoral degrees. Due to the decrease of registrant as candidate participants of this program and to facilitate employees proposed, information system for providing recommendations Study Task program is needed. This research aims to provide recommendations to employees who are highly, moderately or not recommended being able to continue education with Study Task program using an information system. Decision-making in system is Fuzzy Analytic Hierarchy Process (Fuzzy AHP) method with assessment criteria, sub-criteria and their weights can be changed by certain actors. The system was built using the Framework for the Application of Systems Thinking (FAST) method. The system was evaluated by Black Box Testing with the results of all functions running well and System Usability Scale with results of 80.71 which means the system can be received by users. Finally, this system is expected to assist the selection of employees and provide opportunities for employees who are able to continue their education with Study Task program efficiently and reduce the subjectivity of the assessment.

1. Introduction

In carrying out its duties and functions, the Statistics Indonesia (Indonesian: Badan Pusat Statistik, abbreviated as BPS), the national statistical office in Indonesia, must be supported by qualified human resources. In 2019, out of a total of 16,446 employees, the percentage of human resources with 3-year Diploma education and below was 29.54 percent, the last education was 4-year Diploma or Bachelor degree by 54.75 percent, 15.33 percent had a master's degree, and doctoral degree by 0.38 percent [1]. In improving the quality of human resources, statistics Indonesia is assisted by the Education and Training Centre (Indonesian: Pusat Pendidikan dan Pelatihan, abbreviated as Pusdiklat). The Education and Training Centre of Statistics Indonesia has many tasks, one of which is to organize the Study Task program which includes education for Master's and Doctoral degrees.

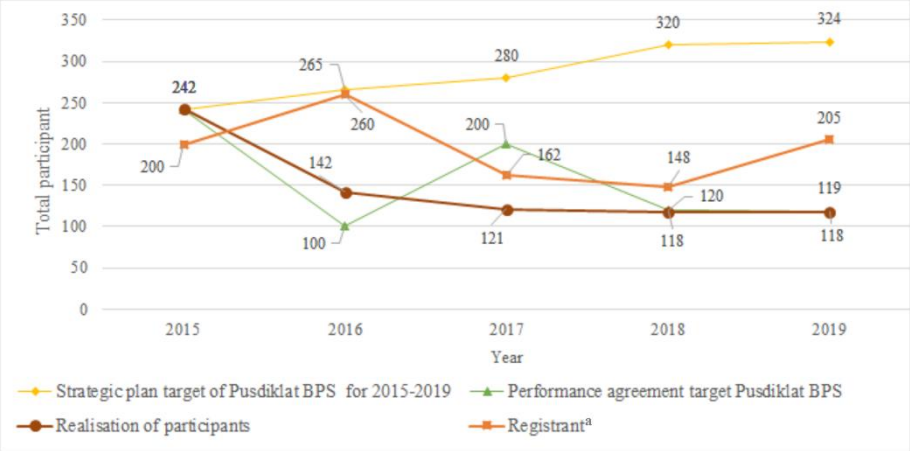

Figure 1. Comparison of the target and the realisation of the Study Task participants 2015-2019 at Statistics Indonesia.
[a] Applied in 2015 has not been fully documented on Simdiklat application

As shown in figure 1, during 2015 to 2019 the performance achievements obtained in the indicator of the number of employees participating in the Study Task financed by Statistics Indonesia tend to experience a downward trend and are lower than the target according to the strategic plan Education and Training Centre of Statistics Indonesia for 2015-2019 [2]-[7]. One of the triggers is the reduced participation of employees in participating in Master's and Doctoral programs with the state budget of Statistics Indonesia scholarships, resulting in the nomination of Study Task participants that is still less than the quota. For example, in 2019, no one registered for the Doctoral program in the Bandung Institute of Technology (Indonesian abbreviation: ITB) [6]. Then in 2020, the proposal of the Study Task for Master's and Doctoral scholarship with the state budget by echelon II officials requires an extension of the deadline up to two times for Master's program and once for Doctoral.

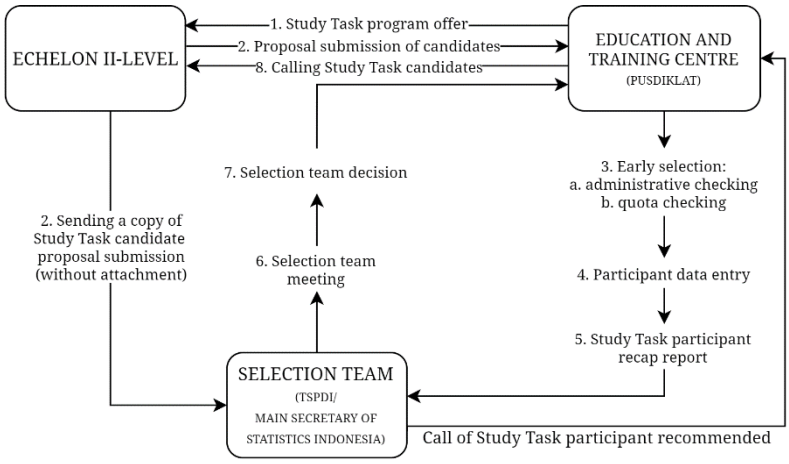

Figure 2. Flowchart of employee selection for Study Task.

The steps of administrative selection and selection of Study Task program candidates can be seen in figure 2. The first step in the selection, employees begin with notification/offer via mail from the Education and Training Centre Statistics Indonesia to echelon II officials [2]. Each submission of proposals for Study Task candidate participants to take part in Master's and Doctoral scholarship programs, both from Statistics Indonesia sponsored scholarships and from non-Statistics Indonesia sponsors, must obtain a written proposal and recommendation from an echelon II-level superior [8]. For this reason, at this step, echelon II officials must be able to select every employee who applies for

scholarships or provides opportunities for certain employees who have met the eligibility standards in accordance with their work units.

Study Task screening potential participants in echelon II and Education and Training Centre on the second and third step of the decision-making related to multiple criteria or Multi-Criteria Decision Making (MCDM). This decision-making is called so because there are certain criteria or requirements that determine an employee can be declared eligible for a recommendation being registered and further selected at the Education and Training Centre of Statistics Indonesia or sponsored by the relevant scholarship provider to continue his studies with the Study Task program, both Master's and Doctoral. However, the decision making so far is still done manually. This has a high risk of subjective decision making. Due to this, the Fuzzy-MCDM approach can be considered useful for handling inaccurate and uncertain data [9]. In addition, the Analytical Hierarchy Process (AHP) method also taken into account because it is considered simple, easy, and very flexible. The AHP process is also used in almost all MCDM related applications with a hierarchical structure [10]. So that the combination approach is Fuzzy AHP is considered being able to overcome the uncertainty and inaccuracy of hierarchical decision making and make the evaluation results more scientific, accurate, and objective [9].

Study Task of Master's and Doctoral program recommendations are based on criteria and sub-criteria with their weighting in a Decision Support System (DSS) in the form of a web-based information system. These criteria and sub-criteria are in the form of requirements for Study Task program, staffing assessments, and work-relatedness. The selection of criteria and sub-criteria along with their weighting was asked to the respondents through an interview approach. The consistency analysis will use the AHP method and then proceed with Fuzzy AHP for weighting. Besides being expected as input for echelon II superiors or related actors being able to provide recommendations for Statistics Indonesia employees in pursuing further education, it is hoped that this system can also bridge the process between the Human Resource Bureau and the Education and Training Centre of Statistics Indonesia.

The research objectives being achieved in this research in general are to assist employees in making decisions that are highly recommended, moderately recommended, or not recommended being able to continue their education to the Master's and Doctoral degrees with the Study Task program. In achieving this goal, there are several specific objectives, namely to develop assessment indicators in the form of criteria and sub-criteria for the weighting of employee assessments for participating in the Master's and Doctoral Study Task programs; formulate decision making on the recommendation of Study Tasks in the form of highly recommended, moderately recommended or not recommended; and build a web-based information system that can be accessed by related actors easily and quickly.

The benefits of the research include selecting every employee who applies for a Study Task scholarship in a subjective manner that can be measured, provide opportunities for employees who have met the eligibility standards to continue their education to the Master's and Doctoral degrees with Study Task, time and cost efficiency in providing recommendations and selecting Study Task participants and also can be a stepping stone between employee assessment data from the Human Resource Department and the Education and Training Centre of Statistics Indonesia in assessment for faster selection of Study Task participants.

In this study, there are research limitations, namely recommendations are given only to Statistics Indonesia employees for the Study Task program and are limited to Master's and Doctoral degrees; the results are only in the category of highly recommended, moderately recommended, and not recommended; the information system built is web-based application; and the Study Task administration system which consists of the registration process and its management is not covered in this study because it already available in the existing system.

Research using Fuzzy AHP has been widely used to conduct employee assessments and performance evaluations. So far there has been no research that uses Fuzzy AHP in assessing employees who are worthy of being recommended for the Study Tasks program and used in the development of web-based applications. Therefore, this research can be said to be new in the management of employee assessment at Statistics Indonesia.

This paper contains 5 sections. Section 1 describes the introduction which include background of research, problem limitation of the current system, research objectives and proposed system development. Section 2 describes the related literature review to the Study Task program in Statistics

Indonesia and about developing web-based application. Section 3 describes methodological analysis related to research methods and system development methods, and also description of the current system analysis description to identify problems and system requirements. Section 4 describes implementation of the recommendation assessment system and web-based information system built. Finally, Section 5 describes the conclusion of the research.

2. Literature Study

2.1. Study Task Program in Statistics Indonesia

According to the Regulation of the Head of the Statistics Indonesia No. 48 year 2012 concerning Study Task, Study Permit, and Promotion of Adjustment of Civil Servant Diplomas in the Statistics Indonesia, Study Task is tasks given to employees to attend education, both in at home or abroad with scholarships covering 4-years Diploma, Bachelor, Master's, or Doctoral programs. The Study Task program referred to in this research covers the educational program for the Master's and Doctoral degrees.

In terms of funding, the Study Tasks organized by the Education and Training Centre consist of the following scholarship programs.

1. State budget of Statistics Indonesia scholarships, cooperation between BPS and universities in Indonesia, e.g. University of Indonesia, Bandung Institute of Technology, Gadjah Mada University, etc.
2. State budget of non-Statistics Indonesia scholarships, scholarship offers from the Ministry of National Development Planning of the Republic of Indonesia or other ministries/agencies with state budget.
3. Non-state budget scholarships, scholarship sponsors such as Studeren in Nederland (StuNed) to study in the Netherlands and Australia Awards Scholarships (AAS), and other countries but are not offered annually.
4. Independent scholarship sponsor, scholarship sponsors sought by employees themselves with permission from their echelon II.

Statistics Indonesia employees who will attend education with the Study Task program are required to qualify the requirements according to the Regulation of the Head of the Statistics Indonesia No. 48 year 2012 are not currently undergoing another educational program, study program as needed, maximal 37 years old for Master's and 40 years old for Doctoral, minimal Diploma/Bachelor education, 3 years work experience, 4 years work experience after previous Study Task and qualify the scholarship sponsor requirements.

In addition, there are other requirements listed in the Master's and Doctoral Statistics Indonesia Scholarship Offer Letter. In this paper using a scholarship offer letter in 2020. The requirements are as follows.

1. General Requirements
   General requirements include 4 years work experience after previous Study Task, proposed by echelon II level, only one study program, completed and submitted a medium-term and long-term project report, statement letter not currently undergoing another educational program and study program is linear with work units.
2. Special Requirements
   Special requirements are requirements that nature can be different for each university, year, and sponsorship. In 2020, requires a minimal GPA of 3.00, qualify age requirements, qualify English test (TOEFL, IELTS, ELPT and the others) minimal score, qualify Academic Potential Test score of Ministry of National Development Planning of Indonesia, make a thesis proposal plan and preferably in linear majoring.
3. Other Requirements
   Other requirements include women are not pregnant when registration and education period, only provides travel costs for first participants calling, ready being placed anywhere according to the needs of the organization.

2.2. Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process is a multi-criteria decision making approach in which factors are arranged in a hierarchic structure descending from an overall goal to criteria, sub-criteria and alternatives in successive levels [11].

The AHP method is used to check consistency. The use of AHP includes the following steps.

1. Define the problem and determine the goal or solution being achieved.
   The problem being solved is described in a clear, detailed, and easy-to-understand way to find a suitable solution for the problem. Solutions to a problem may amount to more than one solution. The solution to this problem is further developed at a later step.
2. Arrange the problem into a hierarchical structure.
   Problems are arranged in a multilevel or hierarchical form so that complex problems can be viewed from a detailed and measurable side. The hierarchical structure starts with a general goal with the criteria below it, if needed can be continued with sub-criteria, and possible alternatives at the lowest level. The hierarchical structure of the AHP method can be seen in figure 3.

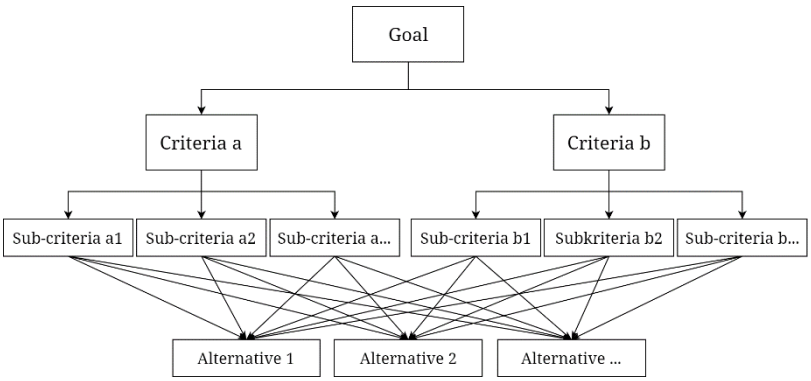

Figure 3. Hierarchical structure

3. Create a pairwise comparison matrix.
   Pairwise comparison matrix is a matrix that describes the relative contribution or influence of each element to each goal or criterion at the level above it. This matrix is able to analyse the sensitivity of the overall priority to changes in considerations. Comparisons are made based on the considerations of decision makers by assessing the level of importance between an element compared to other elements.
4. Do pairwise comparisons.
   The result of the comparison of each element will be a number from 1 to 9 which shows the comparison of the level of importance of an element in the pairwise comparison matrix. If the elements in the matrix are compared with themselves, then the result of the comparison is 1.
5. Determine the relative weight of each element with eigenvalue.
   Each column of the matrix is summed, dividing each value of the column by the corresponding column total to obtain a normalized matrix, then summing the values of each row and dividing by the number of elements to obtain the average to obtain the priority vector (eigenvector). The eigenvector (W) is a non-zero column vector which when multiplied by a pairwise comparison matrix A of size $n \times n$ will produce another vector that has a multiple of the eigenvector itself. Each eigenvector is multiplied by each element at the lowest hierarchical level and summed to obtain the priority weight value (eigenvalue). The eigenvalue (λ) is the characteristic value of a pairwise matrix A of size $n \times n$. The maximal eigenvalue (λmax) is obtained by adding up the result of multiplying the number of columns with the eigenvector. The equation of calculating eigenvector is shown in the formula (1).

$$A \times W = \lambda max \times W \quad (1)$$

6. Checking the consistency of the hierarchy (Consistency Ratio).

AHP measures the Consistency Ratio (CR) by looking at the Consistency Index (CI). The expected consistency is a consistency that is close to perfect, which is less than 10 percent in order to produce a decision that is close to valid. If the CR value is more than 10 percent, then the pairwise comparison assessment must be corrected. Where n is the number of elements (criteria and sub-criteria) and known to us, the CI and CR equations are shown in the formula (2) and (3).

$$\mathrm{CI} = \frac{\lambda max - n}{n - 1} \tag{2}$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{3}$$

The consistency ratio is obtained by comparing the CI with the random generator value or Random Index (RI). The RI values were issued by the Oakridge Laboratory with details of the values shown in table 1.

Table 1. Random Index (RI) values.

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

2.3. Fuzzy Analytical Hierarchy Process (Fuzzy AHP)

The Fuzzy AHP model used in this study is the Chang model [12]. The essence of this method lies in pairwise comparisons that explain the relative changes between pairs of decision elements in the same hierarchy with AHP. The comparison uses a ratio scale associated with the value of the Fuzzy scale. The combined Fuzzy and AHP approach is considered capable of overcoming the uncertainty and inaccuracy of hierarchical decision making and making the evaluation results more scientific, accurate, and reduce high subjectivity [10] If a consistent comparison value with AHP method has been obtained, it will be continued with Fuzzy AHP method which will be described briefly as follows.

1. Define the problem and determine the goal or solution being achieved.
   The hierarchical structure used at this step is the same as the hierarchical structure in the AHP method.
2. Create a pairwise comparison matrix with the transformation Triangular Fuzzy Number scale.
   The pairwise comparison matrix between criteria at this step is the development of the pairwise comparison matrix in the AHP method. The Triangular Fuzzy Number (TFN) are used to approach the AHP scale so that a more flexible pairwise comparison value is obtained with the matrix values of 2 linear functions on either side with lower (l), middle (m), and upper (u) values; and positive reciprocal TFN or inverse of TFN denoted by ($1/u$, $1/m$, $1/l$). The TFN scale can be seen in table 2**.**

Table 2. Fuzzy interest rate comparison scale.

AHP scale of interest	Linguistic variables	Triangular Fuzzy Number (TFN)	Reciprocal
1	Both elements are equally important	(1, 1, 1)	(1, 1, 1)
2	Intermediate	(1/2, 1, 3/2)	(2/3, 1, 2)
3	One element is less important than the other	(1, 3/2, 2)	(1/2, 2/3, 1)
4	Intermediate	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
5	One element is important than the other	(2, 5/2, 3)	(1/3, 2/5, 1/2)
6	Intermediate	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
7	One element is more important than the other	(3, 7/2, 4)	(1/4, 2/7, 1/3)
8	Intermediate	(7/2, 4, 9/2)	(2/9, 4, 2/7)
9	One element is absolutely more important than the other	(4, 9/2, 9/2)	(2/9, 2/9, 1/4)

For *l*-*m*-*u* is TFN value, 1/*u*-1/*m*-1/*l* is reciprocal TFN value, *a* is importance level of first criterion compared to second criterion and *n* is number of element of criteria, an overview of the pairwise comparison matrix of Fuzzy AHP can be seen in table 3.

Table 3. Fuzzy AHP pairwise comparison matrix.

	Criteria 1			Criteria 2			Criteria ...			Criteria *n*		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
Criteria 1	1	1	1	$a_{12}l$	$a_{12}m$	$a_{12}u$	…	...	...	$a_{1n}l$	$a_{1n}m$	$a_{1n}u$
Criteria 2	$1/a_{12}u$	$1/a_{12}m$	$1/a_{12}l$	1	1	1	...	…	...	$a_{2n}l$	$a_{2n}m$	$a_{2n}u$
Criteria ...	...	...	...	...	...	...	1	1	1	...	...	...
Criteria *n*	$1/a_{1n}u$	$1/a_{1n}m$	$1/a_{1n}l$	$1/a_{2n}u$	$1/a_{2n}m$	$1/a_{2n}l$	...	...	...	1	1	1

3. Determine the synthesis value fuzzy priority.
   Based on the extended method analysis, each of the criteria and alternatives were taken and analysed to obtain an extension of an object.
4. Specifies the vector value.
   The weight value for each criterion uses a comparison of the degree of probability between Fuzzy numbers. For 2 TFN of $M_1 = (l_2, m_2, u_2)$ and $M_2 = (l_1, m_1, u_1)$ with degree of probability $M_1 \geq M_2$, the probability level for convex Fuzzy numbers can be obtained by formula 4.

$$V(M_1 \geq M_2) = \begin{cases} 1 & , \text{if } m_2 \geq m_1 \\ 0 & , \text{if } l_1 \geq \mu_2 \\ \dfrac{l_1 - \mu_2}{(m_2 - \mu_2) - (m_1 - l_1)} & , \text{others} \end{cases} \quad (4)$$

The comparison between 2 TFN numbers can be depicted in figure 4 where *d* is the highest intersection between μ_{M1} and μ_{M2}.

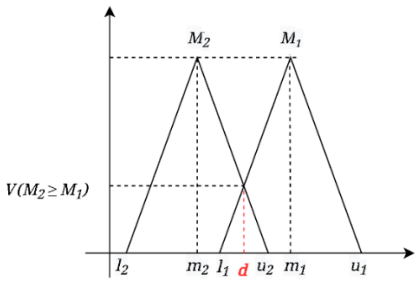

Figure 4. The intersection between M_1 and M_2 on Fuzzy AHP.

It is assumed that:

$$d'(A_1) = \min V(M_1 \geq M_k) \text{ for } k = 1, 2, 3, \ldots, n; k \neq i \quad (5)$$

Then, the value of the weight vector is defined:

$$W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_n)\right)^T \ldots. \quad (6)$$

5. Normalization of Fuzzy weight vector values.
   Normalization of vector values or priority values is important to facilitate interpretation and so that the values in the vectors are allowed being analogous to weights consisting of non-fuzzy numbers. Then the weight vector is obtained in formula 7.

$$W = \left(d(A_1), d(A_2), \ldots, d(A_n)\right)^T \quad (7)$$

After obtaining the normalization of the vector weights for each criterion, sub-criteria, and alternatives, proceed with the composite calculation and obtain the results of the calculation process using the Fuzzy AHP method.

3. Methodology

3.1. Recommendation System Analysis Method

The process of providing recommendations to Study Task candidate participants must be based on the Study Task requirements and other additional requirements. This decision-making analysis method is considered being represented by the AHP algorithm for checking consistency and the Fuzzy AHP algorithm used in assigning weight values. Furthermore, the feasibility of each alternative or Study Task candidate participant is determined using the weight value that has been obtained. The flow of the analytical method in this study is shown in figure 5.

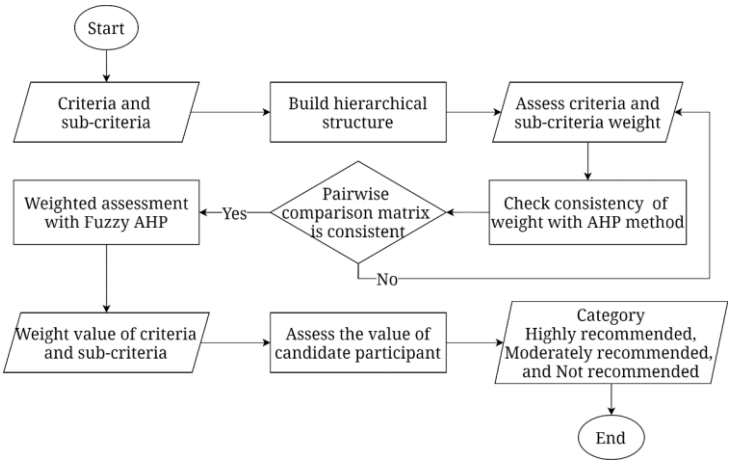

Figure 5. The flow of using Fuzzy AHP in the analysis method.

3.2. System Information Development Analysis Method

The system development method used in this research is the Framework for the Application of Systems Thinking (FAST). FAST method is a hypothetical methodology that shows a representative system development process [13]. The steps in the development system using FAST are described as follows.

1. Scope Definition
   The scope of this research includes the development of an information system for providing recommendations for Study Task specifically for employees of the Statistics Indonesia as well as compiling assessment indicators in providing recommendations to Study Task candidate participants that are measurable. The Study Task program covered is limited to the Master's and Doctoral levels of education.
2. Problem Analysis
   The analysis was obtained by data collection methods in the form of literature studies, interviews, and questionnaires. Literature study to observe problems, topics, and appropriate methodologies. Interview with 2 subject matters, there are the head of the General and IT Division of the Education and Training Centre, also echelon II-level work units represented by employees from the Human Resource and Legal Subdivision of the Statistics Indonesia South Kalimantan Province to explore the problems, obtain Study Task assessment criteria and sub-criteria, and obtain weighted scores from the criteria and sub-criteria. Questionnaires related to system testing evaluation were aimed at 8 respondents. The questionnaire used for system testing and evaluation uses Black Box Testing and System Usability Scale (SUS).
3. Requirements Analysis
   The system created is mapped within the PIECES framework being able to identify data, processes, and the interface of the proposed system. This identification can be done by means of observation or previous interviews. The PIECES analysis is shown in table 4.

Table 4. Requirement analysis with PIECES.

Analysis of	Current System	Proposed system
Performance	There is no system that can provide assessments and recommendations from Study Task registrants for postgraduate and postgraduate Study Task.	Recommendations for Master's and Doctoral Study Task participants can be seen from the assessment with a system that can be used as a tool for decision making.
Information	The data for making recommendations have not been well documented.	The data for giving recommendation decisions can be documented and it is known how the assessment process is.
Economics	Study Task registrants for master's and doctoral degrees need to spend money and time to get a letter of recommendation to a superior at echelon II level and send it to the Education and Training Centre.	Study Task registrants for Master's and Doctoral do not need to spend a lot of money and time to get a letter of recommendation from their superior at echelon II level.
Control	There may be errors in providing recommendations because the assessor only assesses the completeness of the file, not details in meeting the requirements.	The error rate is reduced by an assessment that looks at the fulfilment of the requirements and the consideration of the weight of the criteria in providing recommendations.
Efficiency	The assessment carried out by superiors at the echelon II level is still insufficient, has a high risk of subjectivity, and is inefficient if it does not look at the fulfilment of other requirements and criteria.	The subjectivity of the assessment carried out by superiors at the echelon II level is attempted being minimized and can see a measurable and more efficient assessment.
Services	There is no evaluation service for registrants for S2 and Doctoral Study Task participants at echelon II level.	The system provides facilities for providing recommendations for registrants for Master's and Doctoral Study Task participants at echelon II and Education and Training Centre levels so that they can provide evaluations to applicants who have not been accepted.

4. Logical Design

The results of the business needs analysis are translated into system models that only describe business requirements. Logical design is mentioned in table 4 column Proposed System and described in the form of a use-case diagram. The use case diagram for the proposed system is presented in figure 6. In the use case diagram, it can be seen that the system can be used by four actors or role users, namely Admin, Supervisor, Assessor, and Participants including site visitors. The supervisor team consists of the Education and Training Centre and the Selection Team for Institutional Training and Education Participants (Indonesian abbreviation: TSPDI). The assessment team consists of echelon II officials. In addition, there are also Administrators as system managers and Participants.

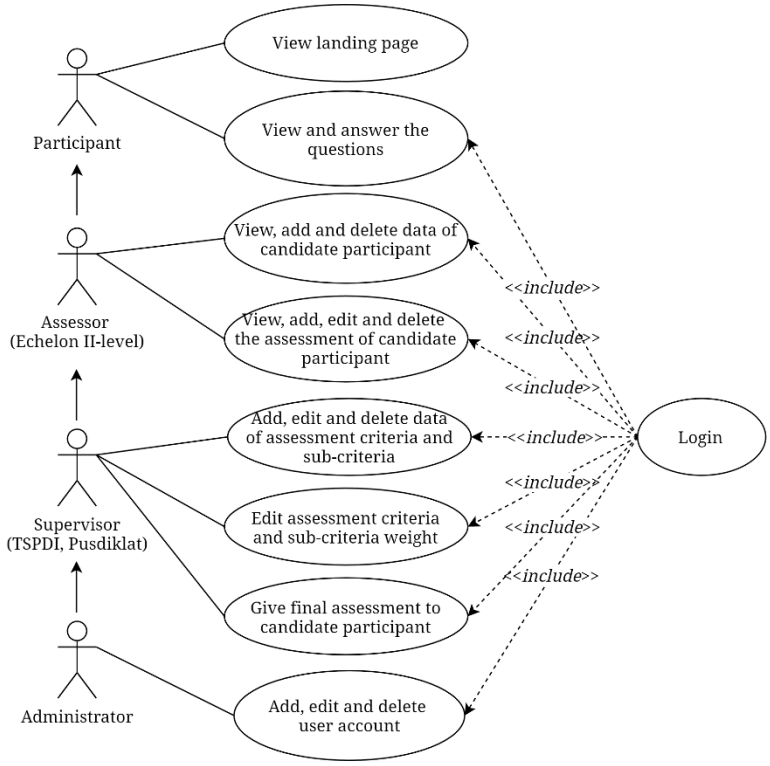

Figure 6. Use-case diagram of the proposed system.

5. Decision Analysis
   The recommendation system will be built using a web-based application. Users can access the web by connecting to a web server via the internet. In addition to providing a system view, the web server also stores all the data used in the system's business processes in the database server.
6. Physical Design and Integration
   Physical design is made in database design and interface design. The database design is made in Entity Relationship Diagram (ERD) as shown in figure 7. In the database there are 14 main tables for login users, assessments of Fuzzy AHP and employee data for Study Task candidate participants. The interface design is made with the help of the Figma application.

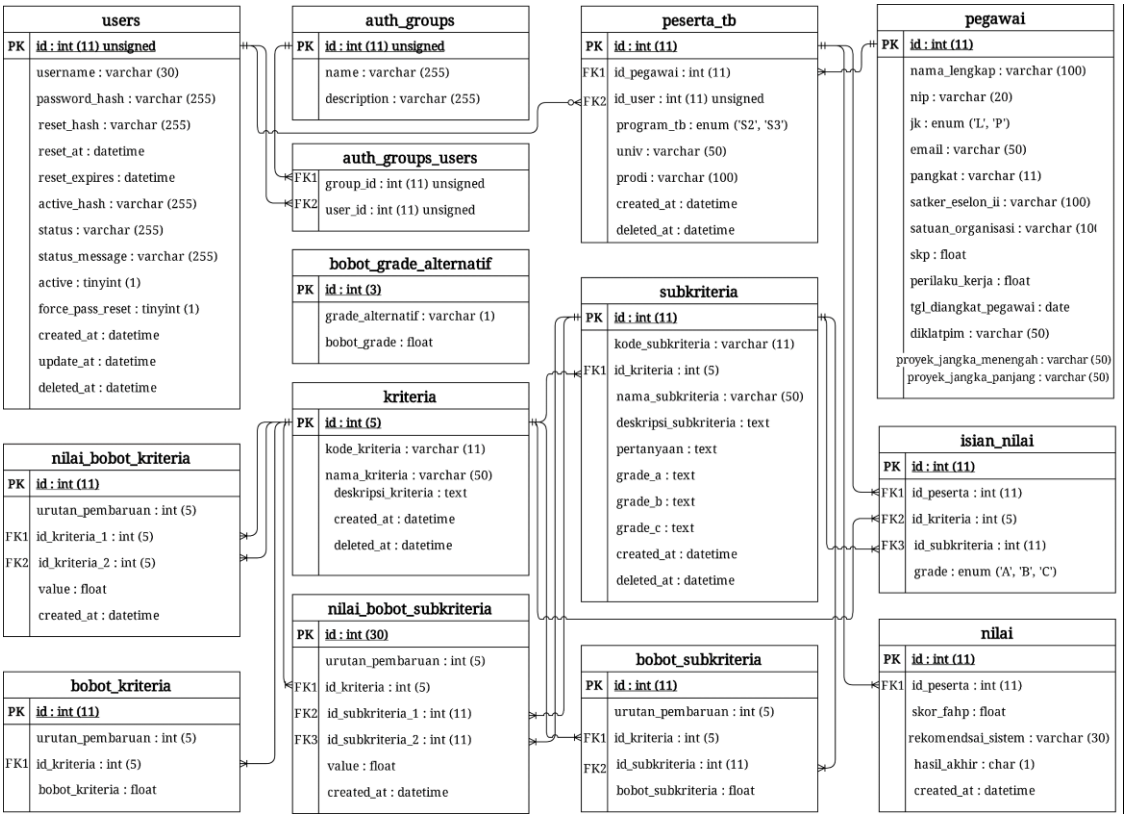

Figure 7. Entity Relationship Diagram (ERD).

7. Construction and Testing
   At this step, databases, application programs, and interfaces are built, implemented and system testing is carried out on its components to determine the level of user acceptance of the new system. The system trial in this study used Black Box Testing and the SUS questionnaire. This testing was conducted on 8 respondents from 3 actors (Supervisor, Assessor, and Participant). After testing the entire system, the system is ready being implemented.
8. Installation and delivery
   At this step the system that has been built will be operated. Applications that are ready being sent to the server and given training to users regarding the use of the system that has been built, as well as developing documentation.

4. Implementation System

4.1. Recommendation System Implementation

In the development of the recommendation system, the assessment indicators in the form of criteria and sub-criteria are compiled from the various Study Task program and staffing assessment requirements used, then selected criteria that can represent and allow for implementation. In the developed web-based information system, indicator weights can be filled dynamically. For this reason, data on criteria, sub-criteria, and their weighting in calculating the recommendation system in writing this paper is a form of initiation in which there are 4 criteria and 16 sub-criteria. The initiation indicators that are formed from the provision of recommendations for Study Tasks for Master's and Doctoral degrees at Statistics Indonesia are as follows.

1. Performance of employees, consisting of:
   a. Employee Work Target (Indonesian abbreviation: SKP)
   b. Work Behaviour
2. Mandatory requirements, consisting of:
   a. Age

b. Rank
c. Working period after being appointed as an employee
d. Active working period after previous Study Task
e. Participation in Leadership Training
f. Medium term project
g. Long term project

3. Special requirements, consisting of:
   a. Grade Point Average (GPA)
   b. English scores (TOEFL, IELTS, TOEIC and the others)
   c. Academic Potential Test score of Ministry of National Development Planning of Indonesia
4. Job related, consisting of:
   a. Can leave job temporarily
   b. Not pregnant
   c. Suitability of study program
   d. Requirements of the work unit

The indicators in the form of criteria and sub-criteria are arranged in a hierarchical form as shown in figure 8.

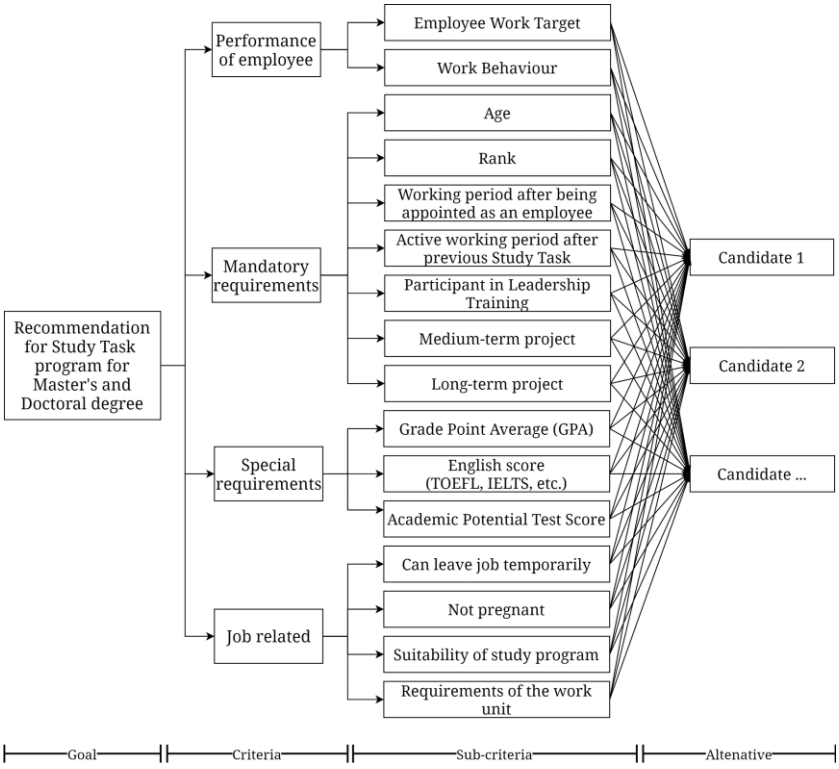

Figure 8. Hierarchy of assessment recommendations for Master's and Doctoral Study Tasks program.

Each criterion and sub-criteria are described in the form of questions and answer choices. One sub-criteria for one question with three answer choices is called an alternative grade. The form of the question and the answer choices are as follows.

Table 5. Form of the question and the answer choices for each sub-criterion.

Sub-criteria	Question	Answer Choice		
		Grade A (highly recommended)	Grade B (moderately recommended)	Grade C (not recommended)
Employee Work Target	What is the last Employee Work Target score of the Study Task candidate participants?	Good (76-100)	Fair (51-75.99)	Poor (0-50.99)
Work Behaviour	What was the final Work Behaviour score of the Study Task candidate participants?	Good (76-100)	Fair (51-75.99)	Poor (0-50.99)
Age	How old are the Study Tasks program candidates at this time?	Less than 36 years old (Master's), less than 39 years old (Doctoral)	36-37 years (Master's), 39-40 years (Doctoral)	More than 37 years (Master's), more than 40 years (Doctoral)
Rank	What is the rank of the current Study Task candidate?	Above Young Arrangers group III/a	Young Arrangers group III/a	Under Young Arrangers group III/a
Working period after being appointed as an employee	How long has the Study Task candidate participant worked since he was appointed as an employee?	More than 3 years	2.5 to 3 years	Less than 2.5 years
Active working period after previous Study Task	How long is the active working period of a Study Task candidate participant after the previous Study Task? (If not, calculated from long after last education)	More than 4 years	3.5 to 4 years	Less than 3.5 years
Participation in Leadership Training	How is the participation in the Education and Training Centre of Statistics Indonesia Leadership Training?	It's done	Undergoing	Not yet/no
Medium term project	Has the medium-term change project report of the Study Task candidate participants been completed?	It's done	Undergoing	Not yet/no
Long term project	Has the long-term change project report of the Study Task candidate participants been completed?	It's done	Undergoing	Not yet/no
Grade Point Average (GPA)	What is the GPA from the last education of the Study Task candidate participants?	Above 3.20	3.00 to 3.20	Less than 3.00
English scores	What is the grade of the English proficiency test scores (TOEFL, IELTS, TOEIC, etc.) of the Study Task candidate participants?	TOEFL iBT >78, or TOEFL CBT >210, or TOEFL ITP >547, or TOEIC >600, or IELTS >6	TOEFL iBT 56-78, or TOEFL CBT 151-210, or TOEFL ITP 450-547, or TOEIC 500-600, or IELTS 5-6	TOEFL iBT <56, or TOEFL CBT <151, or TOEFL ITP <450, or TOEIC <500, or IELTS <5, or ELPT ITB <77
Academic Potential Test score	What is the grade of the Academic Potential Test score by the Ministry of National Development Planning of Indonesia?	Above 544	475 to 544	Less than 475

Sub-criteria	Question	Answer Choice		
		Grade A (highly recommended)	Grade B (moderately recommended)	Grade C (not recommended)
Can leave job temporarily	Are Study Task candidate participants considered able to leave their jobs during the education period?	Yes	Uncertain	No
Not pregnant	Are the Study Task candidate participants not pregnant or planning to become pregnant during the Study Tasks education period?	Yes	Uncertain	No
Suitability of study program	Is the study program chosen by the Study Task candidate participant in accordance with the needs of the organization or field of work?	Yes	Uncertain	No
Requirements of the work unit	Is the education at the Master's or Doctoral level of the candidate participants needed by the work unit?	Urgently needed	So-so	Not needed

First, check the consistency of the weights between criteria. The criteria are coded "K" in the order based on figure 8. The steps for checking consistency with AHP are described as follows.

1. AHP pairwise comparison matrix and its sum

Table 6. AHP pairwise comparison matrix of criteria.

Criteria	K1	K2	K3	K4
K1	1.000	1.000	1.000	1.000
K2	1.000	1.000	3.000	3.000
K3	1.000	0.333	1.000	1.000
K4	1.000	0.333	1.000	1.000
Total	4.000	2.667	6.000	6.000

2. Criteria weighting matrix and eigenvector

Table 7. Weighting of each criteria matrix.

Criteria	K1	K2	K3	K4	Weight AHP or eigenvector
K1	0.250	0.375	0.167	0.167	0.240
K2	0.250	0.375	0.500	0.500	0.406
K3	0.250	0.125	0.167	0.167	0.177
K4	0.250	0.125	0.167	0.167	0.177

3. Matrix normalization and eigenvalue

Table 8. Normalization of each criteria matrix.

Criteria	K1	K2	K3	K4	Total or eigenvalue
K1	0.240	0.406	0.177	0.177	1.000
K2	0.240	0.406	0.531	0.531	1.708
K3	0.240	0.135	0.177	0.177	0.729
K4	0.240	0.135	0.177	0.177	0.729

4. Matrix to calculate consistency

Table 9. Matrix for calculating consistency.

K1	4.174
K2	4.205
K3	4.118
K4	4.118

5. Counting consistency

Maximal eigenvalue = 4.154
CI = 0.051194614
RI = 0.90
CR = 0.056882904

The conclusion that can be drawn from this AHP calculation is that because the CR is less than 10 percent, it can be said that the weight is consistent. The same steps are also used to check the consistency of the sub-criteria.

Consistent weights will be continued by obtaining a weighted assessment using the Fuzzy AHP method. The steps for obtaining the weighted assessment with Fuzzy AHP for the weights between criteria are described as follows.

1. Pairwise comparison matrix with TFN scale

Table 10. AHP pairwise comparison matrix of criteria.

Criteria	K1			K2			K3			K4		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
K1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
K2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.50	2.00	1.00	1.50	2.00
K3	1.00	1.00	1.00	0.50	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00
K4	1.00	1.00	1.00	0.50	0.67	1.00	1.00	1.00	1.00	1.00	1.00	1.00

2. Calculation of Fuzzy Synthetic Extend (Si) value components

Table 11. Calculation of Fuzzy Synthetic Extend value components.

Criteria	Comparison Value			Total			Reverse and Ascending Order		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
K1	4.000	4.000	4.000	15.000	16.333	18.000	0.056	0.061	0.067
K2	4.000	5.000	6.000						
K3	3.500	3.667	4.000						
K4	3.500	3.667	4.000						

3. Fuzzy weight of each criterion

Table 12. Fuzzy weight of each criterion.

Criteria	*l*	*m*	*u*
K1	0.222	0.245	0.267
K2	0.222	0.306	0.400
K3	0.194	0.224	0.267
K4	0.194	0.224	0.267

4. Comparison of synthetic extend values, weight vectors and normalization

Table 13. Comparison of synthetic extend values, weight vectors and normalization.

Criteria	Vector weight				Normalization	
	K1 ≥	K2 ≥	K3 ≥	K4 ≥	Min.	Weight
K1		1.000	0.685	0.685	0.4206	0.1979
K2	0.421		0.353	0.353	1.0000	0.4704
K3	1.000	1.000		1.000	0.3525	0.1658
K4	1.000	1.000	1.000		0.3525	0.1658

The weight column in table 13 is the weight value for each criterion. In the condition of the weighted data being tested, it can be interpreted that the Employee Performance criteria weighs 0.1799; the criteria for the Mandatory Requirements have a weight of 0.4704; as well as the criteria for Special Requirements and criteria for Job Related which have the same weight of 0.1658. In this case, the Mandatory Requirements criteria have the greatest priority than other criteria.

The same calculation method also applies to the sub-criteria. An example of the weighting of the criteria and sub-criteria entered into the hierarchy is presented in figure 9.

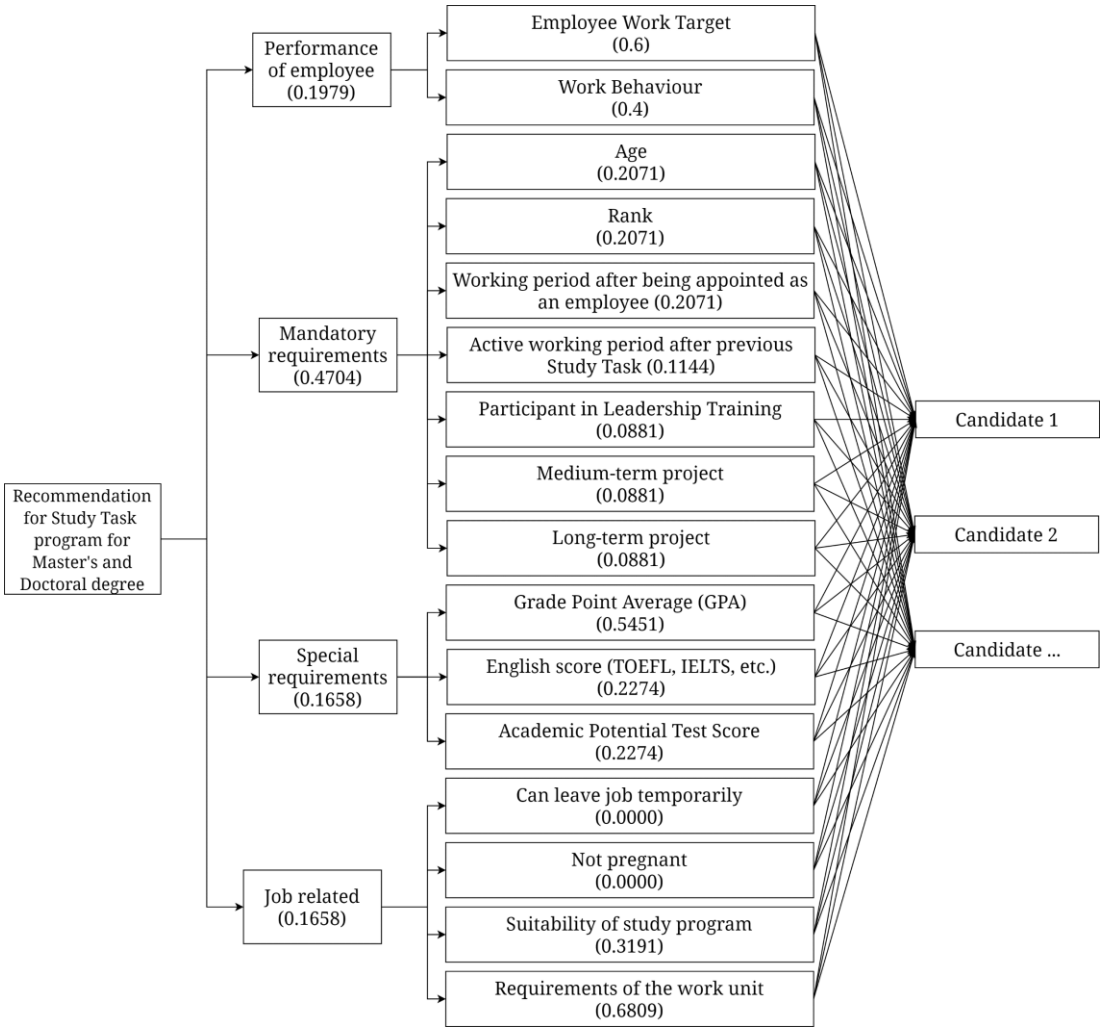

Figure 9. Hierarchy of assessment recommendations for Study Tasks with weights.

Employees or candidate participants in Study Tasks are assessed by giving a grade (answer) for each question. Each answer given, whether the answer or grade A, B, or C produces a grade weight. Grade A has a weight value of 1, grade B has a value of 0.2769, and grade C has a value of 0.0612. Each of

these scores will be a score for each answer choice chosen during the assessment. These are multiplied and added incrementally to produce the value of the weights. The value of this weight is the recommended weighting value for each Study Task candidate participant. The category of the recommended value used is:

1. The "highly recommended" category is given to the value of potential participants from 0.50 to 1.00;
2. The category of "moderately recommended" is given to the value of candidate participants from 0.25 to 0.49;
3. The category of "not recommended" is given to the value of candidate participants from 0.00 to 0.24. As an additional rule, if in the assessment of a Study Task candidate participant there is at least one grade C, then the candidate participant is declared "not recommended".

4.2. System Information Development Implementation

The hardware specifications used by the developer are HP 14-cm0xxx Laptop, AMD Ryzen 3 2200U Processor with Radeon Vega Mobile Gfx 2.5GHz, 4096 MB RAM, and 1 Terabyte hard disk drive. While the software used includes the Windows 10 operating system, PHP programming language version 7.4.15 with CodeIgniter 4 framework, text editor with Visual Studio Code, Database Management System with MySQL phpMyAdmin version 5.0.4, XAMPP server version 3.2.4, Adminty for user interface templates, and the Google Chrome web browser.

In general, the assessment steps with information system are:

1. Login to the application.
2. Supervisors can change the criteria, sub-criteria or their weights.
3. Assessors can add Study Task candidate participants.
4. Study Task candidate participants can answer several questions related to the assessment.
5. Assessors can assess Study Task candidate participants in full or complete several questions.
6. Assessors and Supervisors can see the results of providing system recommendations.
7. Assessors and Supervisors can evaluate the implementation of the selection of prospective Study Task participants.

Furthermore, several implementations of the display of the recommendation system will be presented in Indonesian. There is a landing page that is visited by the user first before accessing the next page. On the landing page there is a menu to login, information to visitors, and instructions for using the system. The interface implementation of the landing page is shown in figure 10.

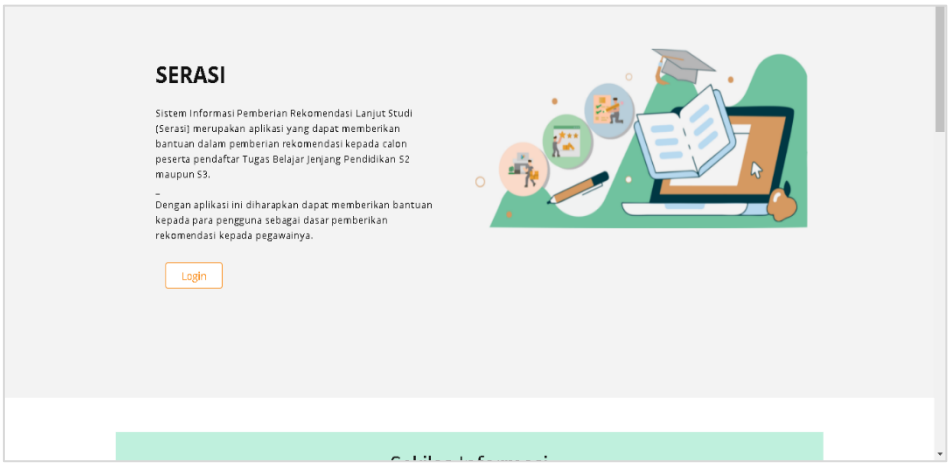

Figure 10. Implementation of landing page.

There are three user main roles that can log in, namely Supervisor, Assessor, and Participants. The menu sidebar of the three user roles is shown in figure 11, figure 12 and figure 13.

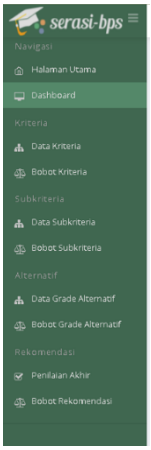

Figure 11. Menu of Supervisor.

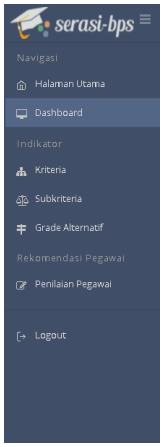

Figure 12. Menu of Assessor.

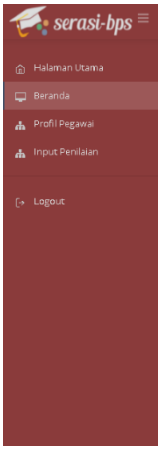

Figure 13. Menu of Participant.

Supervisors can access the data page and weights for criteria, sub-criteria, and grades alternative, as well as provide a final assessment. Implementation of the interface from the criteria data page and the weighting criteria as shown in figure 14 and figure 15.

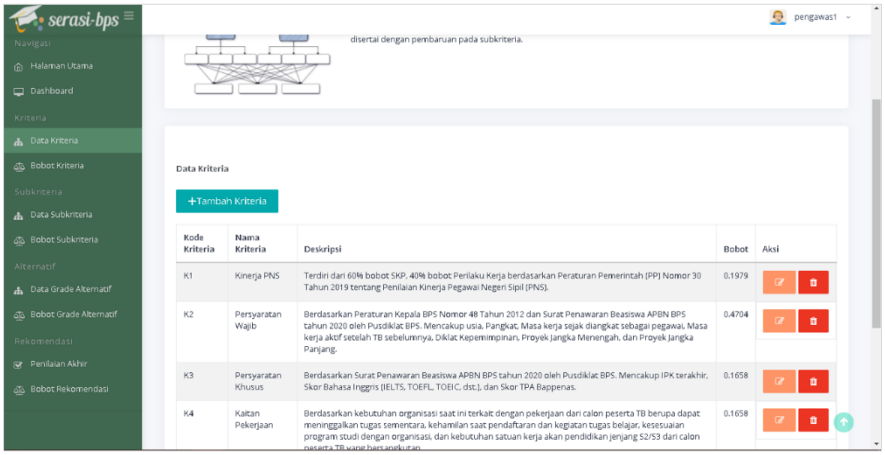

Figure 14. Implementation of criteria data interface.

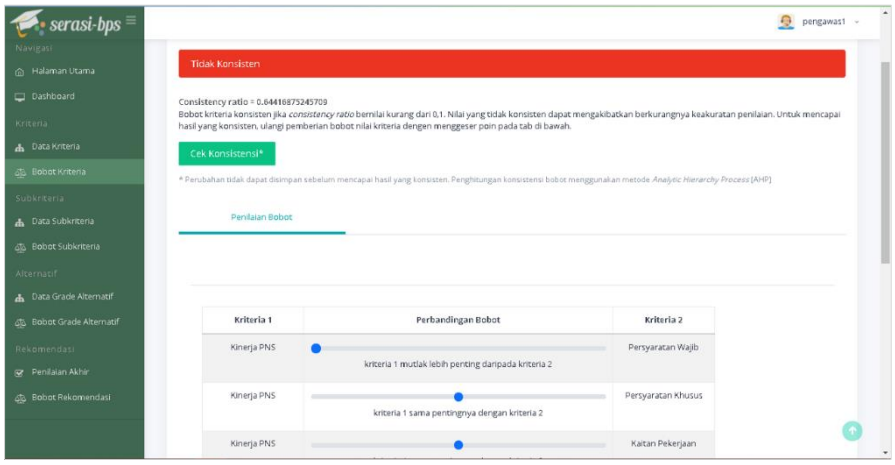

Figure 15. Implementation of weighting criteria interface.

Assessors can access the assessment page and see the weighting process for each Study Task participant candidate. The interface implementation of this page is as shown in figure 16.

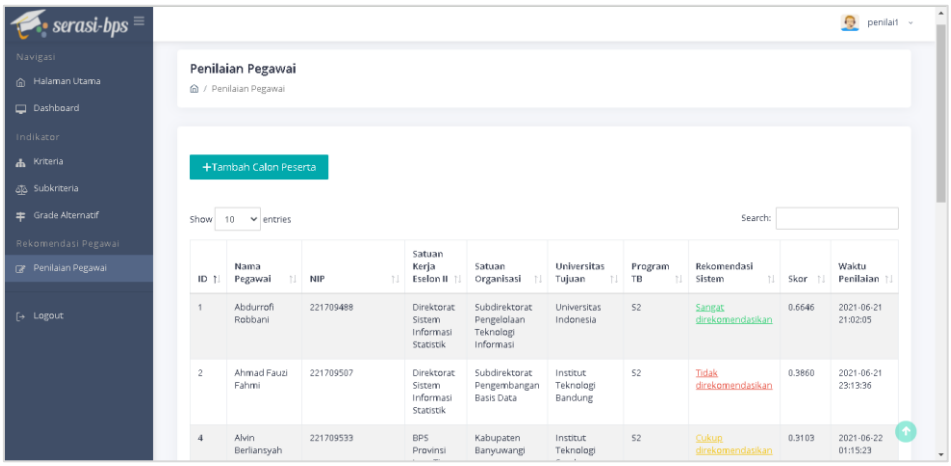

Figure 16. Implementation of weighting process assessment interface.

Participants can access the assessment input page to fill out answers to several questions. Implementation of the interface of these pages shown in figure 17.

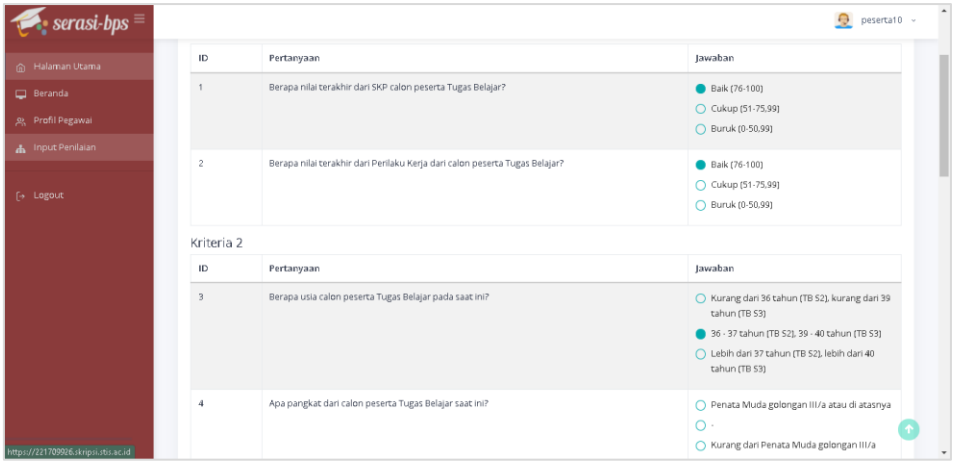

Figure 17. Implementation of candidate participant assessment interface.

4.3. System Information Testing

System information is tested using Black Box Testing and SUS. Black box testing aims to test the functionality of the system without looking at the internal code structure and detailed information of the software being tested. The test results with the Black Box Testing in table 14 show that all functions in the system run well according to the scenario.

Table 14. Black Box Testing result.

No.	Scenario testing	Role user	Results
1.	Show landing page	Supervisor, Assessor and Participant	Success
2.	Do login	Supervisor, Assessor and Participant	Success
3.	Display data criteria and criteria weight	Supervisor and Assessor	Success
4.	Add, edit and delete criteria	Supervisor	Success
5.	Change criteria weight and display weighting process after criteria weights is consistent.	Supervisor	Success
6.	Display data sub-criteria and sub-criteria weight	Supervisor and Assessor	Success

No.	Scenario testing	Role user	Results
7.	Add, change, and delete sub-criteria	Supervisor	Success
8.	Change sub-criteria weight and display weighting process after sub-criteria weights is consistent.	Supervisor	Success
9.	Display data and weights of grade alternative	Supervisor and Assessor	Success
10.	Add and delete data on Study Task candidate participants	Assessor	Success
11.	Add assessment (answer questions) to candidate participants	Assessor and Participant	Success

Testing with SUS questioner aims to evaluate the extent to which the system can be used by users to achieve goals with 10 questions and 5 answer choices. The results of the testing with SUS in table 15 show an average result of 80.71 which means it is included in the excellent category (grade B), and is worth more than 68 which means the system is acceptable to users and feasible to use.

Table 15. SUS testing result.

Respondents	Question										Total	Total×2.5	Results
	1	2	3	4	5	6	7	8	9	10			
1	5	2	4	1	5	1	4	2	5	3	34	85	80.71
2	4	1	5	1	4	2	4	1	4	1	35	87.5	
3	4	2	4	1	5	2	3	2	3	1	31	77.5	
4	4	3	4	1	4	4	4	2	4	3	27	67.5	
5	4	1	4	1	5	2	4	1	4	3	33	82.5	
6	5	2	5	1	5	2	4	1	5	2	36	90	
7	4	1	5	1	3	2	4	2	3	3	30	75	
8	5	1	5	2	5	1	5	1	5	2	38	95	

5. Conclusion

Based on the analysis research, process of providing recommendations to Study Task candidate participants has a risk with high subjectivity decision making. Therefore, it is necessary to develop an Information System for Providing Recommendations for Study Task on Master's and Doctoral Educational Levels at Statistics Indonesia. A recommendation system has been built that can assess Study Task candidate participants using indicators in the Fuzzy AHP method which is based on the Study Task Requirements in the Regulation of the Head of the Statistics Indonesia No. 48 year 2012, Master's and Doctoral Statistics Indonesia State Budget 2020 Scholarship Offer Letter, and adjustments to requires through interviews. The indicators of the assessment and their weights in the information system are can be changed by certain actors. As an initiation, there are 4 criteria and 16 sub-criteria with 3 grade alternatives. This system can provide decisions on Study Task candidate participants in the form of highly recommended, moderately recommended, and not recommended. A web-based system has been built with evaluation results using the Black Box Testing showing that all functions on the system are running well, evaluation using the SUS (System Usability Scale) questionnaire which gives 80.71 results, which means the system can be well received by users and help decision makers by recommend candidates with reduce the subjectivity of the assessment.

References

[1] Statistics Indonesia 2020 *Laporan Kinerja Badan Pusat Statistik 2019 (in Indonesian)* (Jakarta: Statistics Indonesia) p 6

[2] Education and Training Centre of Statistics Indonesia 2016 *Laporan Kinerja Pusdiklat BPS 2015 (in Indonesian)* (Jakarta: Education and Training Centre of Statistics Indonesia) pp 40-45

[3] Education and Training Centre of Statistics Indonesia 2017 *Laporan Kinerja Pusat Pendidikan dan Pelatihan Badan Pusat Statistik 2016 (in Indonesian)* (Jakarta: Education and Training Centre of Statistics Indonesia) p 28

[4] Education and Training Centre of Statistics Indonesia 2018 *Laporan Kinerja Pusat Pendidikan dan Pelatihan Badan Pusat Statistik 2017 (in Indonesian)* (Jakarta: Education and Training Centre of Statistics Indonesia) p 28
[5] Education and Training Centre of Statistics Indonesia 2019 *Laporan Kinerja Pusdiklat BPS 2018 (in Indonesian)* (Jakarta: Education and Training Centre of Statistics Indonesia) p 24
[6] Education and Training Centre of Statistics Indonesia 2020 *Laporan Akuntabilitas Kinerja Instansi Pemerintah (LAKIP) Pusdiklat BPS 2019 (in Indonesian)* (Jakarta: Education and Training Centre of Statistics Indonesia) pp 26-28
[7] Education and Training Centre of Statistics Indonesia 2015 *Rencana Strategis Pusat Pendidikan dan Pelatihan BPS 2015-2019 (in Indonesian)* (Jakarta: Education and Training Centre of Statistics Indonesia) p 32
[8] Statistics Indonesia 2012 *Peraturan Kepala BPS Nomor 48 Tahun 2012 tentang Tugas Belajar, Izin Belajar, dan Kenaikan Pangkat Penyesuaian Ijazah Pegawai Negeri Sipil di Lingkungan Badan Pusat Statistik (in Indonesian)* (Jakarta: Statistics Indonesia) pp 3-4
[9] Chen J F, Hsieh H N, Do Q H 2015 Evaluating Teaching Performance Based on Fuzzy AHP and Comprehensive Evaluation Approach *Applied Soft Computing* 28 pp 100-108
[10] Emrouznejad A and Ho W 2017 *Analytic Hierarchy Process and Fuzzy Set Theory in Fuzzy Analytic Hierarchy Process* (Boca Raton: Chapman and Hall/CRC Press) pp 1-10
[11] Saaty R W 1987 The Analytic Hierarchy Process—What It Is and How It Is Used *Mathematical Modelling* 9 (3-5) pp 161–176
[12] Chang D Y 1996 Applications of The Extent Analysis Method on Fuzzy AHP *European Journal of Operational Research* 95 (3) pp 649–655
[13] Whitten J L and Bentley L D 2007 *Systems Analysis and Design Methods. 7th edition* (New York: McGraw-Hill) pp 71-88