Dealing With Multi-granular Linguistic Scales in Evaluation Processes

Luis Martínez[1], Pedro J. Sánchez[1], Beatriz Montes-Berges[2]

[1] Computer Science Department
University of Jaén, 23071. Jaén Spain
martin,pedroj@ujaen.es

[2]Departament of Psychology
University of Jaén, 23071. Jaén Spain
bmontes@ujaen.es

Abstract

The evaluation processes have been used in many areas such as business, engineering, education, marketing, etc. The evaluation is a process that involves different mechanisms in which it is necessary to define the elements to evaluate, fix the evaluation framework, gather the information and obtain an evaluation assessment by means of an evaluation process. The aim of the evaluation is to obtain information about the worth of an item (product, service, material, etc.). These processes study different aspects, parameters or indicators that are assessed by a panel (group) of experts in a fixed scale defined a priori that does not take into account the experts' knowledge either the nature of the aspects, parameters or indicators evaluated in such a process. In this contribution, we focus on evaluation processes that study qualitative indicators so we propose the use of the Fuzzy Linguistic Approach (Zadeh 1975) to manage the uncertainty related to qualitative information and in addition, we propose the use of multiple scales in the evaluation framework to offer a greater flexibility of expression to the experts due to the fact that, not all the questions allow the same degree of discrimination either the experts have the same knowledge about them. To do so, we propose the use of the linguistic hierarchies presented in (Herrera and Martínez 2001). Subsequently, we present an evaluation model to accomplish the education skills evaluation process dealing with multiple linguistic scales and eventually we shall show a survey to study the reliability and the expert's satisfaction of using of multiple linguistic scales in an evaluation process.

Keywords: Evaluation process, Decision Analysis, Linguistic variables, Linguistic Hierarchies

1 Introduction

The evaluation is a complex cognitive process that involves different mechanisms in which it is necessary to define the elements to evaluate, fix the evaluation framework, gather the information and obtain an evaluation assessment by means of an evaluation process. The aim of any evaluation process is to obtain information

about the worth of an item (product, service, material, etc.), a complete description about different aspects, indicators, criteria in order to improve it or to compare with other items to know which ones are the best. The information gathered in this kind of processes is usually provided by a group of individuals. Usually these experts are forced to express their opinions in a precise numerical scale fixed a priori (Evans and King 1999; Aladwani and P.C.Palvia 2002) independently of the nature of the aspects evaluated or the experts' knowledge. To assess quantitative aspects by means of numerical values is suitable and has got good results, but often are evaluated aspects whose nature is qualitative and the use of numerical assessments are not adequate, because its knowledge involves uncertainty and it is very difficult to assess them precisely if the expert has an uncertain knowledge about them. Sometimes in such cases symbolic approaches are used pretending the numerical scale but their background is similar to the numerical one, so in fact they don't provide advantages with regards to the managing of the uncertainty.

We shall focus our interest on the one hand, in evaluation problems dealing with aspects, parameters, indicators qualitative in nature, that involves uncertainty in the experts' knowledge. While quantitative aspects can be easily described by numbers, qualitative aspects are better described by linguistic sentences than by numbers because it is closest manner to how the evaluators express this kind of knowledge. The Fuzzy Linguistic Approach (Zadeh 1975) represents qualitative aspects as linguistic values by means of linguistic variables and has got successful results dealing with type of information. And on the other hand, we propose the use of evaluation frameworks composed by multiple linguistic scales with different degrees of discrimination and develop an evaluation model to deal with this type of framework.

In the literature can be found different evaluation proposals for different evaluation problems in which the use of the fuzzy linguistic approach has provided successful results (Chen 2001; Devedzic 2001; Martínez, Liu et al. 2006) and as well as can be found proposals for evaluation processes that define evaluation frameworks with different scales (García, Martínez et al. 2003; Herrera, Herrera-Viedma et al. 2004; Martínez, Liu et al. 2005; Sánchez, Pérez et al. 2005). These proposals provide different evaluation models based on decision making analysis and those ones dealing with heterogeneous (numerical, linguistic, interval) scales for evaluation problems that evaluate aspects of different nature. To deal with those heterogeneous scales was proposed the use the 2-tuple fuzzy linguistic model (Herrera and Martínez 2000) in order to manage this framework in a precise and proper way.

The aim of this contribution is to develop and evaluation process dealing with multiple linguistic scales and shows its reliability in order to gather the experts' knowledge in a simple and accurate form to obtain reliable results from the evaluation process. To do so, we develop a study about the education skills of one of the authors of this contribution, the evaluation problem is based on the one presented in (García, Martínez et al. 2003) but in this contribution we propose a multiple linguistic scales evaluation framework. Finally we shall show the results of a survey about the experts' satisfaction of the use of multiple linguistic scales in the evaluation framework.

This contribution is structured as follows: in Section 2 a linguistic background review is introduced in order to show the basic concepts that are necessary to understand the evaluation model applied to the evaluation of education skills and its framework proposed in Section 3. In section 4 is showed a survey about the reliability and satisfaction of the use of multiple linguistic scales in the education skills evaluation process. Finally the paper is concluded in Section 5.

2 Linguistic Background

In this section we shall review some core concepts about linguistic information. We review briefly the *Fuzzy Linguistic Approach,* the *2-tuple Linguistic model* and the *Linguistic Hierarchies.*

2.1 The Fuzzy Linguistic Approach

Usually, we work in a quantitative setting, where the information is expressed by means of numerical values. However, many aspects of different activities in the real world cannot be assessed in a quantitative form, but rather in a qualitative one, i.e., with vague or imprecise knowledge. In such a case, a better approach may be to use linguistic assessments instead of numerical values. The fuzzy linguistic approach represents qualitative aspects as linguistic values by means of linguistic variables (Zadeh 1975). This approach is adequate in some situations, for example, when attempting to qualify phenomena related to human perception, we are often led to use words in natural language.

We have to choose the appropriate linguistic descriptors for the term set and their semantics. In order to accomplish this objective, an important aspect to analyse is the "granularity of uncertainty", i.e., the level of discrimination among different counts of uncertainty. The universe of the discourse over which the term set is

defined can be arbitrary, usually linguistic term sets are defined in the interval [0, 1]. In (Bonissone and Decker 1986) the use of term sets with an odd cardinal was studied, representing the mid term by an assessment of "approximately 0.5", with the rest of the terms being placed symmetrically around it and with typical values of cardinality, such as 7 or 9.

One possibility of generating the linguistic term set consists of directly supplying the term set by considering all terms distributed on a scale on which a total order is defined. For example, a set of seven terms S, could be given as follows:

$S = \{s_0$:None; s_1:Very Low; s_2:Low; s_3:Medium; s_4:High; s_5:Very High; s_6:Perfect$\}$

In these cases, it is usually required that there exist:

- A negation operator $\text{Neg}(s_i) = s_j$ such that $j = g-i$ (g+1 is the cardinality).
- A minimization and a maximization operator in the linguistic term set: $s_i <= s_j \Leftrightarrow i <= j$.

The semantics of the terms is given by fuzzy numbers defined in the [0,1] interval, which are described by membership functions. A way to characterize a fuzzy number is to use a representation based on parameters of its membership function. This parametric representation is achieved by the 4-tuple **(a, b, d, c)**, where **b** and **d** indicate the interval in which the membership value is 1, with **a** and **c** indicating the left and right limits of the definition domain of the trapezoidal membership function. A particular case of this type of representation are the linguistic assessments whose membership functions are triangular, i.e., b = d, so we represent this type of membership function by a 3-tuple (a; b; c). For example, we may assign the following semantics to the set of seven terms:

Perfect = (0.83; 1; 1) *Very High* = (0.67; 0.83; 1) *High* = (0.5; 0.67; 0.83)

Medium = (0.33; 0.5; 0.67) *Low* = (0.17; 0.33; 0.5) *Very Low* = (0; 0.17; 0.33) *None* = (0; 0; 0.17)

which is graphically shown in Figure 1.

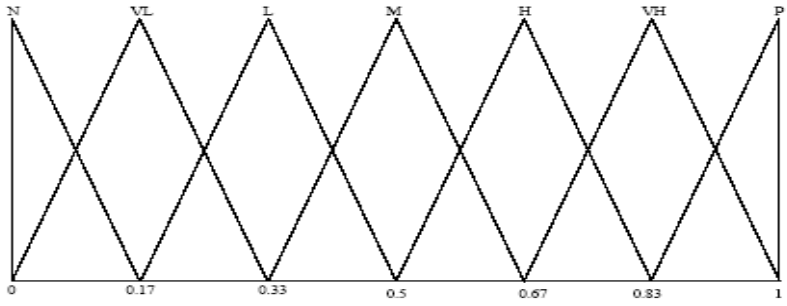

Figure 1: A set of seven terms and their semantics

The most often computational models for dealing with linguistic information are: (i) The semantic model (Degani and Bortolan 1988) that uses the linguistic terms just as labels for fuzzy numbers, while the computations over them are done directly over those fuzzy numbers, (ii) the second one, is the symbolic model (Delgado, Verdegay et al. 1993) that uses the order index of the linguistic terms to make direct computations on labels. However, our proposal for computing with linguistic assessments assessed in different scales takes as representation base the linguistic 2-tuple representation model presented in (Herrera and Martínez 2000) that has shown itself as a good choice to manage non-homogeneous information (Herrera, Herrera-Viedma et al. 2003; Herrera, Herrera-Viedma et al. 2004; Herrera, Martínez et al. 2005). In the following subsection we review this representation model.

2.2 The 2-tuple Linguistic Representation Model

The 2-tuple fuzzy linguistic representation model (Herrera and Martínez 2000) is based on the symbolic method 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 [-0.5,0.5) that supports the "difference of information" between an amount 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 linguistic representation model is developed, which represents the linguistic information by means of 2-tuples $(s_i,\alpha_i), s_i \in S$ and $\alpha_i \in [-0.5,0.5)$.

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:

$$\Delta : [0,g] \rightarrow S \times (-0.5,.0.5)$$

$$\Delta(\beta) = (s_i,\alpha), with \quad \begin{cases} s_i & i = round(\beta) \\ \alpha = \beta - i & \alpha \in [-0.5,0,5) \end{cases}$$

where 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_i) 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].

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

$$\Delta^{-1} : S \times [-0{,}5, 0.5) \rightarrow [0, g]$$

$$\Delta^{-1}(s_i, \alpha) = i + \alpha = \beta$$

Remark 1. *From Definitions 1 and 2 and Proposition 1, it is obvious that the conversion of a linguistic term into a linguistic 2-tuple consist of:* $s_i \in S \Rightarrow (s_i, 0)$

This model has a computational technique based on the 2-tuples were presented in (Herrera and Martínez 2000):

- **Aggregation of 2-tuples**

The aggregation of linguistic 2-tuples consist of obtaining a value that summarizes a set of values, therefore, the result of the aggregation of a set of 2-tuples must be a linguistic 2-tuple. In (Herrera and Martínez 2000) we can find several 2-tuple aggregation operators.

- **Comparison of 2-tuples**

The comparison of information represented by 2-tuples is carried out according to an ordinary lexico-graphic order.

Let (s_k, α_1) and (s_l, α_2) be two 2-tuples represented two assessments:

- If $k < l$ then (s_k, α_1) is smaller than (s_l, α_2)
- If $k=l$ then
  1. If $\alpha_1 = \alpha_2$ then (s_k, α_1) and (s_l, α_2) represent the same value
  2. If $\alpha_1 < \alpha_2$ then (s_k, α_1) is smaller than (s_l, α_2)
  3. If $\alpha_1 > \alpha_2$ then (s_k, α_1) is bigger than (s_l, α_2)

- **Negation Operator of a 2-tuple**

The negation operator over 2-tuples is defined as:

$$Neg(s_i, \alpha) = \Delta\ (g - \Delta^{-1}(s_i, \alpha))$$

where g+1 is the cardinality of S, $s_i \in S = \{s_0,...,s_g\}$.

2.2 Linguistic Hierarchies

In the introduction we have mentioned that one aim of this contribution is to deal with multiple linguistic scales in the evaluation framework. The hierarchical linguistic contexts were introduced in (Herrera and Martínez 2001) to improve the precision of the processes of *Computing with Words* in multi-granular linguistic contexts.

A Linguistic Hierarchy is a set of levels, where each level represents a linguistic term set with different granularity to the remaining levels. Each level is denoted as **l(t, n(t))** being,

- *t* a number that indicates the level of the hierarchy.
- *n(t)* the granularity of the term set of the level t.

The levels belonging to a linguistic hierarchy are ordered according to their granularity, i.e., for two consecutive levels t and t+1, n(t+1) > n(t). Therefore, the level t+1 is a refinement of the previous level t.

From the above concepts, we define a linguistic hierarchy, LH, as the union of all levels t:

$$LH = \bigcup_t l(t, n(t))$$

Given a LH, we denote as $S^{n(t)}$ the linguistic term set of LH corresponding to the level t of LH characterized by a granularity of uncertainty n(t):

$$S^{n(t)} = \{s_0^{n(t)}, ..., s_{n(t)-1}^{n(t)}\}$$

Generically, we can say that the linguistic term set of level t + 1 is obtained from its predecessor as:

$$l(t, n(t)) \rightarrow l(t+1, 2 \bullet n(t) - 1)$$

A graphical example of a linguistic hierarchy can be seen in Figure 2:

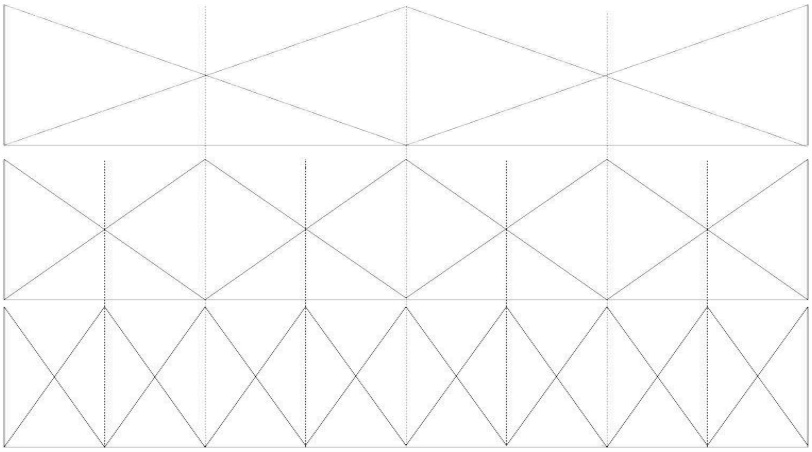

Figure 2: Linguistic Hierarchy

In (Herrera and Martínez 2001) were developed different transformation functions between labels of different levels *without loss of information*.

Definition 3. Let $LH = \bigcup_t l(t, n(t))$ be a linguistic hierarchy whose linguistic term sets are denoted as $S^{n(t)} = \{s_0^{n(t)}, ..., s_{n(t)-1}^{n(t)}\}$, and let us consider the 2-tuple linguistic representation. The transformation function from a linguistic label in level t to a label in level t' is defined as:

$$TF_{t'}^{t} : l(t, n(t)) \rightarrow l(t', n(t'))$$

$$TF_{t'}^{t}(s_i^{n(t)}, \alpha^{n(t)}) = \Delta_{n(t')}\left(\frac{\Delta_{n(t)}^{-1}(s_i^{n(t)}, \alpha^{n(t)}) \bullet (n(t')-1)}{n(t)-1}\right)$$

Proposition 2. The transformation function between linguistic terms in different levels of the linguistic hierarchy is bijective:

$$TF_{t}^{t'}(TF_{t'}^{t}(s_i^{n(t)}, \alpha^{n(t)})) = (s_i^{n(t)}, \alpha^{n(t)})$$

3 A Multiple Linguistic Scale Evaluation Model for Education Skills

In this section we propose an evaluation model to deal with multiple linguistic scales. To do so, first we introduce the problem of evaluating education skills that is carried out in the Spanish Universities to evaluate the lecturers. This problem is classically carried out in a fixed numerical scale in spite of the questionnaires used evaluate qualitative aspects regarding the lecturer skills. Second, once the problem has been introduced we propose the use of multiple linguistic scales in its framework to assess the qualitative aspects and finally we shall propose an evaluation model to deal with the information gathered from the experts that is assessed in a multi-granular linguistic context.

3.1 Education Skills Evaluation Problem

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. Currently, these surveys force the students to express their opinions or preferences in a given numerical scale. An example of a classical questionnaire for this problem is showed in Table 1.

1. The lecturer informs about the contents of the subject	1	2	3	4	5
2. The lecturer informs about the objectives of contents of the subject	1	2	3	4	5
3. The contents provides useful bibliography	1	2	3	4	5
4. The lecturer starts the lectures on time	1	2	3	4	5
5. The lecturer go to class the fixed days	1	2	3	4	5
6 When he does not go to class explains why ?	1	2	3	4	5
7. When he does not go to class does he catch up another day ?	1	2	3	4	5
8. Does he attend to you in his tutorship timetable ?	1	2	3	4	5
9. Does he starts each module showing its objectives ?	1	2	3	4	5
10. Does he ask the students about their comprehension ?	1	2	3	4	5
11. Does he explains clearly and make easy to take hand notes ?	1	2	3	4	5
12. Does he remarks the main aspects of each module ?	1	2	3	4	5
12. Does he remarks the main aspects of each module ?	1	2	3	4	5
13. Does he knows perfectly the subject ?	1	2	3	4	5
14. Does he motivate the students about the subject ?	1	2	3	4	5
15. Does he show examples about the contents of the subject ?	1	2	3	4	5
16. In general, are the lectures interesting ?	1	2	3	4	5
17. Does he propose activities to facilitate the autonomous learning ?	1	2	3	4	5
18. Does he push the students towards a reflexive activity ?	1	2	3	4	5
19. Does he use didactics resources ?	1	2	3	4	5
20. Does he use a suitable teaching method for the students and the subject?	1	2	3	4	5
21. Does he use proper language ?	1	2	3	4	5
22. Does he informs about the evaluation method at the beginning of the course ?	1	2	3	4	5
23. Does he take into consideration the students suggestions about the subject ?	1	2	3	4	5
24. Does he have an equitable treatment with the students ?	1	2	3	4	5
25. is he respectful with the students ?	1	2	3	4	5
26. Does he answer the students' questions with interest ?	1	2	3	4	5
27. Does he use different evaluation methods ?	1	2	3	4	5

Table 1. Numerical Questionnaire

It is easy to see that the evaluated aspects have a qualitative nature and the knowledge about them that the students have it is usually vague and imprecise. However the scale used to assess their knowledge is a numerical one that it is not very adequate in many of these questions.

3.2 A Multiple Linguistic Scale Education Skills Evaluation Problem

To avoid the above problems we propose to assess linguistically the opinions provided by the students, but due to the fact that, different questions can have different degree of distinction and the student can have different degree of knowledge of different questions. We suggest the use of two linguistic scales coming from the linguistic hierarchy presented in Fig. 2 whose syntax will be:

$$S^3 = \{\text{Never, Sometimes, Always}\}$$

$$S^5 = \{\text{Null, A Little, Enough, A lot, Perfectly}\}$$

Using these linguistic scales the questionnaire for the problem will be the following one (see Table 2):

1. The lecturer informs about the contents of the subject	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
2. The lecturer informs about the objectives of contents of the subject	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
3. The contents provides useful bibliography	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
4. The lecturer starts the lectures on time	NEVER		SOMETIMES		ALWAYS
5. The lecturer go to class the fixed days	NEVER		SOMETIMES		ALWAYS
6 When he does not go to class explains why ?	NEVER		SOMETIMES		ALWAYS
7. When he does not go to class does he catch up another day ?	NEVER		SOMETIMES		ALWAYS
8. Does he attend to you in his tutorship timetable ?	NEVER		SOMETIMES		ALWAYS
9. Does he starts each module showing its objectives ?	NEVER		SOMETIMES		ALWAYS
10. Does he ask the students about their comprehension ?	NEVER		SOMETIMES		ALWAYS
11. Does he explains clearly and make easy to take hand notes ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
12. Does he remarks the main aspects of each module ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
13. Does he knows perfectly the subject ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
14. Does he motivate the students about the subject ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
15. Does he show examples about the contents of the subject ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
16. In general, are the lectures interesting ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
17. Does he propose activities to facilitate the autonomous learning ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
18. Does he push the students towards a reflexive activity ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
19. Does he use didactics resources ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
20. Does he use a suitable teaching method for the students and the subject?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
21. Does he use proper language ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
22. Does he informs about the evaluation method at the beginning of the course?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
23. Does he take into consideration the students suggestions about the subject ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
24. Does he have an equitable treatment with the students ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
25. is he respectful with the students ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
26. Does he answer the students' questions with interest ?	NULL	A LITTLE	ENOUGH	A LOT	PERFECTLY
27. Does he use different evaluation methods ?	NEVER		SOMETIMES		ALWAYS

Table 2. Multi-Granular Linguistic Questionnaire

3.3 A Multiple Linguistic Scale Evaluation Model

Our aim is to evaluate the educational skills of the lecturers and professors in the University. On many occasions, evaluation processes have been solved by means of models based on decision analysis (Chen 2001; Devedzic 2001; Martínez, Liu et al. 2006). In our evaluation problem a group of experts evaluate different aspects that may have qualitative nature with different degree of discrimination and the knowledge about them is vague or imprecise. Therefore, these aspects according to section 3.2 will be assessed in a multi-granular linguistic context. Our proposal for solving this evaluation process will be based on a Multiple-Expert Decision-Making (MEDM) scheme presented in (Herrera, Herrera-Viedma et al. 2001; Martínez, Liu et al. 2005) that uses the linguistic 2-tuple model and follows a common resolution decision process scheme (Roubens 1997):

1. Aggregation phase.
2. Exploitation phase.

But slightly modified because the input information is assessed in multiple linguistic scales.

3.3.1 Multi-Expert Decision Scheme with Multiple Linguistic Scales

We shall model the education skills evaluation problem as a MEDM problem dealing with multi-granular linguistic information, such that a group of students $E = \{e_1,...,e_n\}$, provide their opinions about the questions of the questionnaire presented in Table 2, $Q = \{q_1,...,q_m\}$ by means of linguistic terms assessed in the term sets:

S^3 ={Never, Sometimes, Always}

S^5 ={Null, A Little, Enough, A lot, Perfectly}

Belonging to the linguistic hierarchy showed in Fig. 2. Therefore for each evaluated lecturer each student e_i provides a utility vector $U_i = \{p^i{}_1,..., p^i{}_m\}$, where $p^i{}_j$ is the assessment provided by the student e_i to the question q_j. This assessment can be assessed in S^3 or S^5 according to the questionnaire.

Once the students have provided their information by means of utility vectors the evaluation model will carry out the decision based model to compute the evaluation assessments as it is described in the following sections

3.3.2 Aggregation phase

In this phase the multi-granular linguistic information gathered from the opinions provided by the students is combined to obtain collective evaluation value for each questionnaire question. This phase combines the multi-granular linguistic information in two steps.

A) *Normalization Process*

Due to the fact that the questionnaire assessments are assessed in a multi-granular linguistic framework to combine both types of assessments firstly they must be conducted into a common utility space called *Basic Linguistic Term Set* (BLTS), represented by S_T. In this problem we could choose as BLTS any linguistic level of LH, but in our case we have decided to choose as BLTS to unify the input assessments a linguistic term set with five linguistic labels that corresponds to the second level, S^5, of LH (Fig. 2).

$$S_T = S^5 = \{s_0^5, s_1^5, s_2^5, s_3^5, s_4^5\}$$

We have chosen this term set as BLTS because of keeping maximum degree of granularity used by the experts. Therefore, the multi-granular information is unified by means of the transformation function between the levels of the hierarchy (Definition 3):

$$TF_{t'}^{t}(s_i^{n(t)}, \alpha^{n(t)}) = \Delta_{n(t')}\left(\frac{\Delta_{n(t)}^{-1}(s_i^{n(t)}, \alpha^{n(t)}) \bullet (n(t')-1)}{n(t)-1}\right)$$

Once we have chosen the common utility space to express the preferred design options we make uniform all the assessments into the BLTS. Some assessments are directly transformed into the BLTS because they are expressed in a term set with the same semantics, while the other assessments will be unified by means of the transformation function $TF_5^3(c_{ij}, \alpha), c_{ij} \in S_C$. For instance:

$$TF_5^9(SOMETIMES, 0) = (s_2^5, 0)$$

After this transformation process the assessments provided by the students are expressed by means of linguistic 2-tuples in the common utility space, BLTS. This process is applied to all the students' opinions.

B) *Aggregation Process*

This process combines the unified assessments of all the students to obtain a global evaluation value for each lecturer in a two-step process.

1. *Collective question evaluation value*: in this step is computed a collective evaluation, p_j,value for each question according to all the students. To do so, we propose the use of the weighted aggregation operator, $\bar{x}^e$, (Herrera and Martínez 2000), such that:

$$p_j = \bar{x}^e(p_j^i), i = 1,...,n$$

2. *Global evaluation value*: so far, we have a collective value, p_j, for each question, q_j. To obtain a global evaluation assessment, p, for the evaluated lecturer we shall apply another aggregation operator to the collective question assessments of all students. Now, we could consider that all the students are equally important (arithmetic mean) or we could assign different weights to each expert (weighted average).

$$p = \bar{x}^e(p_j), j = 1,...,m$$

3.3.3 Exploitation phase

Finally the decision process applies a choice degree to obtain a selection set of alternatives. Different choice functions have been proposed in the choice theory literature (Orlovsky 1978). The choice functions rank the alternatives according to different possibilities and from the ranking the best one/s are obtained.

In our problem the information is expressed by means of the linguistic 2-tuple representation model that has defined a total order over itself. Then we can rank the results using this order in the case we need to rank the lecturers, but usually in the evaluation process exposed the global evaluation value is useful result.

4 Studying the Satisfaction of Using Multiple Linguistic Scales in the Evaluation Process

So far, we have developed an evaluation model able to deal with multiple linguistic scales in the evaluation process, but an important question would be to know the satisfaction degree of the experts with this type of evaluation scales. Following we present the results of a survey about the satisfaction with the scales presented in the above section. To do so, in the following subsections we describe the survey and its results

4.1 Participants

The sample consisted of a fifty-five students of the M.Sc. in Computer Science at the University of Jaén. The reason to choose these students was that they have experience in this kind of assessment processes. The study was conducted during a session of 30 minutes during a class of the second semester. Eleven of them were women and forty-four were men. The age oscillated between 22 and 26 years-old and the average was 24 years-old. All the participants were volunteers and signed an informed consent.

4.2 Linguistic Response Format Satisfaction Scale

Participants completed 10 items that assessed their satisfaction with the format given to choose their answer. This scale includes five statements referring to a questionnaires that asked for participants' consideration grade about:

1) Valuation Reflection Thought ("With which grade do you think that the response format given in the questionnaire one/two can reflect properly your valuation?")
2) Question Appropriation ("With which grade do you think that the response format given in the questionnaire one/two can be appropriate for the question?")

3) Response Format Satisfaction ("With which grade are you satisfied with the response format given in the questionnaire one/two?")
4) Valuation Reflection Feeling ("With which grade do you feel that the response format given in the questionnaire one/two can reflect properly your valuation?")
5) Valuation Satisfaction ("With which grade are you satisfied with the valuation that falls down from the answers you have given in the questionnaire one/two?")

The Cronbach Alpha Coefficient for this global scale was is $\alpha = 0.51$, what is logical because items about the questionnaire were included. When items were divided into two groups for the questionnaire, the Cronbach Alpha Coefficients were really good. Specifically, the Cronbach Alpha for Questionnaire was $\alpha = 0.86$.

4.3 Questionnaire of Students' Satisfaction with the lecturer work (Linguistic Scales)

This Questionnaire measures the students' satisfaction with the lecturer work. It consists on 27 items with a response option that belongs to multiple linguistic scales as it has been showed in Table 2. Some of these items were "The program includes useful references for the subject" (item 3), "The lecturer uses didactic resources" (item 19), and "The lecturer answer to students' intervention with interest" (item 26). The Cronbach Alpha Coefficient was *0.85*. If we compare this result with similar surveys dealing with numerical scales in which the Cronbach Alpha Coefficient was *0.80*, we can say that we have presented a evaluation model able to model the uncertainty with a suitable approach as the fuzzy linguistic approach that it is able to deal with multiple linguistic scales in a precise in order to manage the different degrees of discrimination that can be appear in this type of problems and that this idea is good accepted by the experts that take part in the evaluation process.

5 Concluding Remarks

In this contribution, we have faced to evaluation problems that evaluate aspects, parameters or indicators qualitative in nature. This means that the knowledge about them implies uncertainty and vagueness. Therefore, we have presented an evaluation model that models this type of information by means of the fuzzy linguistic approach and additionally it is able to deal with evaluation problems defined in multi-granular linguistic contexts. This model is based on a decision analysis method that has been applied successfully in

problems dealing with multi-granular information because it uses the 2-tuple linguistic model and the linguistic hierarchies.

Finally we have presented some results about a survey to know what is the satisfaction of the experts with regards the use of multiple linguistic scales in the evaluation process.

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