Decision Support System to Determine Higher Education Resource Needs Using Accreditation Assessment Standards

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Abstract

Accreditation is an activity to evaluate the eligibility of programs and academic units based on predetermined criteria. In an educational institution, accreditation is an important thing to do to improve quality in the field of education because the aim is to improve quality which includes all aspects of education in the form of science, administration, as well as teaching, and educational staff. College managers really need a decision support system that can produce several alternative strategic decisions quickly and accurately. The existence of decision support system tools used to make strategic decisions makes the manager's work lighter and the results are more accurate. In this study, a decision support system approach was applied to determine the resource requirements of tertiary institutions using accreditation assessment standards consisting of a management subsystem model, data management subsystem, and user interface management subsystem. The result of the research is a design of a decision support system that can be used in an educational institution for determining the need of higher education resources.

Keywords: decision support system, information system, user interface.

I. INTRODUCTION

Organizational management requires systems that can support tactical and strategic decision making at all levels of the organization [1]. Strategic planning and policies are used to define long-term goals and allocate resources. Organizational strategy requires management control, operational control, implementation of tasks and the effective and efficient use of resources to achieve organizational goals [2]. Therefore, it is necessary to plan resource requirements for optimal use of resources.

Strategic decisions must consider all structured and unstructured issues. Structured problems are tactical or operational, such as resource allocation or inventory management. While the problem is unstructured (not programmed), the manager's intuition becomes the basis for decision making. Semi-structured problems are in between structured and unstructured problems which have some structured elements and some unstructured elements. Semistructured problem solving involves a combination of standard solution procedures and human judgment.

The quality of decision information can be improved by providing not only one decision solution but also various alternative decision solutions and their potential impacts. It takes the ability of managers to understand the nature of the problem and make better decisions.

Higher education leaders as top-level managers, in making strategic plans must be in accordance with the vision, mission and goals of the college [3], [4]. Strategic planning must consider the needs and capabilities of the available resources. The number of resources that must be considered in determining strategic decisions makes it difficult for college managers to make decisions. College managers take shortcuts in policy making without regarding to resource requirements. For example, determining how many students' needs do not match with the needs of lecturers and classrooms. The decision on how much the tuition fees are does not consider the operational costs of education, such as lecturer salaries, employee salaries, facilities and infrastructure costs. The impact of this decision will be an imbalance among resources, which will lead to a decline in the quality of higher education. In addition, an imbalance in resource requirements can result in universities as not being able to carry out education according to the rules of ministerial regulations, impacting the value of accreditation.

College managers really need a decision support system that can produce several alternative strategic decisions quickly and accurately. The existence of decision support system tools used to make strategic decisions makes the manager's work lighter and the results more accurate.

Several studies have been conducted related to decision support system in higher education environment. Galvis [5] did a review on decision-making process according to blended learning in higher education. This study analyzes how to achieve an institutional transformation process, including how to link bLearning modalities with current educational approaches so that bLearning innovations can be institutionalized and sustainable. Indrayani et al. [6] did the study to develop a decision support system based on service quality model criteria to choose the private higher education. The system used Analytic Hierarchicy Process (AHP) to generate the final decision based on several criterions, i.e., reliability, responsiveness, assurance, empathy, and tangibles. Similar work that used AHP to develop a decision support system for educational environment was also conducted by Alowaigl et al. [7]. The other work conducted by Akbara et al. [8] developed decision support system course in developed and developing country. The approach, which consists of two main phases—planning and implementation—is descriptive and critical research by considering the recommendations suggested by Kitchenham and tailored to the literature review. According to the study, the higher education system in industrialized nations is prepared to deal with globalization. Komleva et al. [9] developed a quality management decision support system for the educational process that automates the process of gathering data from survey responses. The system is being developed incrementally because of the system architecture, which also offers the work with a variety of data sources. The other work by Makki et al. [10] used mathematical model approach to develop a decision support system framework for capacity planning in higher education institutions. This research aims to put forward a capacity planning admission/ decision support system (DSS)-based framework for student enrollment and admission for universities.

This study used mathematical model as the basis of decision support system to determine the higher education resource needs. Each equation is built based on the rules stated in Accreditation Assessment Standards document.

II. METHODS

A. Decision Support System

A decision support system is an approach (or methodology) to support interactive and flexible decision making. Can be customized and developed specifically to support management problem solving solutions. Decision support systems can help managers make decisions to solve semi-structured problems and support a variety of decision-making style processes. Decision support systems use data, by providing an easy user interface. Decision support systems can combine decisions according to their own wishes to get the value of decision alternatives. The value of an alternative decision is evaluated in relation to achieving goals.

The decision support system consists of components of data management sub system, model management subsystem, and knowledge management subsystem, user interface and user subsystem. A decision support system schema that describes the relationship between components is shown in Figure 1. The decision support system provides modeling as part of solving a structured decision-making problem. One of the models in the model subsystem is a mathematical model. The components of the mathematical model consist of three basic components: decision variables, uncontrollable variables (and/or parameters), and outcome variables (outcomes). Mathematical relationships between components complement each other. The components of a quantitative model are linked together by mathematical expressions (algebra) in the form of equations or inequalities. The outcome of the decision is determined by the decision made (the value of the decision variable), the factors that cannot be controlled by the decision maker, and the relationship between the variables. The modeling process involves the identification of variables and relationships between variables. The model solution will determine these values and the result variables. The result variable as output reflects the level of effectiveness system that shows or achieves its goals.

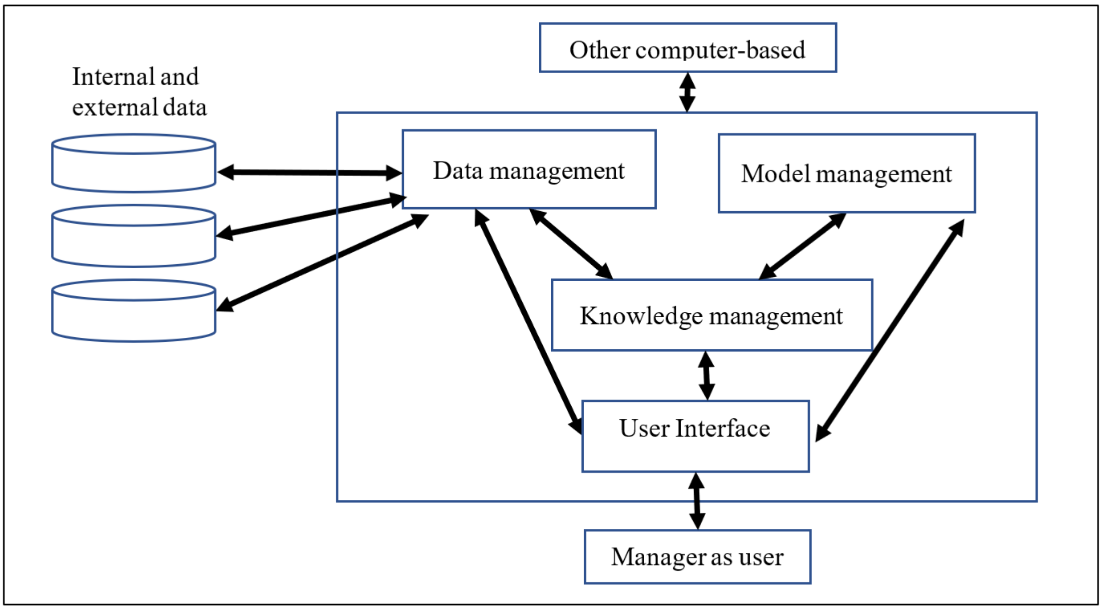

Figure 1. Decision Support System architecture

Higher education strategic planning must consider optimizing the use of available resources. Higher education resources consist of 3 categories: human resources, financial resources, and infrastructure resources. Human resources consist of teaching staff (lecturers), educational staff, and students. Financial resources consist of income and expenses. Infrastructure resources consist of lecture halls, session hours and curriculum. The success of tertiary resource management is measured by the level of achievement using accreditation assessment standards. Assessment of the achievement of resources owned by tertiary institutions is carried out by comparing these resources with accreditation assessment standards.

B. Proposed DSS Model

The design of a decision support system to determine the need for higher education resources using accreditation assessment standards consists of a model management sub-system, a data management sub-system and a user interface management sub-system as shown in Figure 2. The model management sub-system manages the model base that stores mathematical models and result values. The mathematical model consists of sessions, estimates of the number of new students, financial income, financial expenses, educational operational costs, student operational costs. The result value is obtained from the simulation by changing the data on the number of lecturers, the number of classrooms, the increase in the number of students and the number of visitor lecturers.

Result value as an alternative decision that can be used to assist decision making.

The data management sub-system manages the DSS data base. Data sources come from internal data and external data which extraction is stored in the DSS database. Internal data consist of university profile data, study program data, lecturer data, assistant lecturer data, student data, scientific field data, course data, class data, room data, teaching and learning process data, education staff data and financial data. External data consist of accreditation assessment standards and accreditation rules.

The user interface subsystem is managed by the user interface management system (UIMS). The user interface is a system from the user's point of view because the interface is the only part of the system that is seen by the user. The user interface is used by users to communicate with DSS. The user interface commands a DSS with an advance service format supported by a model base management system and a database management system. The design of the dialogue between the decision maker and the DSS consists of data files, rules, resource reports, simulations, and result values.

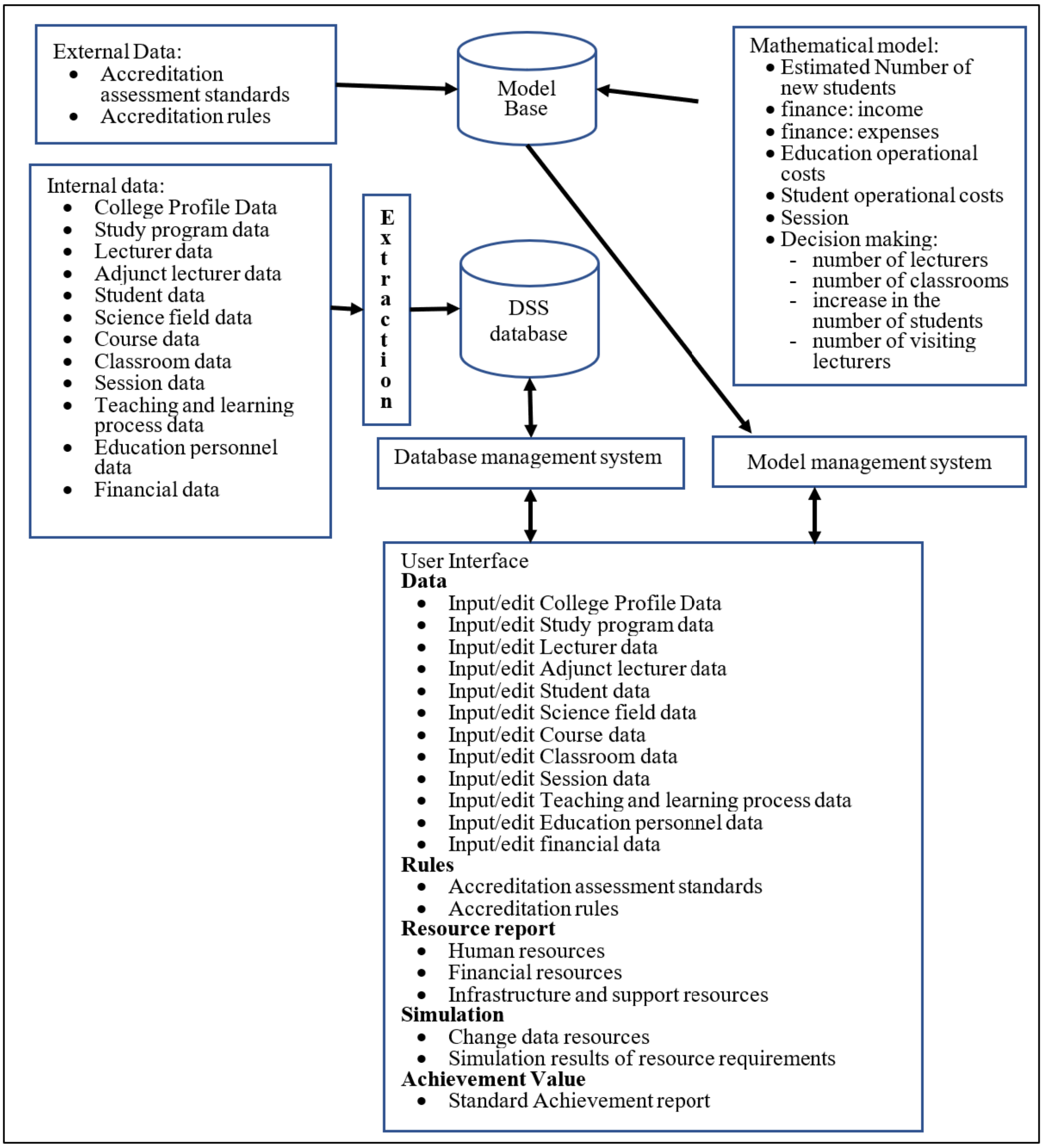

Figure 2. Proposed DSS model to Determine Higher Education Resource Needs Using Accreditation Assessment Standards

C. Mathematical Model

The proposed model uses a number of equations to calculate the score of each criterion based on Accreditation Assessment Standards.

1. Mathematical model of the number of new students that can be accommodated.

$$Tsesi = Jsm \times Jr \quad (1)$$

where:

Tsesi = total available session hours in one week
Jsm = number of session hours in one week
Jr = number of classrooms

Substitution of 1 to 2

$$Jmb = \frac{Tsesi - Jsks_{ml}}{Jsks_{mb}} \times Jmpk_{mb} \qquad (2)$$

where:
Jmb = number of students
$Jsks_{ml}$ = total credit of courses offered by old students for one academic year
$Jsks_{mb}$ = total credit of courses offered by new students for one academic year at current year (TS)
$Jmpk_{mb}$ = number of students per class
mb = new student at TS
ml = old student before TS (TS-1, TS-2 etc)

2. Mathematical Model of SPP Financial Resources (Educational Development Contribution)
   a. Fixed Tuition -variable
   Tuition fee in one academic year consist of fixed fees charged each semester and variable fees charged per credits:

$$TSPP = \sum M_i \times tp_i \times 2 + \sum M_i \times tv_i \times js_i \qquad (3)$$

   where:
   TSPP = total tuition fee for one year
   M_i = number of students to i
   Tp = fixed tuition fee
   i = year of entry
   tv = variable tuition fee
   js = the number of credits offered in one academic year according to the curriculum

   b. Single Tuition Cost (BKT)
   The amount of tuition fee charged by each student can be different each year of entry and the amount is fixed throughout college.

$$TSPP = \sum M_i \times bkt_i \times 2 \qquad (4)$$

   where:
   bkt_i = single tuition fee to i
   i = year of entry

   c. Single Tuition Fee (UKT**)**
   The amount of single tuition fee paid for each student is different and the amount is fixed throughout the course of study. The estimated total single tuition fee is calculated in one academic year which is paid every semester for all active and inactive students:

$$TSPP = \left(\sum Mat_i \times ukt_i\right) \times 2 \qquad (5)$$

   ukt = single tuition
   Mat_i = active/inactive student to i

   The total single tuition cost in real terms is calculated based on active students

$$TSPP = \left(\sum Ma_i \times ukt_i\right) \times 2 \qquad (6)$$

   where:
   Ma_i = active student to i
   i = year of entry

d. Monthly tuition fee
The amount of tuition fee paid by each student every month:

$$TSPP = \left(\sum Mat_i \times bkb_i\right) \times 12 \tag{7}$$

where:
bkb_i = the amount of tuition fee every month to i
i = year of entry

e. Annual tuition fee
The amount of tuition fee paid by each student each year:

$$TSPP = \left(\sum Mat_i \times bkt_i\right) \times 12 \tag{8}$$

where:
bkt_i = the amount of tuition fee each year to i
I = year of entry

3. Mathematical Model of Total funds income of financial resources

$$TDK_{msk} = TSPP + TD_{pbm} + TD_{lain} \tag{9}$$

where:
TDK_{msk} = total funds income financial resources
TD_{pbm} = total fund for teaching and learning process /lab
TD_{lain} = total other funds

4. Mathematical Model of Total Education Operational Costs

$$TBOP = TGH_{dsn} + TGH_{peg} + TB_{pbm} + TB_{tlngs} + TB_{kmhs} \tag{10}$$

where:
TBOP = total educational operational costs
TGH_{dsn} = total salary and honorarium for lecturers
TGH_{peg} = total salary and honorarium for employees
TB_{pbm} = total cost of teaching and learning process
TB_{tlngs} = total indirect costs
TB_{kmhs} = total student expenses fees

5. Mathematical Model of Student Operational Fund (DOM)

$$DOM = \frac{TBOP}{\sum Mhs} \tag{11}$$

where:
DOM = student operational funds
$\sum$Mhs = the total number of students in the study program

6. Mathematical Model Expenditure of financial resources
a. Total lecturer salary

$$\mathrm{TGH_{dsn}} = Tgd_{lm} + \left(Gpd_{br} \times \sum D_{br} \times Jb_{ta}\right) + ((H_{ttp} \times (Js_{br} \times Jk_{br}) - \tag{12}$$

$$(S_{wjb} \times Jd_{Br})) \times Sem + (T_{var} \times Js_{br} \times Jtm_{sem} \times Jk_{br})$$

where:
Tgd_{lm} = total salary of old lecturers
Gp_{br} = new lecturer base salary
$\sum D_{br}$ = number of new lecturers
Jb_{ta} = number of months in 1 academic year
H_{ttp} = fixed honors per credit
Js_{br} = number of new student credits
Jk_{br} = number of new student classes
S_{wjb} = number of mandatory credits charged by the lecturer
Jdt_{br} = number of new permanent lecturers
Sem = number of months in 1 semester
H_{var} = salary per credit
Jtm_{sem} = number of meetings in 1 semester

b. Total employee salary

$$\text{TPGH}_{\text{peg}} = Tgp_{lm} + \left(Gpp_{br} \times \sum P_{br} \times Jb_{ta}\right) \tag{13}$$

where:
TGH_{peg} = total salary and honorarium of employees
Tgp_{lm} = total salary of old employees
Gpp_{br} = monthly salary for new employees
Jb_{ta} = the number of months in an academic year

c. Total expenditure of financial resources

$$TDK_{klr} = TB_{pnl} + TB_{pkm} + TB_{inv} + \text{TGH}_{\text{dsn}} + \text{TPGH}_{\text{peg}} \tag{14}$$

where:
TDK_{klr} = total outflow
TB_{pnl} = total research costs
TB_{pkm} = total cost of dedication to the community
TB_{inv} = total investment cost

7. Mathematical Model The ratio of Total Remaining Funds
From equations 9 and 14, we obtained:

$$SD = TDK_{msk} - TDK_{klr} \tag{15}$$

where:
SD = total remaining fund

8. Mathematical Model The ratio of the number of homebase lecturers to the number of students

$$R_{dt} = \frac{\sum DT}{\sum Mhs} \tag{16}$$

where:
R_{dt} = the ratio of the number of homebase lecturers to the number of students
$\sum DT$ = the total number of homebase lecturers who have knowledge according to the field of study program

9. Mathematical Model The ratio of the number of study program lecturers to the number of students

$$R_{dtps} = \frac{\sum DTPS}{\sum Mhs} \tag{17}$$

where:
R_{dtps} = the ratio of the number of study program lecturers to the number of students
$\sum$DTPS = the total number of study program lecturers who have knowledge according to the field of study program

10. Mathematical Model Result Simulation of resource requirements
    a. Mathematical Model Availability New session for simulation

$$\mathrm{TSS_{br}} = \sum Js_{br} \times Jr_{br} \tag{18}$$

where:
TSS_{br} = total availability of new sessions
Js_{br} = number of new sessions in 1 week
Jr_{br} = number of new classrooms

b. Mathematical Model: Number of new Availability Sessions for the simulation

$$\mathrm{JSS_{br}} = TSS_{br} - TSS_{lm} \tag{19}$$

where:
JSS_{br} = the number of new session availability
TSS_{lm} = total availability of old sessions

c. Mathematical Model of Total Session Requirement for the simulation

$$TKS = \sum (sks_i \times Jk_i) + \sum (sksB_i \times JkB_i) \tag{20}$$

where:
TKS = total available session
$SksB_i$ = number of new sessions to i
JkB_i = number of new classrooms to i
i = semester 1 and semester 2 courses

III. Results and Discussions

A. Simulation Scenario

Simulation models help decision makers identify requirements and other problems in real systems. Experimenting using a simulation model, the real problem is easy to identify, and the results of alternative decisions will convince the decisions taken. Changes in data during the simulation will affect data values that are interconnected with other data values. So that, the simulation uses several mathematical models that has been mentioned in section II. The mathematical calculation model for each data change is presented in Table 1.

TABLE I. List of mathematical model used in every part of simulation

No.	Simulation	The mathematical model used
1	Number of sessions	(1), (10), (15), (16), (17), (18), (19), (20)
2	Number of classrooms	(1), (10), (15), (16), (17), (18), (19), (20)
3	Number of new students	(2), (3), (4), (5), (6), (7), (8), (9), (10) (15), (16), (17), (18), (19), (20)
4	Number of homebase lecturers	(10), (12), (14), (15), (16), (18), (19), (20)
5	number of study program lecturers	(10), (12), (14), (15), (17), (18), (19), (20)
6	Number of employees	(10), (15), (18), (19), (20)

7	tuition fee	(3), (4), (5), (6), (7), (8), (9), (10), (11), (15), (18), (19), (20)
8	Operational cost	(10), (11), (15), (18), (19), (20)
9	Lecturer salary	(10), (11), (12), (14), (15), (18), (19), (20)
10	Employees salary	(10), (11), (13). (14), (15), (18), (19), (20)

The decision resulted from the system is simply determined by an IF-THEN rule as provided in Figure 3, where the score or the value for each part of simulation in Table 1 will determine whether the simulation is exceeded, reached, or not reached the passing criteria. The score of each simulation is calculated by summing up the value resulted from each mathematical model as given in Table 1. The whole system is described in the flowchart in Figure 4.

IF simulation value > minimum score THEN **simulation is exceeded the minimum score**

ELSE IF simulation value = minimum score THEN **simulation reach the minimum score**

ELSE **simulation does not reach the minimum score**

Figure 3. Decision rule of the proposed system. The minimum score is determined by Accreditation Assessment Standards.

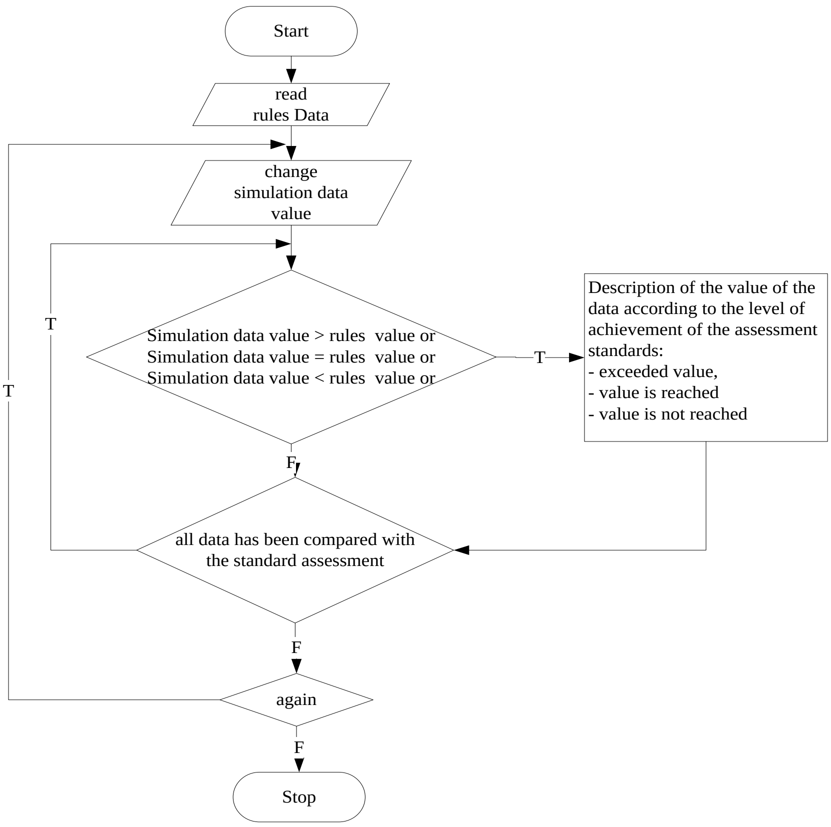

Figure 4. The flowchart of the decision making from the proposed model.

B. Black Box Testing

The black box testing is used to evaluate whether the system works properly or not. In this section, the testing is just focused on the simulation scenario, where the output of each simulation is checked and verified manually by human. This aims to ensure that the system calculate the score correctly and appropriate with the Accreditation Assessment Standards. Based on the experiment, all the simulations work properly and give the same output compared to human calculation. It means that the system is developed correctly.

IV. CONCLUSION

A decision support system is designed to assist in deciding a problem. In this study, a decision support system was designed and built to determine the need for higher education resources using accreditation assessment standards consisting of a management subsystem model, a data management subsystem, and a management subsystem user interface. An educational institution can use the results of this study to determine the need for higher education resources which can then be used in assessing the accreditation of an educational institution. Decision-makers use simulation models to pinpoint needs and other issues in existing systems. When employing a simulation model for testing, it is simple to identify the real problem, and the outcomes of many options will support the chosen course of action. Data values related to other data values will change as the simulation progresses due to changes in the underlying data.

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