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A system for improving suppliers evaluation: the case of procurement in educational institution (Case study: Andalas University)

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Abstract. Supplier selection is one of the problems in both profit and non-profit organizations that need to be resolved efficiently. One of non-profit organizations is a college. Colleges aim to produce quality graduates. One factor influencing the quality of graduates is the availability of facilities and infrastructure to support the learning process. To obtain good quality facilities and infrastructure, a procurement process is needed by involving the supplier selection process. One way to get a good supplier is to use a Decision Support System (DSS) to help the supplier selection process efficiently. The design is done by integrating databases, mathematical models and information models that are packaged in a user interface (UI). Database design consists of a database of criteria, assessments, inventory data and supplier work lists. Design a mathematical model combines a Likert scale for determining criteria with the TOPSIS method for supplier ranking and Knowledge Management as additional support for supplier assessment. The results obtained are not only fixated on the supplier sorting process, but also display information on supplier data, job list and management of inventory items as supporting decision making and increase the effectiveness and efficiency of supplier selection processes into real time.

1. Introduction

In the current era of globalization, it is imperative for any organization to innovate in an effort to improve efficiency in solving a problem. Various ways/approach will be done to get efficient results to minimize time and cost. In the automotive industry in Pakistan, a reduction in costs of 8% was obtained as one of the efficiency applications in the supplier selection process after being implemented in a few months [1]. Efficiency is not only done in profit organizations but also in nonprofits. One of the nonprofit organizations is college. Based on Government Regulation No. 30 of 1990, college is an educational unit organization, which organizes education in higher education, research and community service. One of the goals of universities is to produce qualified human resources / graduates ready to mingle with the community. The quality of the university will greatly affect the graduate quality. Facility and infrastructure factors become one of the key improvements in the quality of graduate related to infrastructure, facilities and other supporting equipments. To achieve good facility quality, good procurement from supplier is needed because good facility and service quality have positive effect to user satisfaction [2].

Procurement is an activity to get goods with minimal cost, quality goods, times and the right location [3]. The procurement process is very closely related to the supplier. Supplier is an important



component that becomes a key factor in the success of a procurement. To obtain a supplier capable of meeting goods or services on demand, a good supplier selection process is required [4]. Supplier selection becomes one of the critical processes in carrying out the procurement process as it may affect the competitiveness of enterprises [5] and this process should be widely understood as a very important management responsibility [6]. The purpose of supplier is to obtain the right supplier because the purchase of raw materials and components represents 40% - 80% of the total product cost. The wrong supplier selection can harm the company. Therefore, supplier selection is an important component that must be done in a company [7].

Decision-making to select supplier is not easy. In fact, many things must be considered in making a decision to choose a supplier. There are several ways in making decision in choosing a supplier, among others (1). Multi-person decision making, which includes perspective, responsibility, expert experience as decision maker [8]. (2). Decision-making based on field facts which are then translated with systematic and logical approaches to gain priority and weight [9]. The decision-making process at this time has grown rapidly along with the development of information technology and digital in the world. At the moment, the decision-making process can be done quickly and easily. This is thanks to the integration of hardware, software and knowledge of an expert to produce a DSS which aims to support decision makers in making a decision on a problem effectively and efficiently [10]. Therefore, with this decision support system, the supplier selection problem will be more easily resolved.

Andalas University (UNAND) is one of the universities, located in the hills of Limau Manis, Pauh District, approximately 15 Km from downtown Padang, the capital of West Sumatra. Based on observations made on 10 of the 15 faculties in UNAND, it is known that there are problems for supplier selection process. The assessment process of suppliers have been conducted using different assessment indicators. Assessment of each supplier is also done on the basis of habits, in the sense that there is no standard indicator / criterion for the assessment. This will obviously make different assessment results for each supplier. In addition, the change of criteria can also occur on the same faculty because of the change of officials concerned. In addition to the different criteria, the assessment of previous suppliers also does not exist. The objective of the supplier assessment evaluation is to compare past supplier performance with the present. Whether there is an increase or decrease in performance in the procurement process. Based on some of these shortcomings, it will have a negative impact on the effectiveness and efficiency of the process of selecting suppliers in the future. In addition, another problem that will come up is a cost problem. If the selected supplier is the wrong supplier, it can harm the university by getting bad goods from supplier. Therefore, a supplier evaluation DSS is needed as a basic process to identify, determine and measure the best parameters to get a reliable supplier. DSS is needed to integrate between suppliers, warehouses and customers so that the procurement process can be carried out in a short time, optimal service and avoid large costs [11].

2. Literature Review

2.1. Decision Support System (DSS)

DSS can be interpreted as an information system that is combined with data and sophisticated analytical models that have been adapted to support decision making and assist in solving complex problems [12]. DSS typically highlights the importance of information technology in improving the efficiency and effectiveness that users adopt to make decisions [13]. DSS functions as a facility that strengthens decision-making capabilities, but does not completely replace the decision-maker's role. DSS is used in decision-making that involves consideration of managers, or on decision-making that is not fully resolved by calculation [14]. The purpose of DSS conducted by Keen and Scott in his book Management Information Systems [15] has three objectives. (1). Help managers make decisions to solve semi-structured problems. (2). Support the manager's assessment instead of trying to replace it. (3). Improve manager decision-making effectiveness rather than efficiency.

2.1.1. DSS Components

There are several components that make up the decision support system. These components consist of three subsystems, namely data management subsystem, model management subsystem, dialog management subsystem and knowledge management. The following is a modeling of the components of the decision support system that will be used to build the system

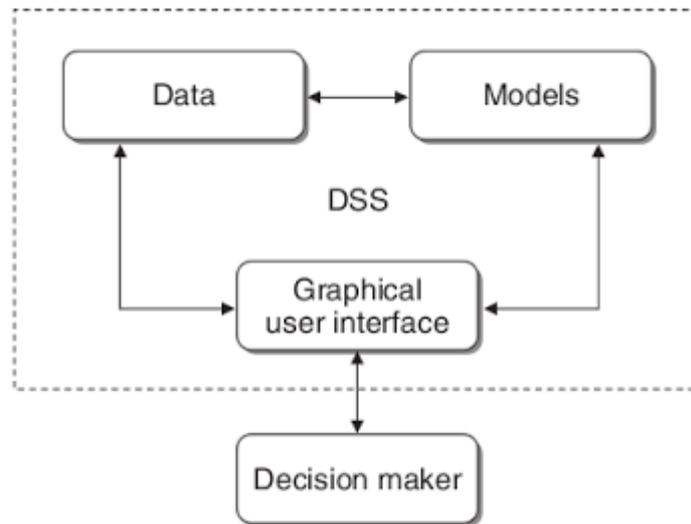


Figure 1. DSS Components (Turban, 2005)

2.2. Supplier Selection

Suppliers are one of the most important parties to the success of manufacturers / producers compared to other parties. All companies will typically rely on products and services from other businesses to support their ability to serve their customers. Suppliers will intensively support the manufacturing process of a company. Costs incurred by a company in collaboration with suppliers will have a major impact on product costs [16]. Supplier selection is an important process carried out in the procurement process because by getting a good supplier, the company will also have a good impact. The decision-making process in supplier selection consists of four steps [17]: the definition of the problem, the formulation of the criteria, the qualifications and the last option. Selection of suppliers aims to obtain the source material with quality, price, time, quantity, and desired services, as well as technical assistance required. Selection criteria is one of the important things in the selection of suppliers, the criteria used should reflect the supply chain strategy as well as the characteristics of the items to be supplied. Supplier selection is one of the most important activities of a company, since the purchase of raw materials and components represents 40% - 80% of the total product cost and impact on company performance. Therefore, the selection of suppliers must be done carefully in order to maintain and improve the company's profits.

2.3. Likert Scale

Likert scale is a method of calculating the scale used to measure attitudes, opinions, and perceptions of a person or group of people about a social phenomenon. There are two forms of the Likert-scale question model: positive question form, used to measure positive attitudes and negative questions used to measure negative attitudes [18]. Design process of weights in Likert scale follow the steps below:

1. Determine the total score of all items
- 2.

$$Ti = \sum_{k=1}^5 (R_k * k) \tag{1}$$

Ti = Total score of all items, i : 1, 2, 3, ... , n.
 R_k = number of respondents
 k = Likert scale score option (1, 2, 3, 4, 5)

3. Determine the total percentage

$$a_i = \frac{(ti \times 2)}{100} \tag{2}$$

a_i = the percentage total for each criteria (i = 1, 2, 3 ..., n).

4. Determine the weight of each criteria
- 5.

$$b_i = \frac{a_i}{\sum a_i} \tag{3}$$

b_i = weighting criteria (i = 1, 2, 3 ..., n), where Σb_i = 1

2.4. TOPSIS Method (Technique for Order Preference by Similarity to Ideal Solution)

TOPSIS method is one of multiple criteria decision-making methods or alternative options with the smallest distance from the positive ideal solution and the greatest distance from the negative ideal solution to a geometrical point by using the Euclidean distance. it will rank alternatives based on the relative value priority of an alternative to a positive ideal solution. Alternatives that have been ranked then used as a reference for decision makers to choose the best solution desired. TOPSIS method is the preferred method to solve the problem of decision making with MADM (Multiple Attribute Decision Making). This method has a simple and easy to understand concept, an efficient computational process, and has the ability to measure the performance of decision alternatives in a simple mathematical form [19]. Here are the steps of TOPSIS method calculation:

1. Build a decision matrix

The decision matrix X refers to m alternative that evaluated based on the n criterion. The X decision matrix can be seen as follows:

$$X = \begin{matrix} & x_1 & x_2 & x_3 & \cdot & \cdot & x_n \\ \begin{matrix} a_1 \\ a_2 \\ a_3 \\ \cdot \\ a_m \end{matrix} & \begin{bmatrix} x_{11} & x_{12} & x_{31} & \cdot & \cdot & x_{n1} \\ x_{12} & x_{22} & x_{32} & \cdot & \cdot & x_{n2} \\ x_{13} & x_{32} & x_{33} & \cdot & \cdot & x_{n3} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ x_{m1} & x_{m2} & x_{m3} & \cdot & \cdot & x_{mn} \end{bmatrix} \end{matrix} \tag{4}$$

a_i (i = 1, 2, 3, .. , m) = supplier alternatif and x_j (j = 1, 2, 3,... ,n) = criteria alternative

2. Make a normalized decision matrix

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \tag{5}$$

r_{ij} = an element of a normalized decision matrix R,
 x_{ij} = an element of the X decision matrix

3. Makes a normalized matrix of decision weight

$$v_{ij} = w_j r_{ij} \tag{6}$$

Where:

V_{ij} is an element of a normalized weighted decision matrix V,

W_j is the weight of the jth criteria

r_{ij} is an element of the decision matrix normalized by R

4. Determine the matrix of positive ideal solutions and negative ideal solutions

Positive ideal solutions are denoted A +, while negative ideal solutions are denoted A-.

Following are the equations of A + and A-:

$$A+ = \{(\max |j \in J), (\min |j \in J'), i = 1, 2, 3, \dots, m\} \tag{7}$$

$$A- = \{(\min |j \in J), (\max |j \in J'), i = 1, 2, 3, \dots, m\} \tag{8}$$

Where:

$J = \{j = 1, 2, 3, \dots, n \text{ and } J \text{ are benefit criteria}\}$

$J' = \{j = 1, 2, 3, \dots, n \text{ dan } J' \text{ are cost criteria}\}$

5. Calculate separation

Calculation of the separation value is divided into S + d S-. Here are the similarities of the two separations:

$$s_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2} \tag{9}$$

$$s_i^- = \sqrt{\sum_{j=i}^n (v_{ij} - v_j^-)^2} \tag{10}$$

Information:

V_{ij} is an element of the normalized weighted decision matrix

V_j^+ is the matrix element of a positive ideal solution,

V_j^- is the matrix element of the negative ideal solution

6. Calculating proximity to positive ideal solutions

$$c_i^+ = \frac{s_i^-}{(s_i^- + s_i^+)}, 0 \leq c_i^+ \leq 1 \tag{11}$$

Where:

C_i^+ is the relative proximity of the 1st alternative to positive ideal solutions,

S_i^+ is the 1st alternative distance from positive ideal solutions,

S_i^- is the first alternative distance from the negative ideal solution

7. Ranking alternatives.

Alternatives are sorted from the largest C + value to the smallest value. The alternative with the largest C + value is the best solution.

3. Research methodology

A good research is need for systematic measures and clear. The steps used contain the work sequence that will be carried out in designing decision support systems. The research consists of stages, namely: (1). Preliminary study to determine the criteria to be used in the study. (2). Designing criteria and their weights used in the evaluation of suppliers and experts as research respondents. (3). Designing DSS supplier evaluation. The research stages can be seen in the following **Figure 2**:

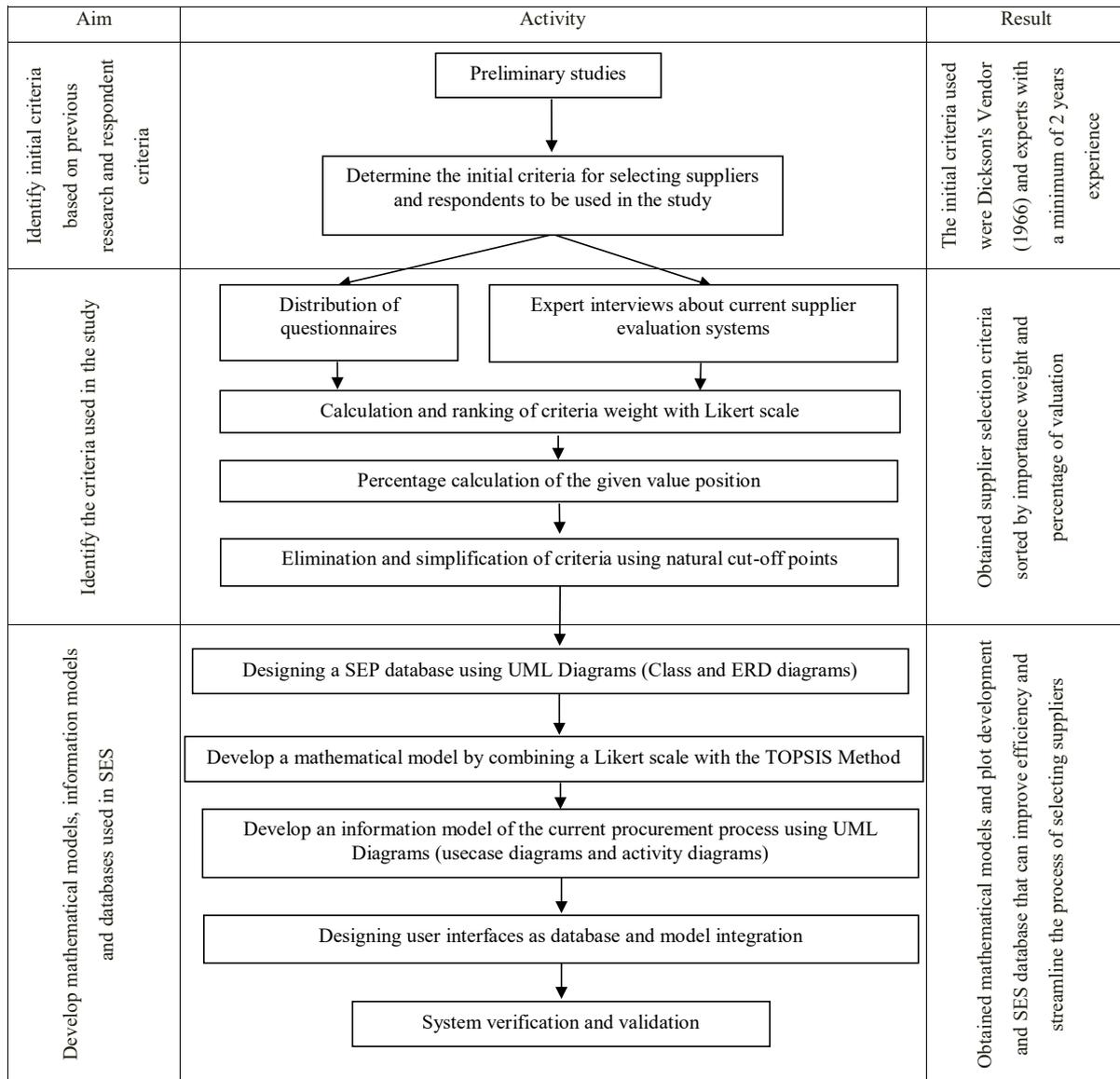


Figure 2. Methodology chart

4. Design of decision support system

4.1. Design of Criteria

The characteristic of the items to be assessed in the supplier's assessment process are critical items. This characteristic includes price of expensive goods, a procurement process that takes a long time, obstruction of the teaching and learning process if there is no such item and an extra careful care

process. Based on the results of questionnaires given to the procurement experts and interview result at UNAND, the results of the following criteria were obtained:

Table 1. Weight of supplier assessment criteria

No	Criteria	Weight	Code
1	Quality of good	0.220	Qg
2	Repair service	0.202	Rs
3	Price of goods	0.197	Pg
4	Supplier behavior	0.193	Sb
5	Delivery time	0.188	Dt

4.2. Model development

Model development is carried out on the TOPSIS method for ranking supplier values. This method requires initial input in the form of criteria weight and criteria assessment scores. The initial value of determining the criteria weighting value in this method is given directly by the decision maker. The development of mathematical models is done in the equation of calculation 6. However, in this research, the assessment of criteria weight is given based on the results of calculating the weight value using the Likert scale method. Supplier assessment is given by 2 (two) assessment teams. The development of the mathematical model of the TOPSIS method can be seen in the following equation $V_{ij} = b_j * (P^1_{ij} + P^2_{ij}) / N$, $i = 1, 2, 3, \dots, m$ and $j = 1, 2, 3, \dots, n$

Remarks:

P1ij is the value for the first assessment

P2ij is the value for the second assessment

N is total of evaluator. If P1 or P2 = 0, then N = 1

4.3. Design of database

Database design is tailored to the needs of the system based on the results of interviews with experts in the procurement of goods. Database handling consists of supplier data tables, supplier work lists, criteria weights and inventory of goods data. Database design uses entity relationship diagrams (ERD) in visual paradigm software. Design (ERD) is used to model data requirements of an organization, usually carried out by system analysts in the requirements analysis phase of a system development project.

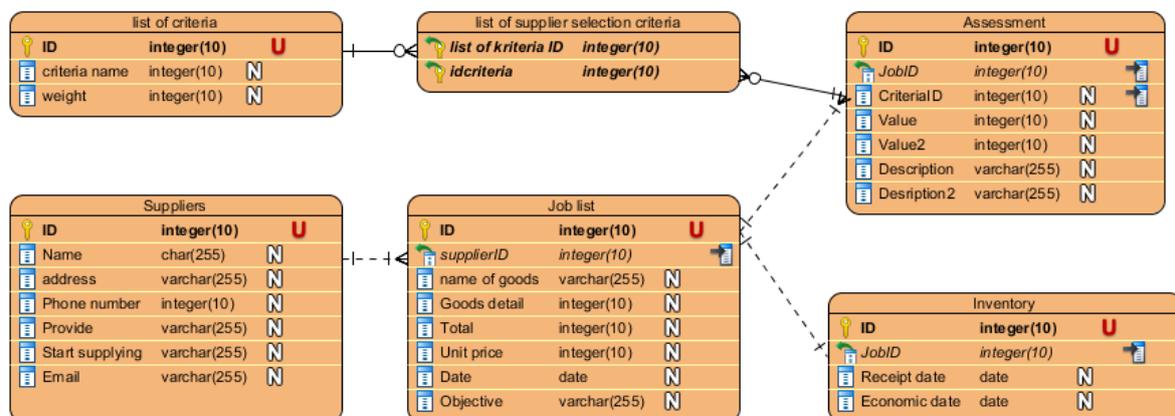
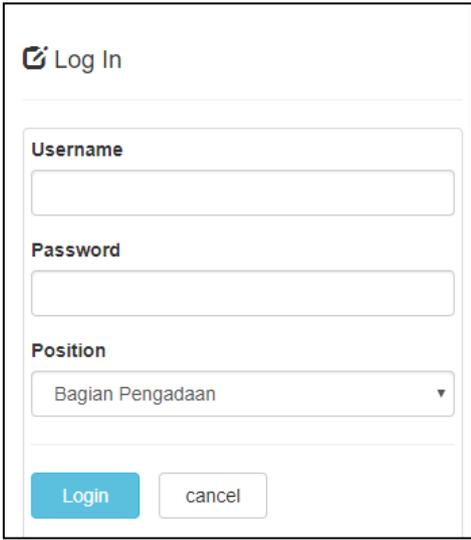


Figure 3. Display of database SES

4.4. Design of information model

The design of the information model of the supplier evaluation system that is carried out not only provides information about the criteria and results of supplier assessment but also displays information about supplier data. In addition, the design of the model also provides information that can display a list of data supplier work that has been done, providing inventory information about the lifespan of an item, providing detail of information supplier ratings as additional support in the supplier selection. All information is integrated into the Supplier Evaluation System (SES) to improve the results of decision makers. SES also equipped with the distribution of permission to separate the responsibilities of each user. Design of information model is presented in the user interface as follows:

1. DSS has restrictions on access rights that are useful as a limitation of system management responsibilities. This can be shown in **Figure 4** below:



The image shows a login form with the following elements:

- Title: Log In
- Username: Text input field
- Password: Text input field
- Position: Dropdown menu with 'Bagian Pengadaan' selected
- Buttons: 'Login' (blue) and 'cancel' (white)

Figure 4. Display of login process

2. DSS provides supplier data needed by the procurement department. Supplier data is used to facilitate procurement in identifying suppliers who want to be searched quickly and accurately. The data provided has been adjusted to the needs of the system. it can be shown in **Figure 5** below:

No.	Name	Address	Phone number	Provide	Start supplying	Email	Action
1	PT XYZ	Komp Unand Blok DIII/15/04 Ulu Gadut Padang	085274332244	PC Laptop Printer	0000-00-00	farid2500@gmail.com	[Action icons]
2	PT EFG	Jl Prof HM Yamin SH 119, Balai Baru (Pasar Baru), Padang Barat, Padang	085274334477	PC Laptop Printer	0000-00-00	farid2500@gmail.com	[Action icons]
3	PT CDE	Jl Prof HM Yamin SH 138, Belakang Tangsi, Padang Barat, Padang	085274332288	PC Laptop Printer Mesin FotoCopy, Proyektor	0000-00-00	farid2500@gmail.com	[Action icons]
4	PT BCD	Jl Raya Padang Bukittinggi Km. 28, Pasar Usang, Batang Anai, Padang Pariaman, Sumatera Barat 25581	08563696964	PC, Laptop, Printer, Proyektor	0000-00-00	farid2500@gmail.com	[Action icons]
5	PT ABC	Komp Unand Blok DIII/15/04 Ulu Gadut Padang	085274332211	PC Laptop Printer	0000-00-00	farid2500@gmail.com	[Action icons]

Figure 5. Display of suppliers data

3. DSS provides a job list menu that has been done by each supplier by displaying item details, quantity, the price of goods, date of work, a location of goods placement. This data is used to make it easier for Bapeng to know what work each supplier has done.

Supplier Name : PT XYZ

No.	Goods name	Detail	Total	Unit price (Rp)	Date	Goods location	Action
1	Komputer	Komputer All In One Asus V200-BC014M N3700 Specification: Processor Intel N3700 (2M Cache, Up to 2.40 GHz) Memory DDR3 2GB Hard Disk 500GB WiFi LAN Card Reader Webcam DVDRW Keyboard + Mouse	2	4.830.000	2017-11-21	Dosen Jurusan Teknik Industri	[Action icons]
2	Printer BROTHER DCP-1616NW	Mono Laser Multifunction Resolusi (Optik) Up to 600x1,200dpi Memory 32MB & kecepatan processor 200Mhz Warranty 3 years / 36 months	1	1.832.000	2018-01-08	Jurusan Teknik Industri	[Action icons]

Figure 6. Display of job list

4. DSS provides an assessment menu that is used to provide an assessment of suppliers both quantitative and qualitative assessments that are adjusted to the criteria provided. The assessment menu also shows the assessment details provided by the assessment team as supporting the selection to determine the supplier to be chosen. The assessment menu also displays and provides

knowledge to the assessment team about the explanation of each criterion for the assessment that will be given (knowledge management). Knowledge management is explained when the detail button is pressed. Explanation details are used to equalize the perception of the assessment team in providing an assessment. In addition to detailed information on the explanation of the criteria, the assessment menu is also completed with information on the assessment given. The purpose of the information is as an additional support from the results of calculations (quantitative data) on the decisions to be taken in the form of qualitative data. Why is the rating given high or why is the value given low? The results of the assessment are also completed with assessment status. The purpose of the status is to explain whether the value given is in the very good category or the other.

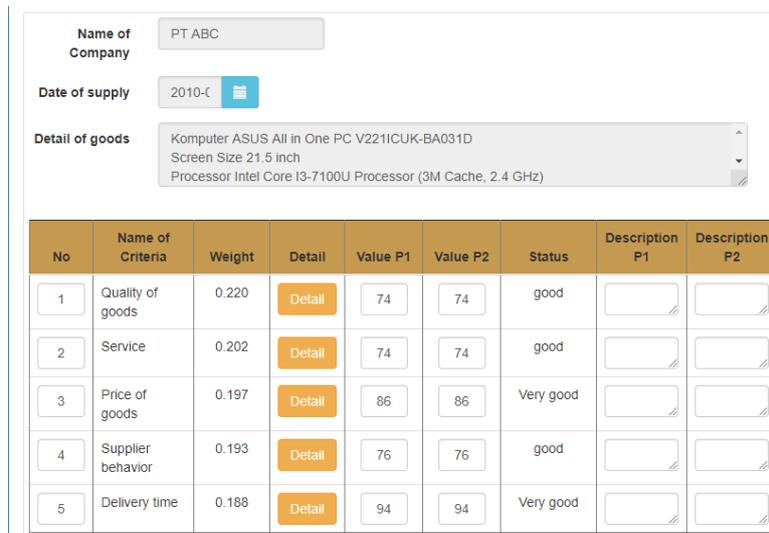


Figure 7. Display of supplier assessment

5. DSS provides an active period of inventory data. This menu is used as an additional support in determining the items to be updated. The selection of goods can be done by looking at the number of active periods of goods marked with the status of "used life has expired". The purpose of this menu is to accelerate the selection of goods (efficiency) in the procurement process. The inventory menu is applied based on the concept of supply chain management by integrating suppliers with warehouses in the right number and location to minimize work time and costs.

No.	Name of goods	Location	Recive date	economic life	Status	Action
1	Komputer	Dekanat Fakultas Teknik	19-07-2010	20-06-2016	Umur Pakai Habis	
2	Komputer	Dosen Jurusan Teknik Industri	21-11-2017	20-10-2022	Umur Pakai Masih aktif	
3	Proyektor	Ruang Rapat Jurusan Teknik Mesin	17-08-2016	16-12-2020	Umur Pakai Masih aktif	
4	Printer BROTHER DCP-1616NW	Jurusan Teknik Industri	07-01-2014	10-01-2016	Umur Pakai Habis	
5	Proyektor	Ruang Seminar Teknik Mesin	17-08-2015	14-08-2019	Umur Pakai Masih aktif	
6	Mesin Fotocopy	Jurusan Teknik Industri	2011-07-22	2021-08-22	Umur Pakai Masih aktif	

Figure 8. Display of inventory

4.5. Verification and validation system

Verification system aims to ascertain whether the computational assumptions and logic are working correctly according to the design. system verification is done using the trace / walkthrough technique. This technique is done by trying the application directly to see if there is an error in the system. Based on the results of the trial with one of the faculties, the design can be used according to the needs of the procurement system. System design is also able to facilitate the supplier evaluation process to choose a good supplier.

System validation aims to ensure that the system built is correct and meets the needs of the faculty. The validation technique used is desk checking technique. This technique is done by checking whether the designed model and database are running correctly. Examination is done by comparing the results obtained in the SES application for the supplier's assessment with manual calculations using Ms. Excel. The results by using dummy data obtained are as follows:

Table 2. Result of assessment by Ms. Excel

Suppliers	Point	Percentage	Range	Status
PT ABC	0.4452	44%	≥ 40	enough
PT XYZ	0.4360	43%	≥ 40	enough
PT EFG	0.7458	74%	≥ 60	good

No.	Name of suppliers	Name of goods	Value	Status	Date	Value Detail
1	PT ABC	Komputer	44	enough	2010-07-20	
2	PT XYZ	Komputer	43	enough	2017-11-21	
3	PT EFG	Komputer	74	good	06-03-2018	

Figure 9. Result of assessment on SES

5. Conclusion

Based on research results, then obtained some conclusions. (1) Obtained the development of database used in SES. The database that has been designed does not only display criteria data and supplier assessment results, but also provides tables that are able to provide information about suppliers. In addition, the SES database design also provides a table that is able to display information on suppliers' work lists that have been carried out, provide inventory information about the life of an item, provide detail of supplier assessment information as additional support in supplier selection. (2). Obtained the development of a mathematical model of supplier evaluation from a Likert scale combination with the TOPSIS method. Likert scale produces criteria that will be used in supplier assessment. The criteria obtained include: quality of goods (0.22), repair services (0.202), price of goods (0.197), supplier behavior (0.193), delivery time (0.188). Model development is carried out on the TOPSIS method provided by increasing the number of assessors in providing supplier assessments. Model development is done by developing 1 assessment variable into 2 assessor suppliers which is marked by P1 and P2 notation. Assessment of SES is carried out by the department and faculty. The calculation is also able to sort suppliers based on the assessment given by the user or the procurement section based on the name of the goods supplied by the supplier. (3). Obtained development of an information model that is able to speed up and simplify the process of selecting a supplier. Model development is done by comparing current supplier selection business processes with the design of developing supplier selection processes. The development of the information model is also able to provide a short flow of supplier selection processes by reducing the actors involved in the supplier selection process. The development of the model design is able to shorten the selection process of suppliers that require a minimum of 5 days to be real time. (4). SES design is also provided with an easy to understand user interface (user friendly). SES design is also equipped with knowledge management. Knowledge management is given on detail of assessment as an explanation of the criteria of each supplier. Additional explanation is used as information in equating the assessor's perception. In addition, knowledge management is also provided in the same menu as shown in the description column. The information column aims to collect the assessment information that the assessment team wants to provide qualitatively. SES has also been adjusted to the needs of the UNAND faculty procurement system which can improve the effectiveness and efficiency of the supplier selection process.

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