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Research Article

A MODEL FOR FACULTY EVALUATION IN HIGHER EDUCATION ECUADORIAN THROUGH MULTI-CRITERIA DECISION ANALYSIS

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ABSTRACT

The Information systems do not work alone and it is not possible to buy one adjusted to business requirements, their construction is a process that start of models and conform to the standards of the organization, governmental, political, financial and others. This paper is oriented to provide a model based in Multi-criteria Decision Analysis (MCDA) to evaluate the teaching quality, in particular case of Quevedo State Technical University, Ecuadorian University located in the regionof "Los Ríos".

The model has to adjust to both governmental and institutional laws and regulations, and then to analyze the quality requirements of state institutions; the selection of accepted method is important to ensure objectivity, transparency and acceptance in community University.

The design of model has as main elements the definition of requirements, structuring of objectives through trees of hierarchical objectives, according informant type and the modeling of preferences to obtain good utility functions.

INTRODUCTION

In recent years there have been considerable changes in the university system, so in a globalized context the organization and funds are being directed to efforts to transform the traditional university into "universities of entrepreneurship"[1].

Entrepreneurship in academic literature not only refers to aspects related to the business and commercialization of intellectual property of the university, but also that trainers develop entrepreneurial minds with personal skills, attributes, behavior and motivational abilities that may be useful in aspects (Social, labor, etc.) [2].

The evaluation of Higher Education Institutions (HEIs), career programs, research departmental, academic staff, and any component of an institutional context is nothing new; In many countries regulations have been established to guarantee the quality of higher education[3].To do this, different models and techniques are applied to measure the components that are the object of analysis; with the objective of knowing the current situation and identify weaknesses to improve, thus, the evaluation of a program is becoming more complex and formal.

In United States several associations have recommended clarity in procedures, use of standards and consistency of results [4][5]. In Europe, the need to develop tools for evaluation is recognized throughout the European Union[6];so too in Spain, regulations have been established in recent years for teacher evaluation[7].Same in Portugal, universities have submitted evaluation procedures to the programs.

In 2005, the ranking of the human development index by the United Nations countries such as Ecuador, Peru, Colombia, Venezuela and others were classified in a human development group at the level of Ibero-america and in the world context Latin American countries obtained the scores lower (UNESCO, 2008). Ecuador is no stranger to global change, as there is greater public investment for higher education processes.

This paper proposes an evaluation model for teachers with classification purposes based on the use of the multicriteria decision aid method (MCDA)[8]. The evaluation of teachers as a problem of decision making with multiple criteria is considered; a member is valued taking into account criteria of different weight, so there may be ratings that are more highly valued as an academic than a researcher or on contrary. Many Universities in Ecuador are constantly seeking a model of assessment for teachers that is transparent, documented and accepted for compliance with government regulations and statutes of the same University.

This model has been designed within the legal and institutional framework of the Higher EducationInstitutions (HEIs) of Ecuador to be used initially in the Faculty of Engineering Sciences (FES) of Quevedo State Technical University (UTEQ), FES is an academic unit which has 8 academic careers and 75 teachers of different specialties.

LITERATURE REVIEW

The transformation of higher education caused by changes in government policies, increased investment, and continuous improvement of teachers are key elements to measure growth, so it is very necessary periodic evaluation processes [9].

Given the nature of academic activities and the organizational structure in universities, evaluation systems are quite complex, mostly oriented towards assessments based on achievements and objectives, but for the control institutions is very important that be according to standards. Which often bring conflicts between academic and administrative members, while some argue that it is possible to accurately measure the different key aspects, others argue that the use of tools to measure affect the autonomous and free development of the university [10]

The Council for Evaluation, Accreditation and Quality Assurance of Higher Education (CEAACES) of Ecuador use a multi-criteria decision model for the evaluation process of higher education institutions (HEI)[3], they define the problem of the categorization of HEIs as a MCDA problem due to the variety of criteria and heterogeneity of the elements of analysis, as a result of the application of this model several universities in that country were grouped into five categories (A, B , C, D and E).

Multi-Criteria Decision Making (MCDM)[11], consists of making decisions in a multi-criteria scenario, is presented when an object can be evaluated from different points of view (criteria) to which a weight is assigned considering its degree of importance; it is very common problems with which an individual can be at any time, as well as evaluate the acquisition of a house, a vehicle or a trip, all of them could be evaluated according to criteria such as: amenities, budgets, tastes, etc. .

Decision making problems are classified in two categories: MCDM (Multi-Criteria Decision Making) and MODM (Multi-Objective Decision Making)[12], the best difference of the two classes is in existence of predetermined alternatives. MODM deals with optimization problems in which several objective functions should be satisfied, while MCDM is associated with the problems in which alternatives have been predetermined. It means making preference decisions (e.g., evaluation, prioritization, selection) over the available alternatives that arecharacterized by multiple, usually conflicting, attributes

There are many methods available for MCDM. These methods can be divided to deterministic, fuzzy and stochastic. When there is certainty in the alternatives, we go for deterministic and if uncertainty is apparent, fuzzy and stochastic models are useful. MCDM are introduced by different methods like Weighted sum Model (WSM)[13], Weighted Product Model (WPM)[14], Analytic hierarchy process (AHP)[15], Elimination and Choice Translating Reality (ELECTRE), TOPSIS (for the Technique for OrderPreference by Similarity to Ideal Solution) etc. The SDSS applies the most common and easiest way ofMCDM known as WSM.

In [16], they propose a teacher evaluation model based on legal and institutional aspects of Portuguese Universities and specifically to be used by the Higher Technical Institute of the Technical University of Lisbon. This model is structured with the application of multicriteria decision analysis (MACBETH)[16], where it establishes hierarchical levels for the determination of the areas of activity in a first level and the criteria of evaluation in a second level.

The proposed method

The structuring of MCDM decision-making problems has identified phases. Usually the first step in this technique is the definition of the problem in a decision-making context, where the decision-maker and external elements make significant contributions to the process based on their expertise and established legal bases[17].

The second and third step determines the most relevant alternatives and decision criteria. In this way the first three phases of the decision-making process constitute the "Structuring of the problem" and the last two are the "Problem Analysis". (Figure 1)

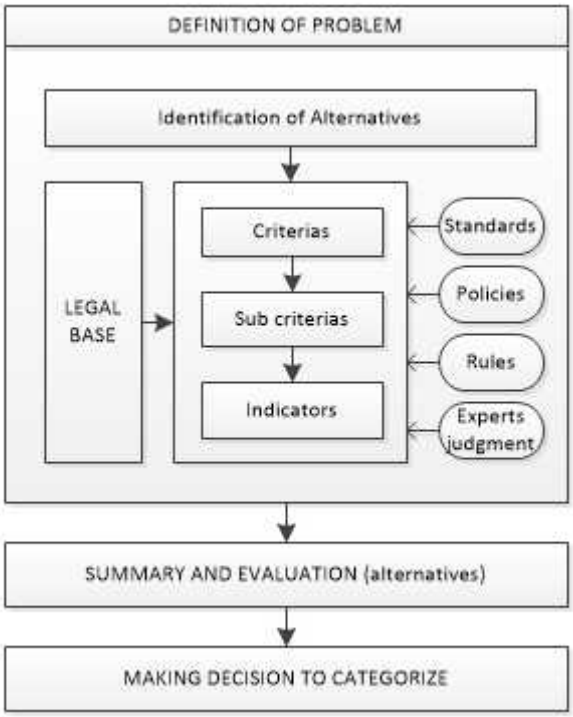


Fig.1 Key components of the process of building a multicriteria model for teacher evaluation

The analysis phase of the decision-making process can take two basic forms: qualitative and quantitative, the qualitative analysis is based primarily on the reasoning and the experience of the decision maker; includes the decision maker's intuitive impression of the problem. When using the quantitative approach, the analyst concentrates on the facts or data associated with the problem and develops mathematical expressions that describe the objectives, constraints and relationships existing in the problem.

The regulations for construction of model establish the laws and regulations issued by the control state institutions; in Ecuador HEIs are in the regulation of educational ladder, elaborated based on the LOES (Organic Law of Higher Education) in force.

This law establishes mandatory comprehensive assessment, “all professors and researchers who are holders and occasional students will be subject to the integral evaluation process that each university or polytechnic school will

obligatorily implement and execute each year. The frequency with which evaluations are carried out in each institution shall be taken into account. "

Definition of problem

In order to understand the methodological structure is essential to indicate the theoretical bases that define a decision-making problem from the multi-criteria point of view, the basic assumptions are addressed in the following sequence:

We have a defined set of objects to be evaluated. This case is the evaluation of the teaching staff of an HEI, let this set:

$A = d_1, d_2, d_3, \dots, d_n$

The evaluation problem consists in ordering the alternatives according to a global order of preference.

Let $X = X_1, \dots, X_j, \dots, X_m$ a set of qualitative or quantitative attributes, an attribute X_j being a set of at least two elements $\{x_j\}$ expressing different levels of an underlying dimension. Therefore, any object of evaluation can be characterized by the expression $(x_1, \dots, x_j, \dots, x_m)$ which represents its evaluation with respect to attributes $X_1, \dots, X_j, \dots, X_m$.

Where X represents a set of points of view, defined a priori, covering all the aspects, consequences or components consensually accepted as important and significant for discrimination between any pair of evaluation objects in A, also the set X of attributes satisfies the condition of preferential independence; that is, it is possible to order the elements x_j, according to a preference system, independently of the evaluation levels on the rest of the $(n-1)$ attributes. It is denoted by P_j the preference relation associated with X_j where $j = (1..n)$

With respect to preference relation P_j, each attribute X_j is bounded by a higher value (the best level) and a lower level (the worst level).

Lets $(x_1, \dots, x_j, \dots, x_n)$ and $(y_1, \dots, y_j, \dots, y_n)$ the evaluation profiles of two teachers a y b for each attribute X_j, one and only one of the following situations takes place:

$$\text{strict preference } P_j \text{ it reads: it is strictly preferred } a:$$
$$a\, P_j\, b \text{ if: } V_j\ x_j > V_j\ y_j \text{ or}$$
$$b\, P_j\, a \text{ if: } V_j\ y_j > V_j\ x_j\ ;$$
$$\text{Inferential } I_j \text{ it reads: is indiferent } a:$$
$$a\, I_j\, b \text{ if: } V_j\ x_j = V_j\ y_j$$

It is assumed that the values V_j vary between scale 0,1 ; corresponding 1 to best evaluation of X_j and 0 to worst evaluation.

With respect to the aggregation of preferences, it is said that if there is complete information about preferences between the criteria, then it is possible to define a function of real value

$V: X \rightarrow \mathbb{R}$

$$V\ x_1, \dots, x_j, \dots, x_n = f\ V_1\ x_1, \dots, V_j\ x_j, \dots, V_n\ x_n\ ,$$

Such that for any pair of evaluation objects a and b of A we have to:

$$a > b \text{ If and only if } V\ a \geq V\ b$$

It is assumed that the function V is an additive form function (additive function) for evaluating the form:

$$V\ a = w_j V_j\ a\ , j = 1, n$$

$$\text{Where: } i) \quad w_j = 1 \text{ and } ii)\ w_j > 0, \text{para } j = 1, \dots, n.$$

In this model, the weighting constants w_j are the commitment values (weights) that reflect, in terms of overall preferences, the increase in the value of a criterion necessary to compensate for a decrease in the value of another criterion.

It is necessary to clarify that the applied method is not a deductive approach but rather a constructivist perspective in the solution of a problem.

Thus, it is not assumed a priori the existence of a well-defined global function of preferences, but attempts to construct this function from simple models such as those described above.

Determination of criteria and actors

In this step, the criteria that form part of the model are determined, the legal restrictions established by the higher education control agencies in the country are fundamental for their definition.

Legal aspects

In Ecuador, the state institution that regulates higher education is the Council of Higher Education (CES), and in the latest version of the regulation of career and ranking of the professor and researcher of the higher education system (RCEPI). They establish in title IV the Evaluation and improvement of the academic staff. Art. 75 that the integral evaluation of the performance will be applied to all the academic personnel of the institutions of higher education, public and private. Comprehensive performance assessment encompasses teaching, research, and academic management or management activities.(CES, 2016)

The same regulation establishes the actors of the process:

1. Self-evaluation: This is the evaluation that academic staff periodically performs on their work and their academic performance.
2. Co-evaluation: This is the evaluation made by academic and managerial peers of the institution of higher education.
3. Hetero-evaluation: It is the evaluation that students perform on the learning process taught by the academic staff.

In addition it indicates the main criteria that are the activities that can realize the personal academic

1. Teaching activities: self-evaluation 10-20%; co-evaluation of peers and managerial 20-30% and hetero-evaluation 30-40%.
2. Research activities: self-evaluation 10-20%; co-evaluation of peers 40-50% and managerial 30-40%.
3. Management activities: self-evaluation 10-20%;co-evaluation of peers 20-30%, managerial 30-40%; y hetero-evaluation 10-20%.

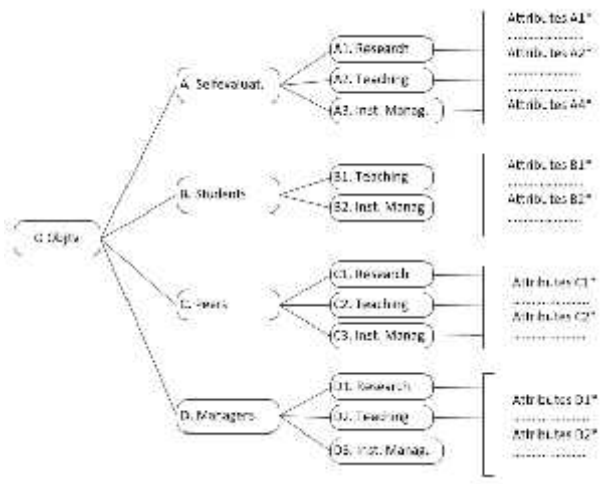


Fig. 2 Section of the hierarchical tree structure of objectives

The model has a hierarchical structure where nodes of a higher level$j$ ($j = 1, \dots, m$)are defined as the origin of the arc and those of a next leveli_j ($i_j = 1, \dots, n$), as nodes Child of the first level$j$; the criteria, sub-criteria and attributes are established from the second level.

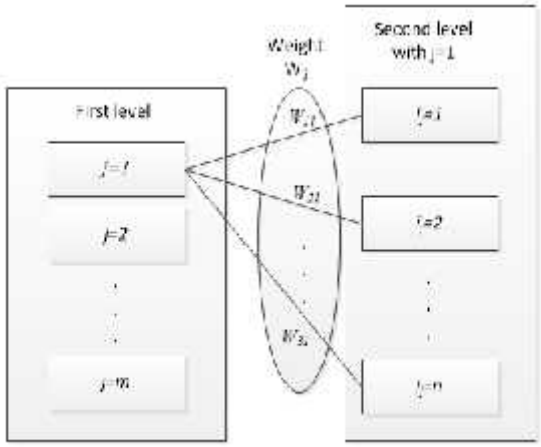


Fig. 3 Intra-criteria representation of a hierarchical tree of objectives

$P_{i_j}$is defined as the utility descriptor associated with each evaluation criterion i_j, and let$P_{i_j}^d$ is the utility of a faculty member$d$with respect to the criterion i_j; thus$V_{i_j}^d = V_{i_j}^d(P_{i_j}^d)$is the partial score value obtained by element$d$in the evaluation criterion i_j, the result of having converted its utility into a Value by using the utility function V_i.

In order hand $W_{i_j}$is defined as the weight assigned to criterion i, the score value $V_{i_j}^d$corresponding only to the level of the problem analyzed, is given by:

$$V_j^d = \sum_{i_j=1}^{n} V_{i_j}^d W_{i_j}$$

With$\sum_{i_j=1}^{n} W_{i_j} = 1$ and $W_{i_j} > 0, \forall i, j and V_{i_j}^d = 100$ When the utility of a faculty member dn the evaluation of criterion$i_j$is equal to the criterion.

Assign thresholds to define categories

According to the current policies of the state institutions in Ecuador, categorization of teachers is not strictly established, but it does take into account their scoring scores and corresponding academic and economic stimulus allocations.

However, this does not exclude that each HEI of the country can establish in its statutes a set of categories according to an interval of assessment.

Consider V^das the total utility of a member $d$of faculty, and $V$is an ordered vector descended from the utilities of the evaluated teachers so that if $V^x > V^y > V^z$then $teac\square erxismorevaluedt\square anyandz$.

When it is necessary to establish categories such as the most common {excellent, relevant, sufficient, deficient} it is necessary to determine the boundaries, a simple way is from the minimum and maximum value of the utility and then define intervals based on preferences.

Let$V_1, V_2 y V_3$be the boundaries of the categories, then:

Stimulus allocations.= $$\begin{array}{c} deficient\, 0 \le V^d < V_1 \\ sufficient V_1 \le V^d < V_2 \\ relevant V_2 \le V^d < V_3 \\ excellent V^d \ge V_3 \end{array}$$

Definition of attributes

The leaf nodes of the evaluation structure correspond to the attributes or indicators [18]. The term indicator refers to variable; a variable the operational representation of an attribute (quality, characteristic, property) of a system; each variable is associated with a value, which can take at a given time what it defines to its current state.

Considering the objectives and purposes of teacher categorization, the selected indicators have, above all, a synchronous character (present condition). The use of diachronic indicators (trends) is more relevant in the context of a prospective assessment.

The definition of values for standards, norms, thresholds, in the teacher evaluation model, is based on diverse sources of information

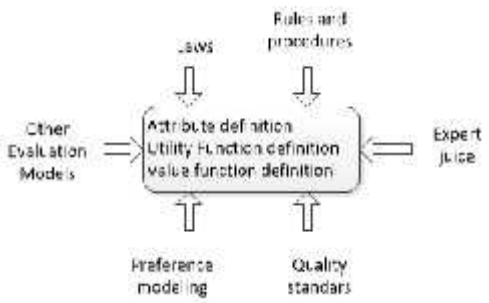


Fig. 4 Attribute Definition

The characteristic of these problems allows the definition of very heterogeneous indicators, so they can be quantitative or qualitative with different scales of measurement (years, hours, monetary, etc.), which makes it necessary to apply the valuation model based on values of utility and weighted weights the definition of utility functions[19].

Valuation Functions

Establishing the valuation scale for an attribute can be something simple as so complex depending on its type, if the variable is qualitative, it will be established by a set of values

in a finite domain; for attributes quantitative is more complex as a historical behavior of the variable which makes it very necessary to define a function for its assessment, then the problem to be to find a function that can be obtained by linearor nonlinear procedures according to the data set analyzed [20].

The assessment of alternatives to indicators is generally referred to as valuation. It consists in determining the "value" of each evaluation object with respect to each of the indicators. For example, the number of hours a teacher cannot be close to zero because the more academic activities, research, linking or management in the university, the better contributions are obtained for the development of the university career..

The following are two examples of utility functions for a first indicator called the Time (Hours) load weekly and the plan's compliance in the period.

The modeling of the quantitative variables can be due to linear and nonlinear functions, for this it is important to obtain a good fit of the function, although in some situations the behavior of the indicator makes use of sophisticated methods for the estimation of the function.

RESULTS

For the implementation of the proposal was used Generic Multi-Attribute Analysis (GMAA)System; it is a Decision Support System (DSS) based on an additive multi-attribute utility model that accounts for incomplete information concerning the inputs and is intended to allay many of the operational difficulties involved in the Decision Analysis cycle[21].

Three hierarchical objectives trees have been defined for the UTEQ teacher evaluation, since not all the informants can use

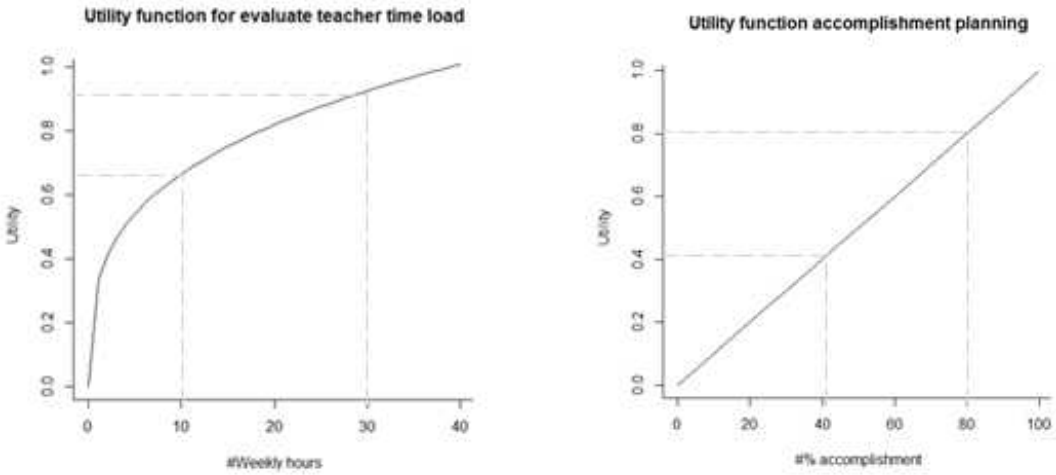


Fig. 6 Utility functions graphs

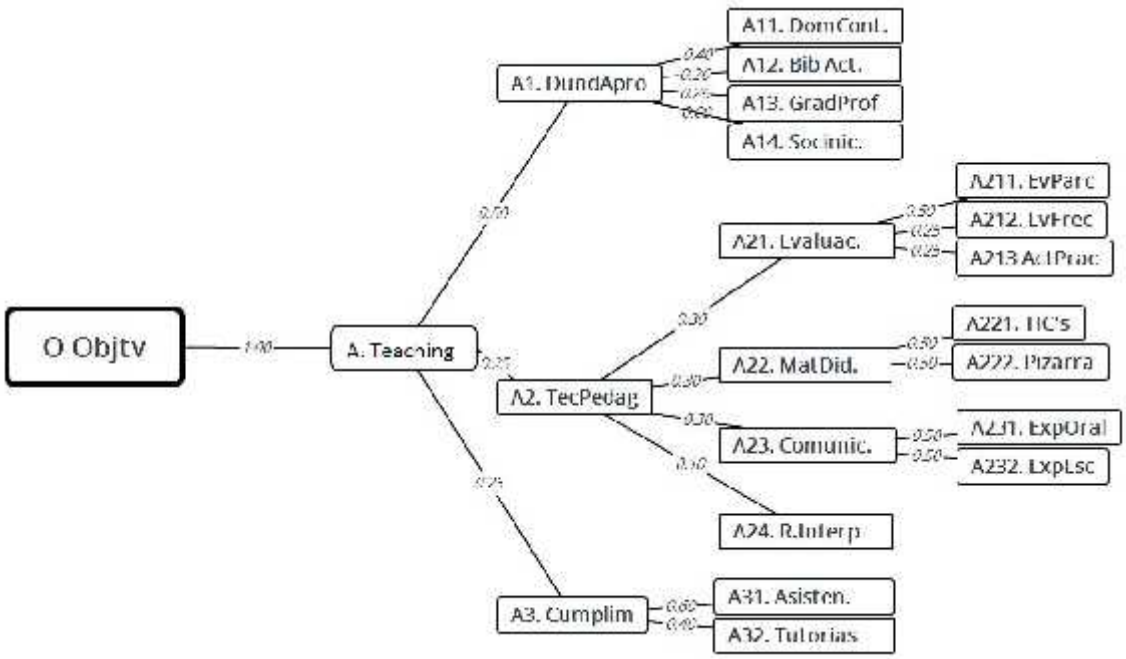


Fig. 6 Decision Tree for Student Teacher Assessment - Weight Distribution

the same indicators, this is obtained for *self-assessment*, *students*and for *authorities and peers*; the basic criteria used are *Teaching*, *Research*and *Management* with the exception of student-type informants who only have the criterion of *Teaching.*

Nodes and trees getting for teacher evaluation.

The description of each element of hierarchical trees is established by a descriptive matrix, this matrix uses 6 columns to characterize the indicators, and in the figure below is a section of this matrix.

Table 1

Tree	Nodes
self-assessment	37 attributes , 10 criteria and sub-criteria
students	14 attributes, 10 criteria and sub-criteria
authorities and peers	25 attributes, 10 criteria and sub-criteria

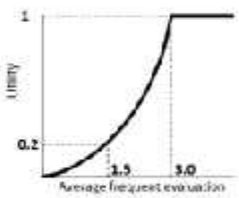
Attribute description sample

The figure below corresponds to the hierarchical tree of objectives that is applied so that the student evaluates to the teacher.

function; the utility function of the attributes is obtained from the standards required for teacher evaluation that is contained in the Law and regulations, also considered for non-linear functions the behavior of the variable that in most cases have come Defined in evaluation models proposed by the government, however, it is necessary to define increasingly precise functions based on historical data, which implies that a record of the data is maintained through an information system.

The application of the method in a real case follows a set of well-defined steps Planning, collection, evaluation and results; The manual application of the instruments consumes time and human resources, so it is essential to implement a data collection system that is at the service of the informants, in the evaluation phase, the data are recorded in the tool GMAA software, so that through an automated process obtain the ranking based on the MAUT (Multi-Attribute Utility Theory) method implemented in the software.

Table 2

Variable Type	Criterion, Sub-Criteria, Indicators and Categories	ID	Description	Criterion or Main Indicator	Utility Graphs
IND	Schedules	D1	**Descriptor:** It evaluates if the teacher complies with the established schedules for administrative management **Calculation of the indicator and scale:** HIGH: The teacher complies responsibly with the established schedule. MEDIUM: The teacher partially complies with the established schedule. LOW: The teacher does not meet the established schedule.		
IND	Evaluation	A2212	**Descriptor:** It evaluates the average of frequent evaluations for each evaluative cut in each subject, it is considered 3 frequent evaluations by cut as acceptable. **Calculation of the indicator and scale:** In a subject the average of frequent evaluations is found with the following formula: $prom\_ev\_frec\_asign = \frac{num\_eval\_frec}{n\ cortes}$ To find the average number of frequent evaluations we divide the sum of the average of frequent evaluations per subject for the number of subjects, as indicated below in the formula	Evaluation	

The objective tree constructed for informants (Authorities and pairs), is presented below, it contains the four fundamental aspects (Teaching, Research, Linkage and Management), by extension and size the self-assessment tree is not shown.

The final utility value (objective function) is determined with the values obtained in each of the trees and the distribution of weights according to the modeling obeys to what has been defined in the figure below:

CONCLUSSION AND FUTURE WORKS

The matrices developed to describe each of the hierarchical trees, define indicator code, descriptor and establish the utility

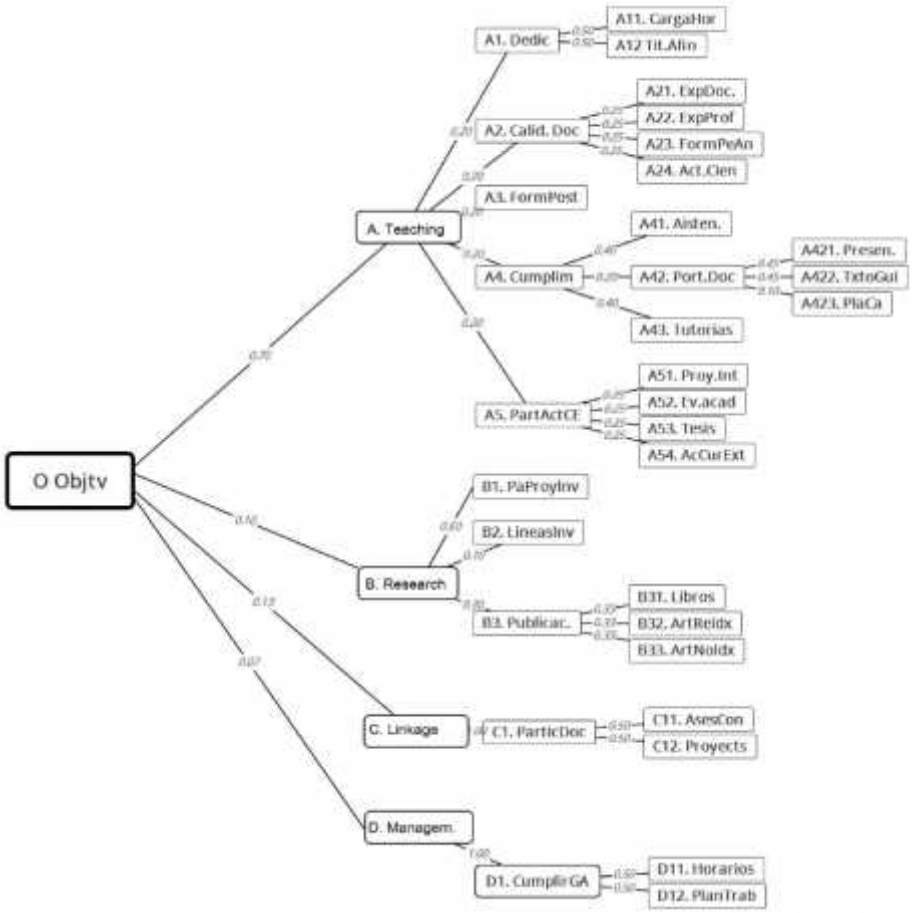


Fig. 7 Decision Tree for Authorities and Pairs Teacher Assessment - Weight Distribution

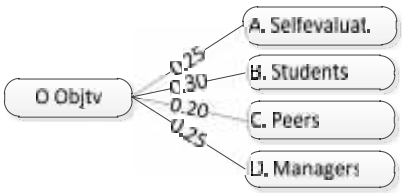


Fig. 8 Decision tree for actors in the teacher evaluation process-Weight Distribution

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