A JAVA Based System for Evaluating Educational Skills

F. Herrera, C. García
Dept. of C. S. and A.I.
University of Granada,
18071 - Granada, Spain
herrera@decsai.ugr.es

L. Martínez, P.J. Sánchez
Dept. of Computer Sciences
University of Jaén
23071 - Jaén, Spain
martin,pedroj@ujaen.es

B. Montes
Dept. of Psichology
University of Jaén
23071 - Jaén, Spain
bmontes@ujaen.es

Abstract Evaluation processes related to the quality of the education in the Universities have become really relevant for the institutions and Governments recently. Often, these processes are carried out by means of surveys where the students are forced to provide their opinions using a numerical scale, although the evaluated aspects may be vague imprecise or their nature qualitative. Here, we present a JAVA based system that automatizes these evaluation processes and offers a greater flexibility to express the opinions because it is based on a decision model that offers the possibility to provide them by means of heterogeneous information [5, 10] (numerical, linguistic and interval-valued) according to the nature and the uncertainty of the aspect qualified. The evaluations obtained by the system regarding the quality are expressed in a linguistic way using the 2-tuple linguistic representation model [6] to facilitate an easy understanding of the results.

Keywords: Heterogeneous information, quality evaluation, JAVA system.

1 Introduction

The evaluation of the educational quality in the Universities referred to the skills of their lecturers and professors is more and more important nowadays. This evaluation is usually carried out by means of surveys in which the students qualify different aspects related to the educational and research skills of the lecturers and professors. These surveys force the students to express their opinions or preferences in a given numerical scale belong to a specific domain in spite of the different aspects to qualify may have different nature and the knowledge about them is vague and imprecise. The use of fuzzy techniques have provided good results in different evaluation problems [3, 12].

In this contribution we present a JAVA based system developed for the *Office of Quality for the Universities of Andalucía* (South of Spain) that facilitates, improves and automatizes its current evaluation processes. This system is based on the linguistic decision and evaluation models presented in [4, 5, 10] that manage heterogeneous information (numerical, interval-valued and linguistic), so it will offer a greater flexibility and better rapport with reality to face this type of evaluation problems than the current ones. We shall outline the working of the main modules implemented in our JAVA system to carry out the whole evaluation process.

This contribution is structured as follows: in the section 2 we review briefly the linguistic 2-tuple representation model that will be used to deal with heterogeneous information, in the section 3 we present the decision process in which is based on the evaluation model to study the educational quality in the Universities that has been used to implement the evaluation JAVA system, in the section 4 we shall present the first version of the evaluation JAVA system and its working. Eventually some concluding remarks and future work is pointed out.

2 Linguistic representation model based on 2-tuples

This representation model was presented in [6] for overcoming the drawbacks of loss of information presented by the classical linguistic computational models [7] and it has been useful to managing heterogeneous information [8, 4, 10]. In this contribution, we shall use this representation model to manage heterogeneous information.

The 2-tuple fuzzy linguistic representation model is based on symbolic methods and takes as the base of its representation the concept of Symbolic Translation.

Definition 1. *The Symbolic Translation of a linguistic term* $s_i \in S = \{s_0, ..., s_g\}$ *is a numerical value assessed in* $[-.5, .5)$ *that support the "difference of information" between a counting of information* $\beta \in [0, g]$ *and the closest value in* $\{0, ..., g\}$ *that indicates the index of the closest linguistic term in* $S(s_i)$*, being [0,g] the interval of granularity of* S*.*

From this concept a new linguistic representation model is developed, which represents the linguistic information by means of 2-tuples (r_i, α_i), $r_i \in S$ and $\alpha_i \in [-.5, .5)$. r_i represents the linguistic label center of the information and α_i is the Symbolic Translation.

This model defines a set of functions between linguistic 2-tuples and numerical values.

Definition 2. *Let* $S = \{s_0, ..., s_g\}$ *be a linguistic term set and* $\beta \in [0, g]$ *a value supporting the result of a symbolic aggregation operation, then the 2-tuple that expresses the equivalent information to* β *is obtained with the following function:*

$$\Delta : [0, g] \longrightarrow S \times [-0.5, 0.5)$$

$$\Delta(\beta) = (s_i, \alpha), \;\; with \; \begin{cases} s_i & i = round(\beta) \\ \alpha = \beta - i & \alpha \in [-.5, .5) \end{cases}$$

where $round(\cdot)$ *is the usual* round *operation,* s_i *has the closest index label to "*β*" and "*α*" is the value of the symbolic translation.*

Proposition 1.*Let* $S = \{s_0, ..., s_g\}$ *be a linguistic term set and* (s_i, α) *be a linguistic 2-tuple. There is always a* Δ^{-1} *function, such that, from a 2-tuple it* *returns its equivalent numerical value $\beta \in [0, g]$ in the interval of granularity of S.*

Proof. It is trivial, we consider the following function:

$$\Delta^{-1} : S \times [-.5, .5) \longrightarrow [0, g]$$
$$\Delta^{-1}(s_i, \alpha) = i + \alpha = \beta$$

Different operators over linguistic 2-tuples can be reviewed in [6].

3 The Evaluation Scheme

On many occasions, evaluation processes have been solved in the literature by means of decision analysis tools [2, 3, 4].

In this contribution, we propose a model for evaluating the educational and research skills, of the University lecturers, based on a decision process that studies a set of aspects for each lecturer $X=\{x_1, \ldots, x_m\}$ that are evaluated by n students $E=\{e_1, \ldots, e_n\}$ providing their evaluations in different domains, D^k, according to the nature of the evaluated aspect by means of utility vectors:

$$\{p^k_{il}, \ldots, p^k_{im}\}$$

Let p^k_{ij} , $i \in \{1, \ldots, m\}, j \in \{1, \ldots, n\}, k \in \{N, I, L\}$ being the evaluation assigned to the aspect x_j by the student e_i assessed in the domain D^k. Each student fill a pool in which provides a vector with his/her evaluations. The domains used in this problem to assess the evaluations may be: **N**umerical, **I**nterval-valued and **L**inguistic.

To evaluate the educational and research skills for a lecturer, we propose a two-phase fuzzy evaluation model based on a Multi-Expert Decision-Making process dealing with heterogeneous information [5, 10]:

1. Aggregation phase
   (a) Make the information uniform
   (b) Aggregation process
   (c) Transforming into linguistic 2-tuples
2. Exploitation phase

In the next subsections, we present in detail the working of both phases.

3.1 Aggregation phase

In this phase the individual evaluation utility vectors provided by the students are combined to obtain a collective utility vector. As the students evaluations are assessed in different domains, numerical (D^N), interval-valued (D^I) and linguistic (D^L) this phase is accomplished in different steps:

1. *Making the information uniform.* The heterogeneous information is unified into a specific linguistic domain, called Basic Linguistic Term Set (BLTS) and symbolized as S_T. The BLTS is chosen according to the conditions shown in [9]:

$$S_T = \{s_0, ..., s_g\}$$

Once the BLTS has been chosen each numerical, linguistic and interval-valued evaluation, s^k_{ij}, provided by the experts is transformed into a fuzzy set in S_T, $F(S_T)$ using the respective transformation functions [10]:

(a) **Transforming numerical values**, $p^N_{ij} \in [0, 1]$, **into** $\mathbf{F}(S_T)$:

$$\tau : [0, 1] \rightarrow F(S_T)$$
$$\tau(p^N_{ij}) = \{(s_0, \gamma_0), \ldots, (s_g, \gamma_g)\}, \quad s_i \in S_T, \gamma_i \in [0, 1] \quad (1)$$
$$\gamma_i = \mu_{s_i}(p^N_{ij}) = \begin{cases} 0 & if \quad p^N_{ij} \notin Support(\mu_{s_i}(p^N_{ij})) \\ \frac{s^N_{ij} - a_i}{b_i - c_i} & if \quad a_i < s^N_{ij} < b_i \\ 1 & if \quad c_i < p^N_{ij} < d_i \\ \frac{c_i - p^N_{ij}}{c_i - d_i} & if \quad d_i < p^N_{ij} < c_i \end{cases}$$

Remark 1: We consider the membership functions $\mu_{s_i}(\cdot)$, of $s_i \in S_T$, are represented by a parametric function (a_i, b_i, c_i, d_i) [1].

(b) **Transforming linguistic values**, $p^L_{ij} \in S$, **into** $\mathbf{F}(S_T)$:

$$\tau_{SS_T} : S \rightarrow F(S_T)$$
$$\tau_{SS_T}(p^L_{ij}) = \{(s_k, \gamma_k)/k \in \{0, \ldots, g\}\}, \forall p^L_{ij} \in S \quad (2)$$
$$\gamma^i_k = max_y min\{\mu_{p^L_{ij}}(y), \mu_{c_k}(y)\}$$

where $\mu_{p^L_{ij}}(y)$ and $\mu_{s_k}(y)$ are the membership functions of the fuzzy sets associated with the terms $p^L_{ij} \in S$ and $s_k \in S_T$, respectively.

(c) **Transforming interval values**, $p^I_{ij} \in [0, 1]$, **into** $\mathbf{F}(S_T)$: Let $I = [\underline{i}, \overline{i}]$ be an interval value in [0,1]. We assume that the interval-value has a representation, inspired in the membership function of the fuzzy sets [11]:

$$\mu_I(\vartheta) = \begin{cases} 0 & if \quad \vartheta < \underline{i} \\ 1 & if \quad \underline{i} \leq \vartheta \leq \overline{i} \\ 0 & if \quad \overline{i} < \vartheta \end{cases} \quad (3)$$

The transformation function is:

$$\tau_{IS_T} : I \rightarrow F(S_T)$$
$$\tau_{IS_T}(p^I_{ij}) = \{(s_k, \gamma_k)/k \in \{0, \ldots, g\}\} \quad (4)$$
$$\gamma^i_k = max_y min\{\mu_{p^I_{ij}}(y), \mu_{s_k}(y)\}$$

where $\mu_{p^I_{ij}}(y)$ is the membership function associated with the interval-valued p^I_{ij}.

So far, the input information has been unified into fuzzy sets in the BLTS, now the evaluation model aggregates the input information to obtain a collective utility vector.

2. *Aggregating individual utility vectors.* For each evaluated aspect, a collective value is obtained aggregating the above fuzzy sets on the BLTS that represents the individual evaluations assigned by the students using an aggregation operator. The collective utility vector is expressed by means of fuzzy sets on the BLTS as follows:

$$\{p_1 = (s_0, \gamma_0^{c1}), \ldots, (s_g, \gamma_g^{c1}), \quad \ldots \quad , p_m = (s_0, \gamma_0^{cn}), \ldots, (s_g, \gamma_g^{cn})\},$$

being p_j, the collective value for the parameter x_j, such that,

$$\gamma_0^{cj} = \mu(\gamma_0^{ij}),\ i \in \{1, ..., n\}$$

Being μ an *aggregation operator* and i the number of students.

Therefore, applying the Δ function (Definition 2) to the value β obtained in (6) we shall obtain a collective preference relation whose values are expressed by means of linguistic 2-tuples:

$$\Delta(\chi(\tau(\vartheta))) = \Delta(\beta) = (s, \alpha) \tag{5}$$

3. *Transforming into 2-tuples*: The collective utility vector expressed by means of fuzzy sets in the BLTS is far from the initial expression domains, are difficult to manage for several mathematical calculations and hard to understand by the experts. So they will be transformed into linguistic 2-tuples in the BLTS to facilitate its managing and the comprehensibility of the results. This transformation is carried out using the function χ:

$$\chi : F(S_T) \rightarrow [0, g]$$
$$\chi(\tau(\vartheta)) = \chi(\{(s_j, \gamma_j), j = 0, \ldots, g\} = \frac{\sum_{j=0}^{g} j \cdot \gamma_j}{\sum_{j=0}^{g} \gamma_j} = \beta \tag{6}$$

Therefore, applying the Δ function (Definition 2) to the value β obtained in (6) we shall obtain a collective preference relation whose values are expressed by means of linguistic 2-tuples:

$$\Delta(\chi(\tau(\vartheta))) = \Delta(\beta) = (s, \alpha) \tag{7}$$

3.2 Exploitation phase

In decision analysis this phase uses the collective preferences obtained in the aggregation phase to look for the best alternative(s) using different choice functions [13, 14]. However, in this evaluation problem it will compute an overall value expressed by means of a linguistic 2-tuple [5]. This overall value expresses a linguistic measurement of the quality about the skills of the lecturer or professor evaluated.

4 A JAVA Evaluation System for Educational Quality in Universities

Once we have shortly reviewed the model that implements our system. We are going to present the implementation of the version 1.0 of this system.

In this section we shall show the working of the main modules of the system according to their aim:

1. *Designer Module*: it is in charge of the design of the survey forms that will be filled by the students.
2. *Filler Module*: it is used by the sources of information to fill the survey.
3. *Results Module*: it is the main module regarding the objective of our system, because this module gathers all the survey forms and obtains the quality evaluation for each lecturer or professor.

4.1 Survey designer

This module generates the survey form that will be used to evaluate the lecturers. This module is important because the forms can variate according to different criteria (subjects, type of lecturer, ...). This module allows to define each question and select its domain that could be *numerical, interval-valued or linguistic* depending on the nature or uncertainty of the question. The domain is selected after preliminary study. The module allows to define new ranges for numerical information and new linguistic term sets for linguistic information. In the Figure 1 we can see how can we add a question to a survey and how can we create a new linguistic term set.

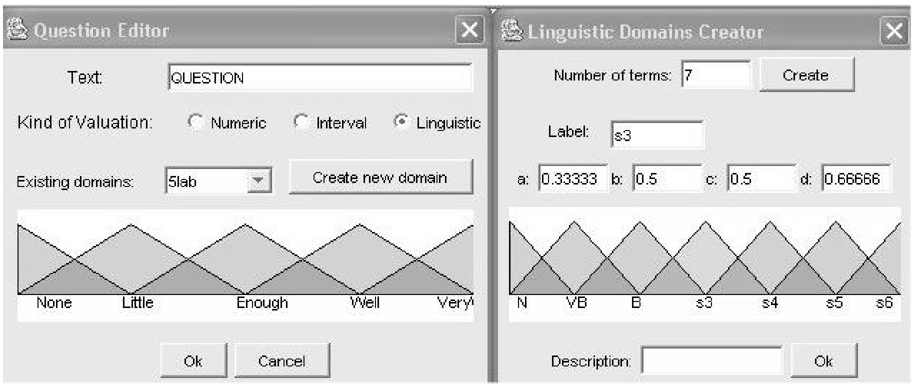

Figure 1: Adding questions and creating term sets

The initial interface of this module to add questions can be seen in Figure 2

When a question is selected its domain is graphically showed.

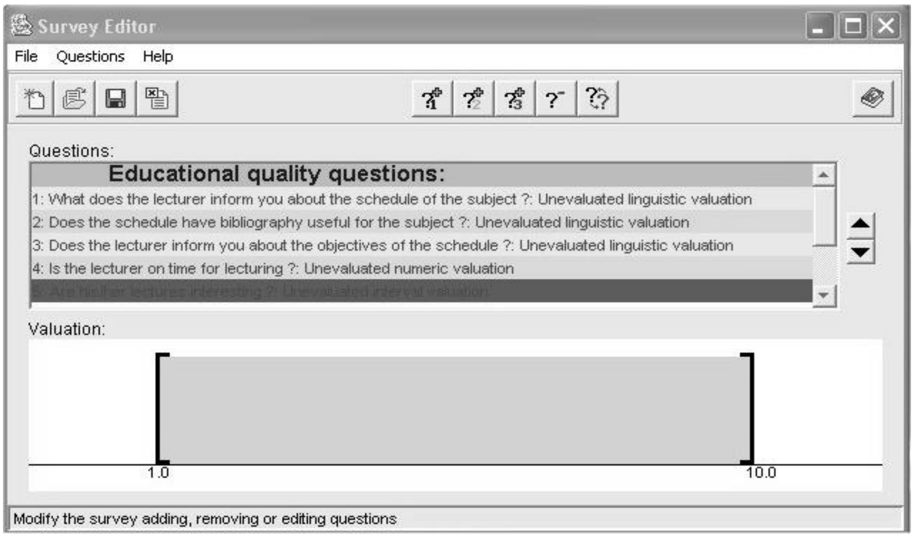

Figure 2: Module to design surveys

4.2 Survey Filler

This module is used by the sources of information to fill each form according to their own perceptions and opinions. The answers will be assessed in the domain defined in the Survey designer module. In the Figure 3 we can see how to fill a question assessed in a linguistic domain:

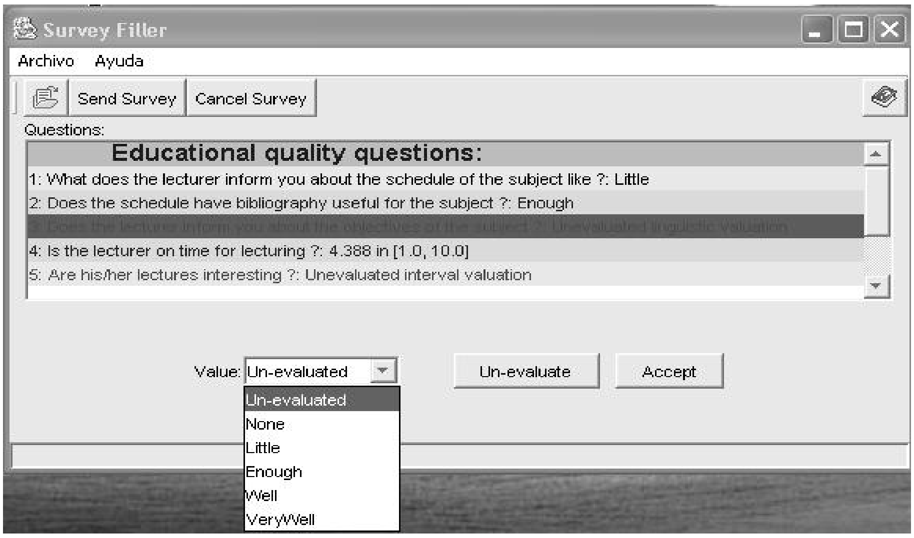

Figure 3: Answering a question assessed in a linguistic term set

Once the linguistic term has been chosen the user must accept the evaluation selected.

4.3 Survey Results

This module computes the result about the quality skills of a lecturer or professor evaluated according to the process shown in Section 3 and is expressed by means of a linguistic 2-tuple.

In this version this module implements the evaluation process to obtain the quality result using the arithmetic mean operator for the aggregation phase and in the exploitation one. This selection is done due to the fact, it was used in the before surveys of the *Office of Quality*. In the future we want to offer an interface that allows to choose among different methods to be applied in order to obtain the evaluation result.

Now, the results are stored in a Data Base such that we can deal with them in different ways.

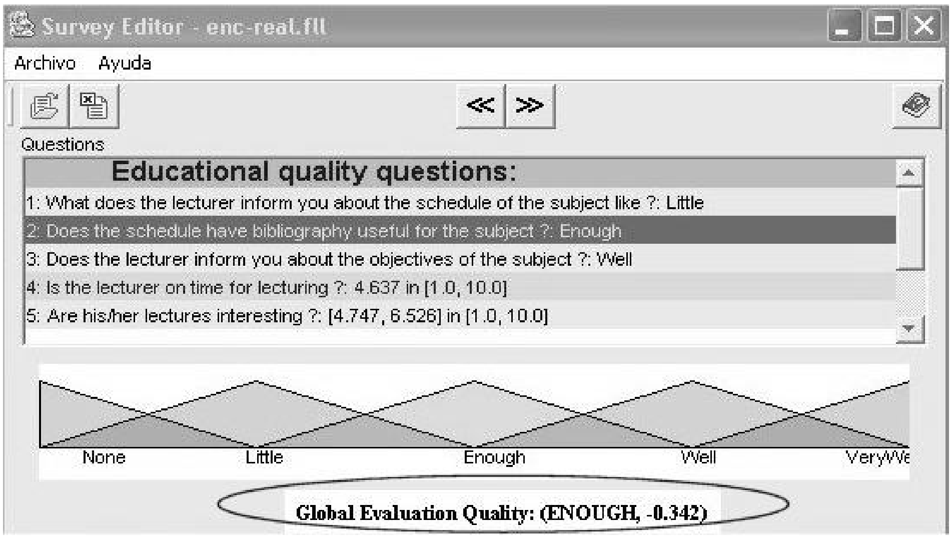

Figure 4: UML scheme for an automatic educational quality evaluation

In the above figure we can see rounded by a circle that the quality evaluation is expressed by means of a linguistic 2-tuple assessed in a linguistic term set with five labels.

In the presentation we shall explain in further detail the different modules and possibilities they offer their users.

5 Concluding Remarks and Future Work

So far, we have implemented the theoretical background developed in [4, 5, 10] in an evaluation system that automatizes the surveys done in the Universities about the quality of their lecturers and professors. Due to the fact, we are developing this system as result of research project granted by the *Office of Quality for the Universities of Andalucia* (Spain). But in the future we want to apply similar methods in the study of quality of textile products.

In addition as we have aforementioned we want to offer different methods for the evaluation process, because depends on the problem it will be necessary to apply different aggregation operators and different methods in the exploitation phase.

Acknowledgements

This work is partially supported by the Research Projects TIC2002-03348, UJA23(UCUA), PromoJaén Project belongs to EQUAL Initiative and FEDER Funds.

References

[1] P.P. Bonissone. *A fuzzy sets based linguistic approach: theory and applications.* Approximate Reasoning in Decision Analysis, North-Holland, 1982. 329-339.

[2] C.T. Chen. Applying linguistic decision-making method to deal with service quality evaluation problems. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, 9(Suppl.):103–114, 2001.

[3] G.B. Devedzic and E. Pap. Multicriteria-multistages linguistic evaluation and ranking of machine tools. *Fuzzy Sets and Systems*, 102:451–461, 1999.

[4] F. Herrera, E. Herrera-Viedma, L. Martinez, F. Mata, and P.J. Sanchez. *A Multi-Granular Linguistic Decision Model for Evaluating the Quality of Network Services.* Intelligent Sensory Evaluation: Methodologies and Applications. Springer, pp. 71-92, 2004.

[5] F. Herrera, E. Herrera-Viedma, L. Martínez, and P.J. Sánchez. A linguistic decision process for evaluating the installation of an ERP system. In *9th International Conference on Fuzzy Theory and Technology*, pages 164–167, Cary (North Carolina) USA, 2003.

[6] F. Herrera and L. Martínez. A 2-tuple fuzzy linguistic representation model for computing with words. *IEEE Transactions on Fuzzy Systems*, 8(6):746–752, 2000.

[7] F. Herrera and L. Martínez. The 2-tuple linguistic computational model. Advantages of its linguistic description, accuracy and consistency. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, 9(Suppl.):33–49, 2001.

[8] F. Herrera and L. Martínez. A model based on linguistic 2-tuples for dealing with multigranularity hierarchical linguistic contexts in multiexpert decision-making. *IEEE Transactions on Systems, Man and Cybernetics. Part B: Cybernetics*, 31(2):227–234, 2001.

[9] F. Herrera, L. Martinez, and P.J. Sanchez. Managing heterogeneous information in group decision making. In *Proceedings Ninth International Conference IPMU 2002*, pages 439–446, Annecy (France), 2002.

[10] F. Herrera, L. Martínez, and P.J. Sánchez. Managing non-homogeneous information in group decision making. *European Journal of Operational Research*, To appear, 2004.

[11] D. Kuchta. Fuzzy capital budgeting. *Fuzzy Sets and Systems*, 111:367–385, 2000.

[12] J. Liu, D. Ruan, and R. Carchon. A linguistic evaluation approach for strengthened safeguards relevant information. In *Proceedings of the Joint 9th IFSA World Congress and 20th NAFIPS International Conference*, pages 651–656, Vancouver (Canada), July, 2001.

[13] S.A. Orlovsky. Decision-making with a fuzzy preference relation. *Fuzzy Sets Systems*, 1:155–167, 1978.

[14] M. Roubens. Some properties of choice functions based on valued binary relations. *European Journal of Operational Research*, 40:309–321, 1989.