

COMPUTING PROJECT  
**COMPUTER SCIENCE ENGINEERING**  
**SURVEY QUALITY SYSTEM**

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## 1. Outline

With Intention to automatize the process of quality evaluation of the university teachers, it is intended to develop a system with capacity to offer a bigger flexibility of expression to the students and to all make the management of the evaluation process. The most important innovative factor of this implementation is that is capable to deal with some domains of information using diffuse techniques of management and models of decisions making multi-expert.

A further detail of the theoretical background that has been used to develop this system can be seen in further detail in the appendix I.

## 2. Objective

We want to develop a system evaluation of the teachers quality that deals with fuzzy techniques of management and models of decision making multi-expert. So we are going to use a Java platform and a data-base system of management. Our objective is to divide the application in five distinct modules that are:

- Survey Editor
- Survey Filler
- Survey Aggregator
- Database Management
- Average Results

Survey Editor: The objective is to create surveys with the possibility to be answered for the students with four types of answers: Numeric, Interval, Linguistic, Enumeration.

Survey Filler: This module will previously allow to the students a good interface for the fulfilling of the surveys, using the four types answers spoked before.

Survey Aggregator: This module will allows an easy and fast visualization of the results survey concerning a teacher. The visualization will be made in four ways:

- To visualize all the answers of each survey
- To visualize the average of answers of all the surveys of one teacher in each question
- To visualize the averages for type of question of an survey
- To visualize the average of answers for type of questions of all the answered surveys

Database Management: This module will permit a good database management, being able to create, to modify and to delete registers of students, subjects and teachers.

Average results: This module allow a numerical and graphically visualization of the averages answers of the surveys. This module still allows numerically to visualize the results of the standard deviation of the survey answers to each question.

### **3. System Analisis**

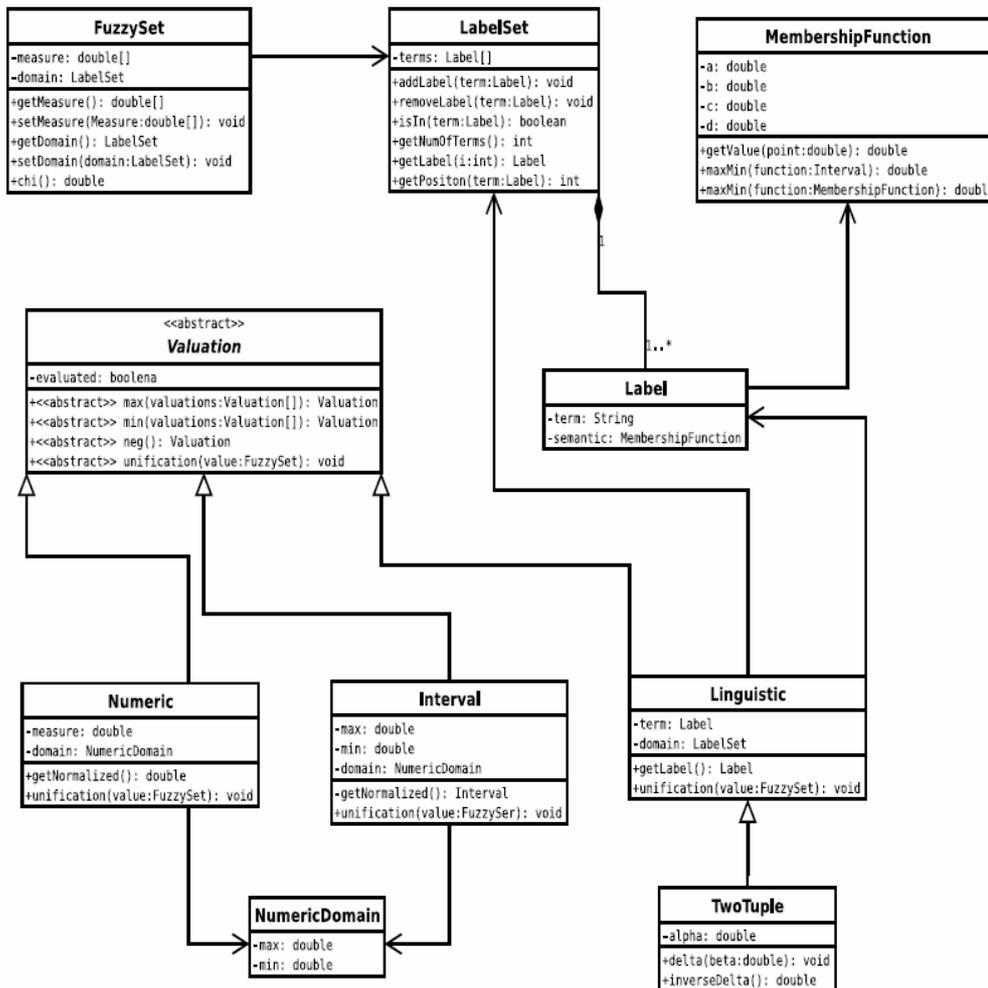
#### Programs used to develop system

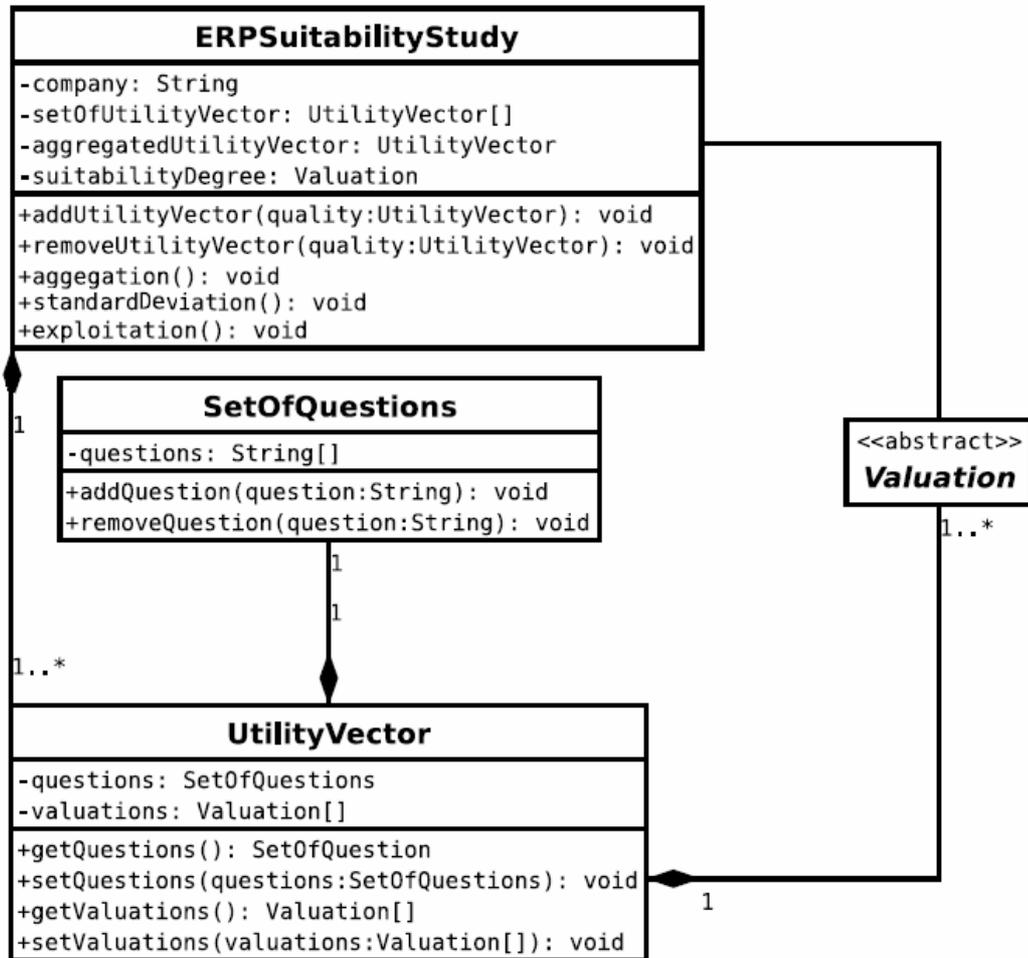
JBuilder X enterprise v 10.0.176.0  
BlueJ v 2.0.1

#### Minimum System Requeriments to run program

CPU Intel Pentium IV.  
Virtual machine JAVA 1.4.2.  
Minimun 60 MB Hard disk space needed.  
40 MB to JAVA virtual machine if you don't have yet.  
20 MB to the aplication "Calidad Docente".  
256 MB of RAM.  
Windows XP o Windows 2000 Operating System.

### 4. UML Diagrams





## 5. Initial Interface

Here we show the initial interface of the application that allows us to use the different modules of the system developed.

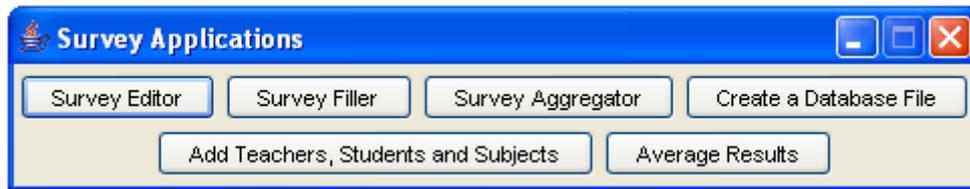


Figure 1: Survey Application

## 6. Data Base Management

The application must manage the data of the teachers, students, surveys and results involve in the quality evaluation. Although it is necessary that Database have been well created and managed from the beginning to be able to work with the rest of the application.

When the application is executed, looks for database file by defect in a folder called database. The database file loads by defect is: EDUCATIONALQUALITY.JDS. If the application cannot find the file or is damaged, it will show a dialogue box similar of figure 2 that will allow to select manually the database file we wish.

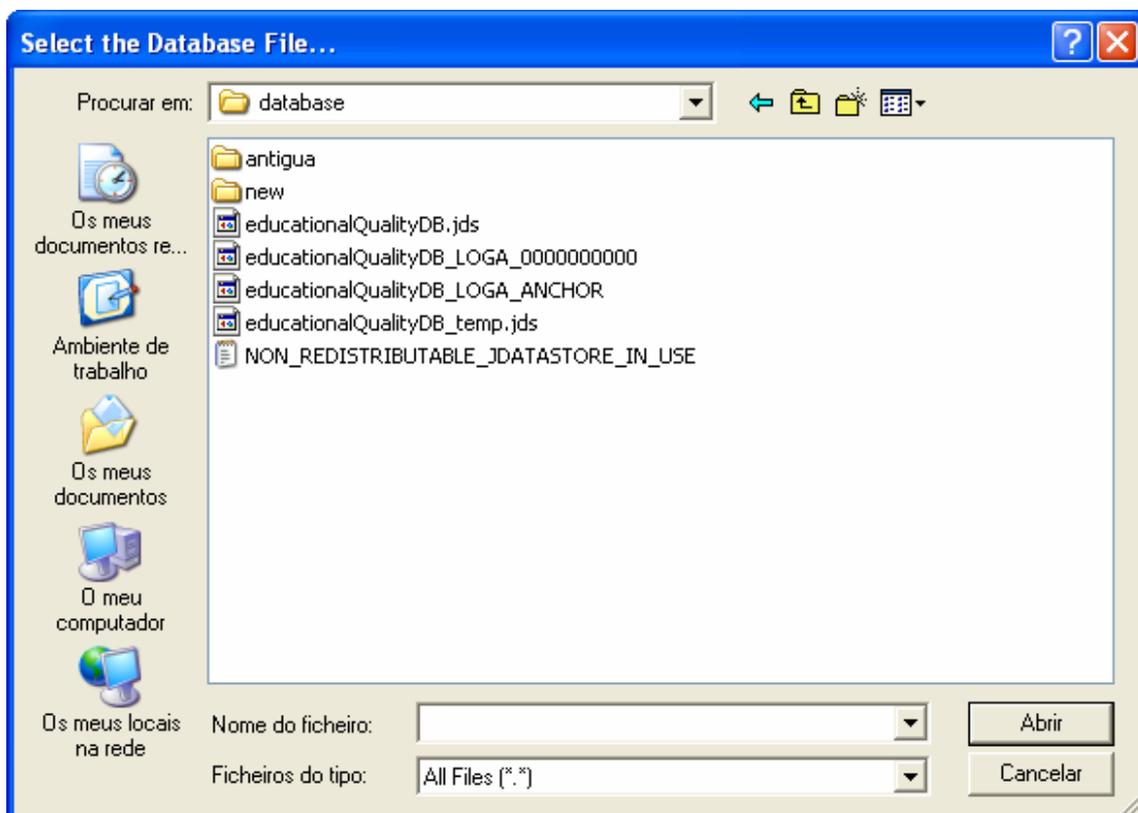


Figure 2: Database file selection

If we don't select a database file, the program will create one by default in the directory database but this will be empty.

The different modules from our application will use a single database file. During the execution of each one of the modules we will be able to select a new database file. We will only have to press in the menu bar in each one of the modules the option "Database" and will appear a dialogue box similar to the figure 2 to select our new database file. Once it has been selected, the new file will be used by application from that moment until it becomes to select another one.

### 6.1. Create a Database file

As we have already said before, the application will use by default a database file where it will store all the information. But also we have the possibility to create new database files. It only be necessary to press in the button "Create a Database file" like in figure 1. Once we pressed that button will be appear a dialogue box similar to the figure 2. We need to give a name to the new database file and choose a folder where it will be stored. We pressed the button "Save" and the database file will be created empty in the indicated folder and will be ready to be used in our application from that moment.

### 6.2. Database file Management

Our application needs data in the database. The data will be about the teachers, subjects and students that are involved in evaluation. In order to store this information in the database we have designed the following tables:

Teachers: Store the data of each teacher involved in the quality evaluation.

Subjects: It stores the evaluated subjects.

Students: It stores the students that will evaluate the teachers.

Teachers - Subjects: this table have the relation between teachers and subjects. Only for this version, we assume that there is no more than one teacher to each subject.

table of Students - Subjects. In this table we have the relation of the students with the different subjects in which he are registered. This information is used to control the surveys that a student must fill up. Once a student has completed all the surveys for each one of the subjects in which he is registered, no longer will be able to return to fill up the survey anymore.

In order to access to these tables of the database we must press the button "Add Teachers, Students and Subjects" that is in figure 1. It will appear a window similar to the figure 3. In such a table we will be able to add, delete and to move the data from our database.

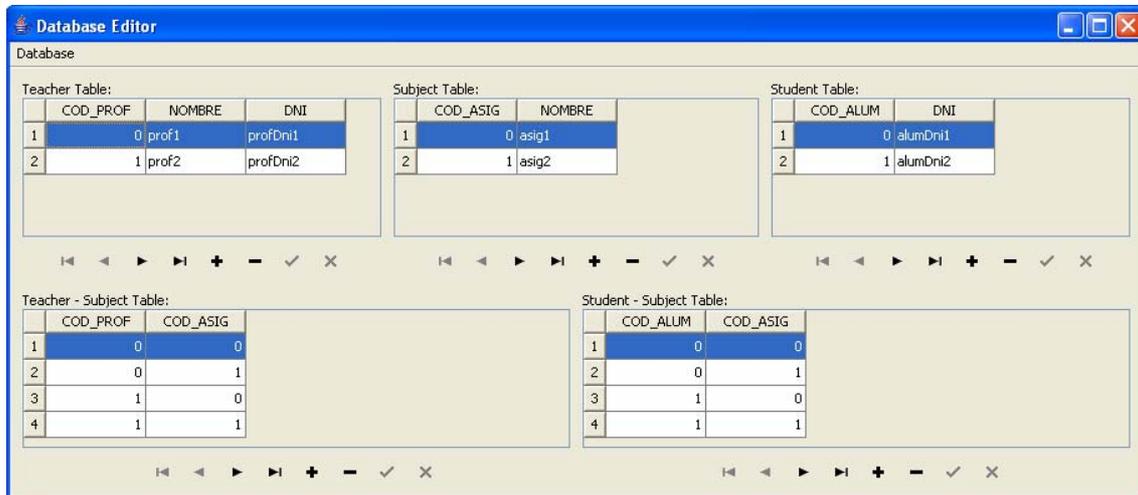


Figure 3: Database Editor

### 6.3. Surveys Management

Now we are going to describe the modules that allow to create and to respond surveys. The module survey will be accessible to the students who will be responsible to fill up these surveys of the educational quality.

## 7. Create Survey

This module will allow to create a survey to the expert personnel for the accomplishment of the questions relative to the evaluation of the Teachers Quality. We can see in figure 4 the interface window.

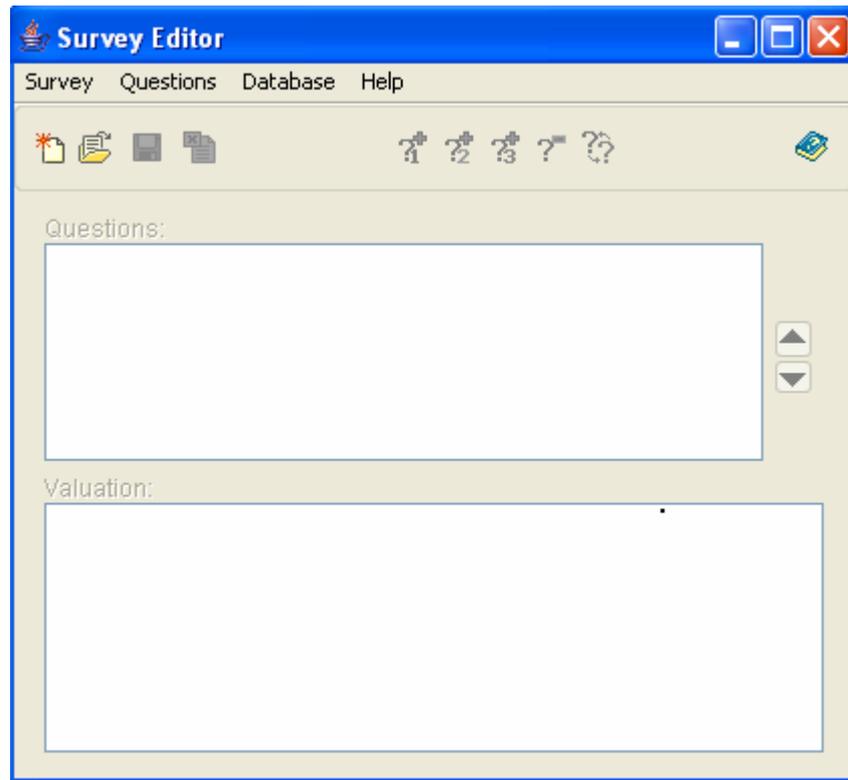


Figure 4: Survey Editor Window

Once we are in the module to create survey, we press the button  to create a new one, or if we have stored in the database and want to complete it or to modify, we press the button  . If we press in the button  it will appear a window similar to the shown one in figure 5.

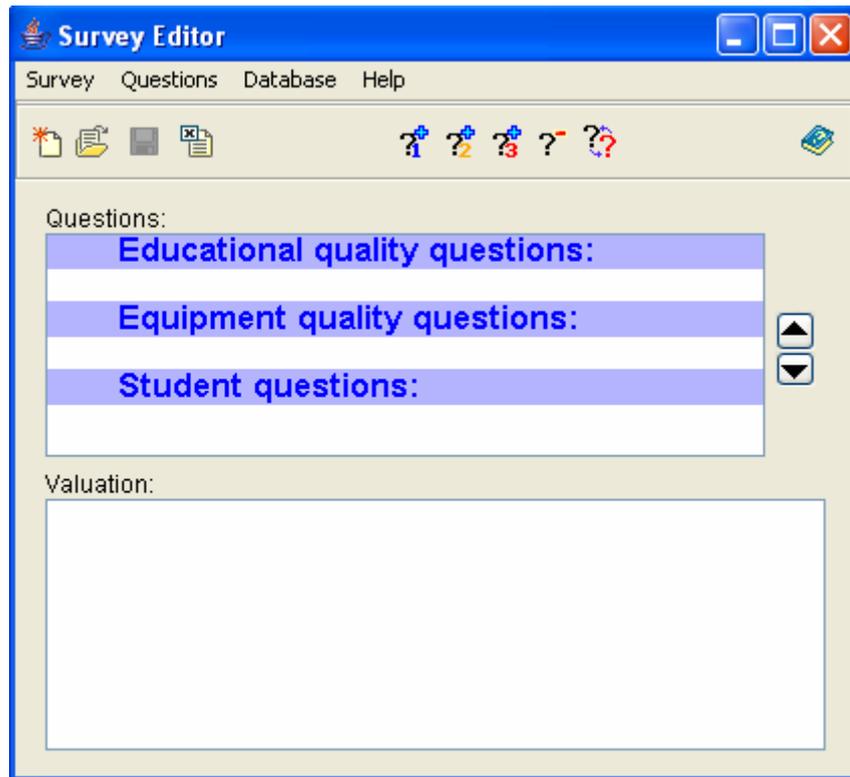


Figure 5: New Survey

if we use a survey already created, it will show the window that we can see in figure 6.



Figure 6: Open Survey

Here we could select any survey that was stored in the database and will appear a window similar to figure 7. Once we have begun to create a survey or to modify a existing one, we will be able to add questions or to modify them. We remembered that the implemented survey is divided in 3 parts, one for questions related to the teaching, other for questions related to the equipment and last for questions related to the students.

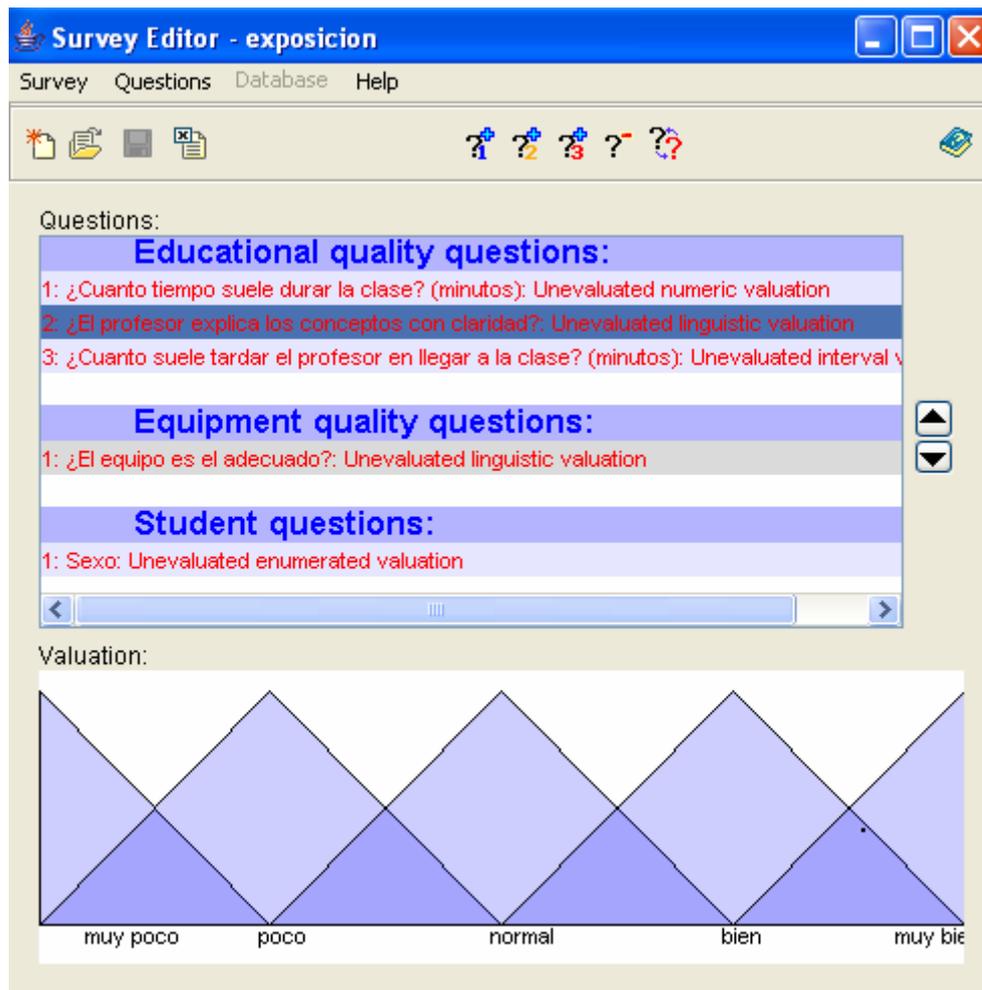


Figure 7: New Survey with questions

In order to insert the questions in some of these categories we have three buttons to add questions related to the teachers , to add questions related to the equipment , and to add questions related to the students . Also we have the possibility of erasing a question  or modifying it .

### 7.1. Insert Questions

When we want to add a question we will press on the corresponding button of the group and will appear the window shows in figure 8.

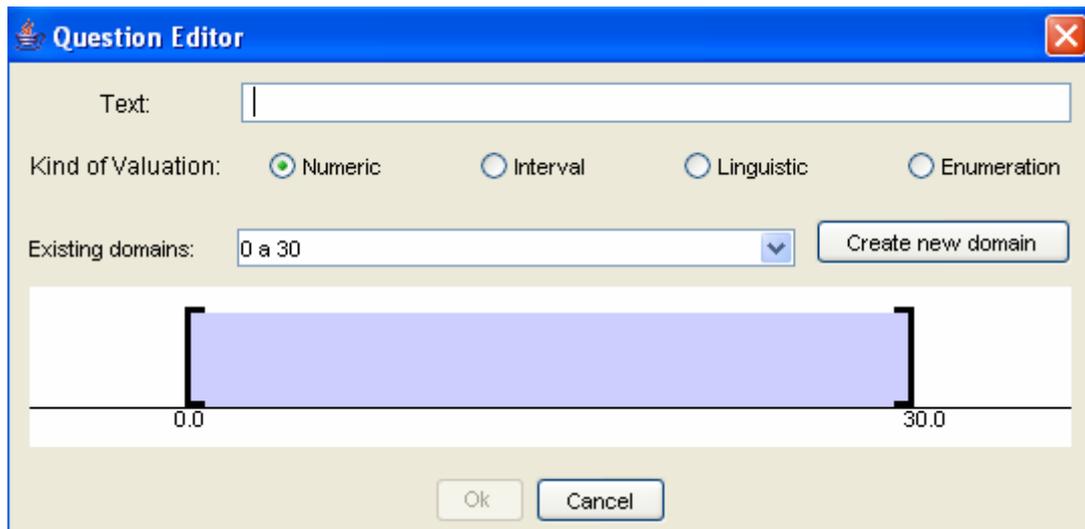


Figure 8: Question Editor Window

In this interface we will introduce the question, the information domain where it will be evaluated (numeric, interval, linguistic, enumeration or we will be able to create one new one if the existing ones do not adjust to our necessities. All it is in figure 9.

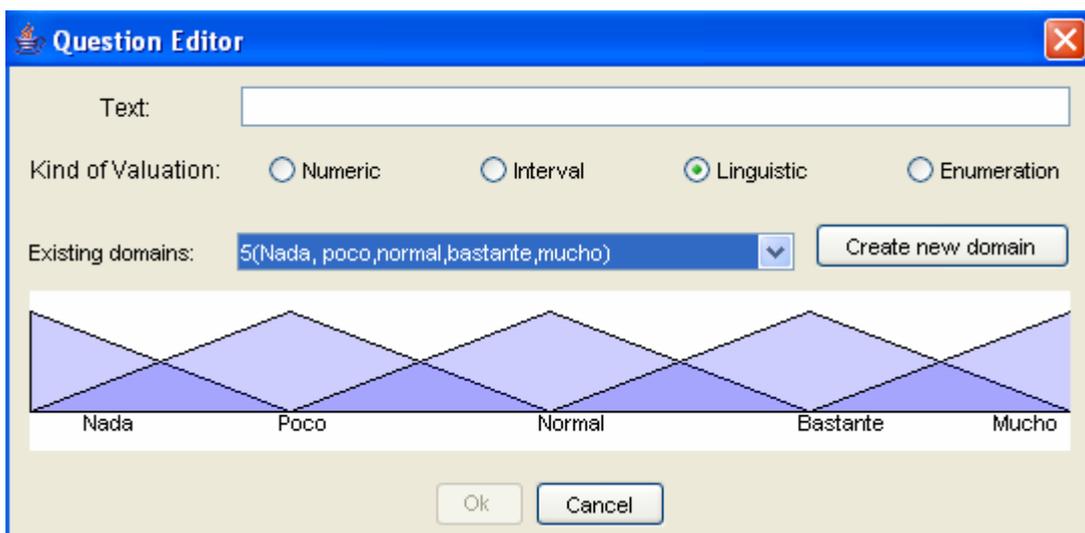


Figure 9: Question Editor with Linguistic Domain

If we do not have an expression domain where a question can be evaluated, we can create a new one by pressing the button "create domain" and will be appear a window like in the figures 10(numeric), 11(interval), 12(linguistic), 13(enumeration) depending on the expression domain which we have selected. In a interval or numeric domain, the window that will appear to us allows to introduce the limits superior and inferior for this type of values corresponding to the current question. We will have to give a domain name and this one was stored in the database file.

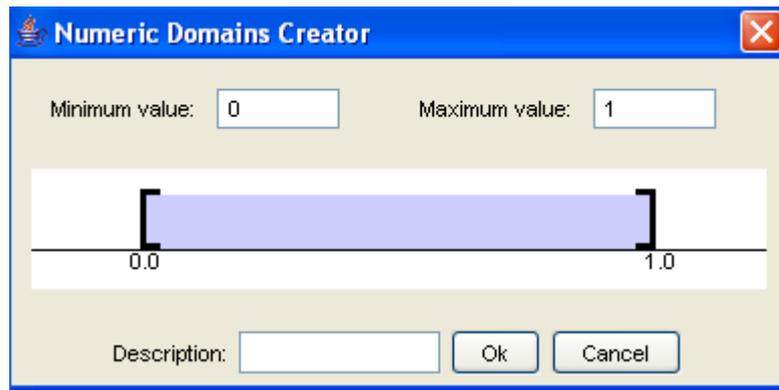


Figure 10: Numeric Domain Creator Window

For linguistic domains, We will have to choose their number of labels, always an number, and then press the button "create". Once fact this will be a graphical representation of the labels that triangular and uniformly distributed. We can give a name to each label selecting it with the mouse and in addition we will be able to give values to the different parameters until adapting the fuzzy set diffuse that represents the label according to our necessities. In order to finish we will put name to the domain for its storage in the database file.

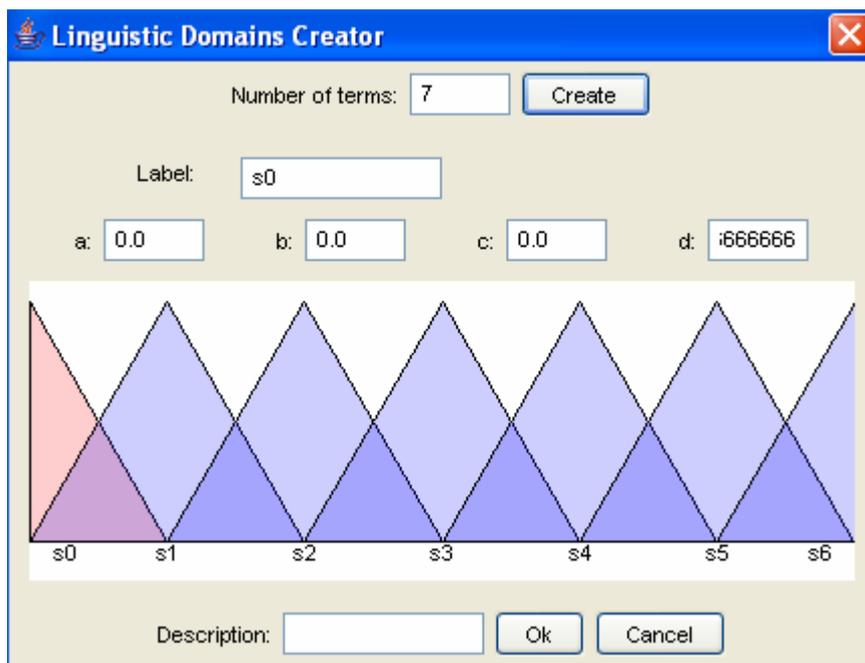
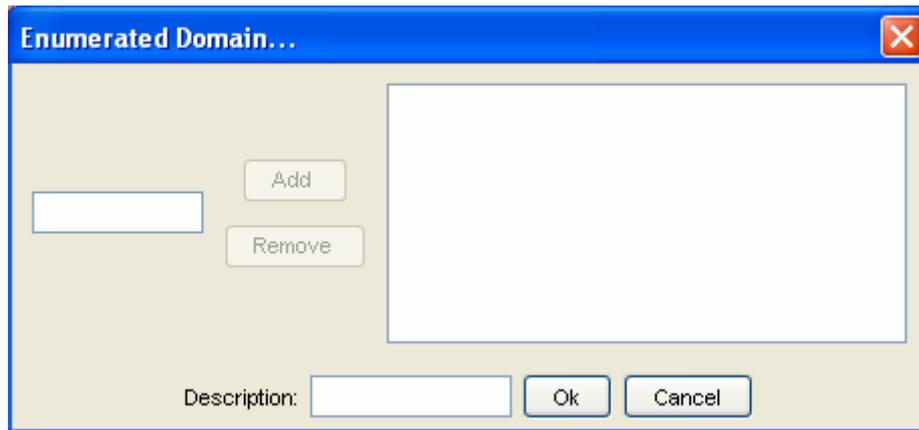


Figure 11: Linguistic Domain Creator Window

For values that represents only by a set of labels whose meaning does not have possibility of interpretation, for example, man or woman. We needed to create domain where these labels take shelter. Just writing the label and adding it to the set. When we finish we will give name him to the domain for its storage in the database file.



The window is similar to the one for creating a question of the survey unless it already has values for all its elements. We can modify any of them and press the button "OK" and the changes they will be stored. Once we have completed all the survey we will have a screen similar to which is in figure 12:

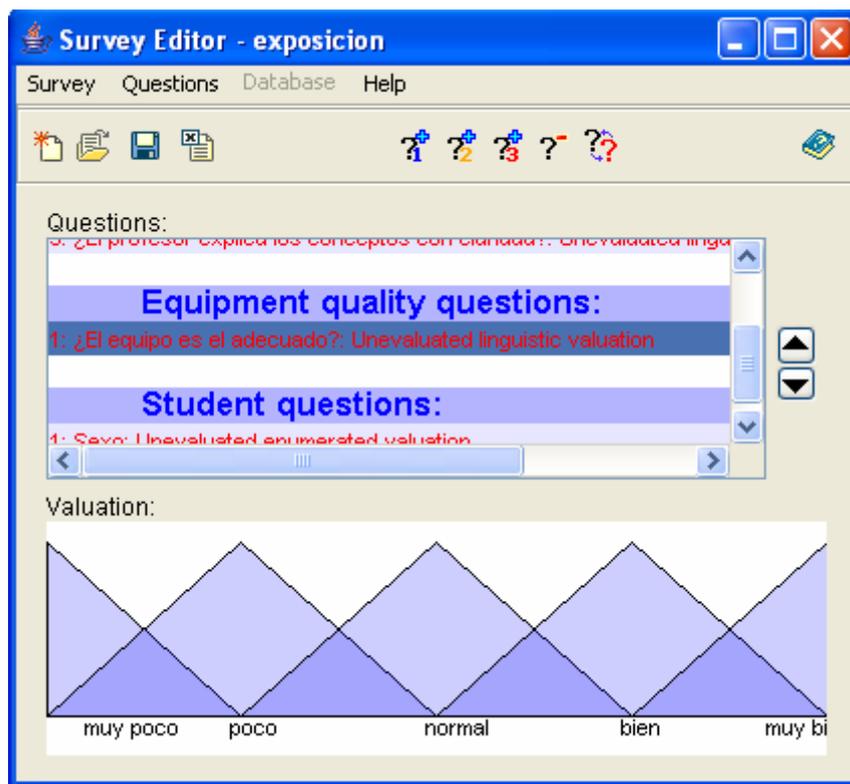


Figure 12: New Survey

We just only need to save the survey with a name and will be stored in the database file.

## 8. Survey Filler

We will now describe the module that allows to fill up the data of a survey that is stored in the database file. This is the module that the students in the database file will have to execute for being able to complete a survey. In order to respond the survey, the student will have to press the button "Survey Filler" of the main window(Figura 2)", being immediately following window(Figura 13).

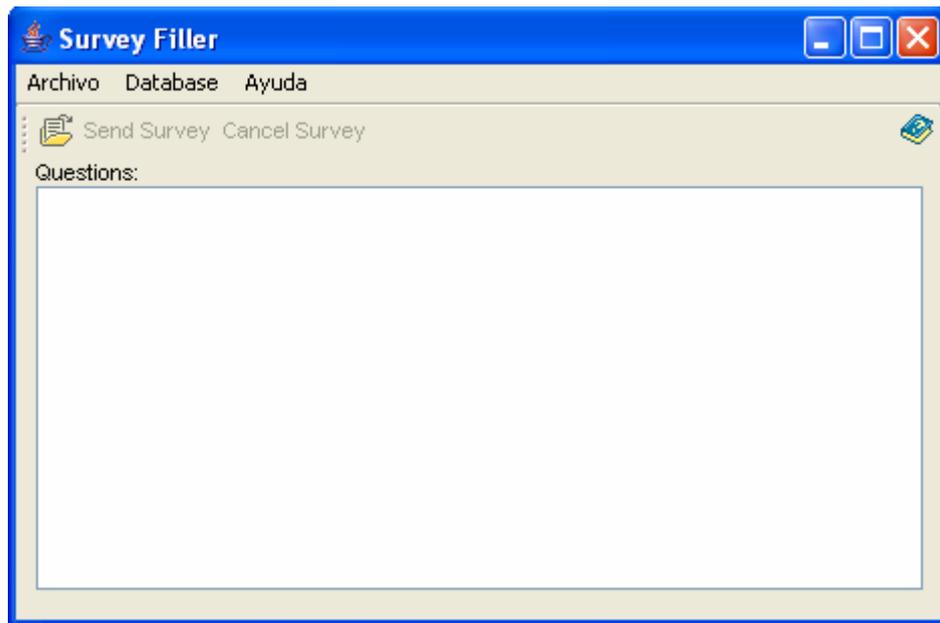


Figure 13: Survey Filler Window

In order to avoid that a student can answer the same survey several times, the application does not allow a student to evaluate more than once the survey for same teacher-subject. In this way we are assuring the reliability of the obtained results. Next we will describe the operations to make in this operation:

- a) First it must be chosen the survey that is going to fill up in icon "Open". Immediately it will appear a new window in which the user will have to identify itself and choose an option related to the subject and teacher to evaluate.

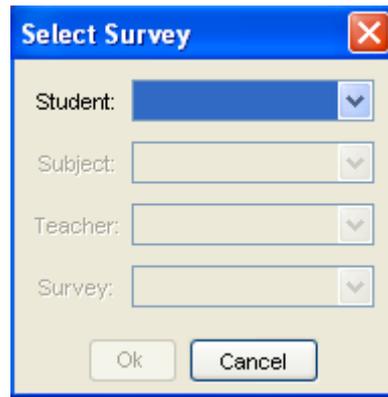


Figure 14: Survey Selector

- b) After the identification of the student, it must be successively selected the subject, the teacher and the name of the survey that will be filled up (figure 15).

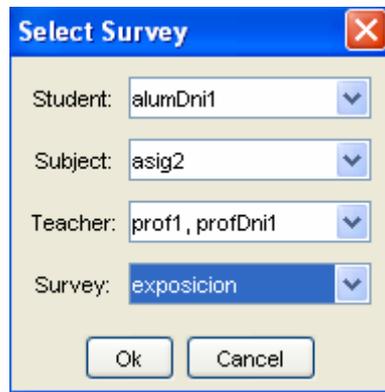


Figure 15: Survey Selector filled up

- c) Finally, to fill the survey, the student will press the button "OK", and will appear the window of the survey selected (Figure 16).

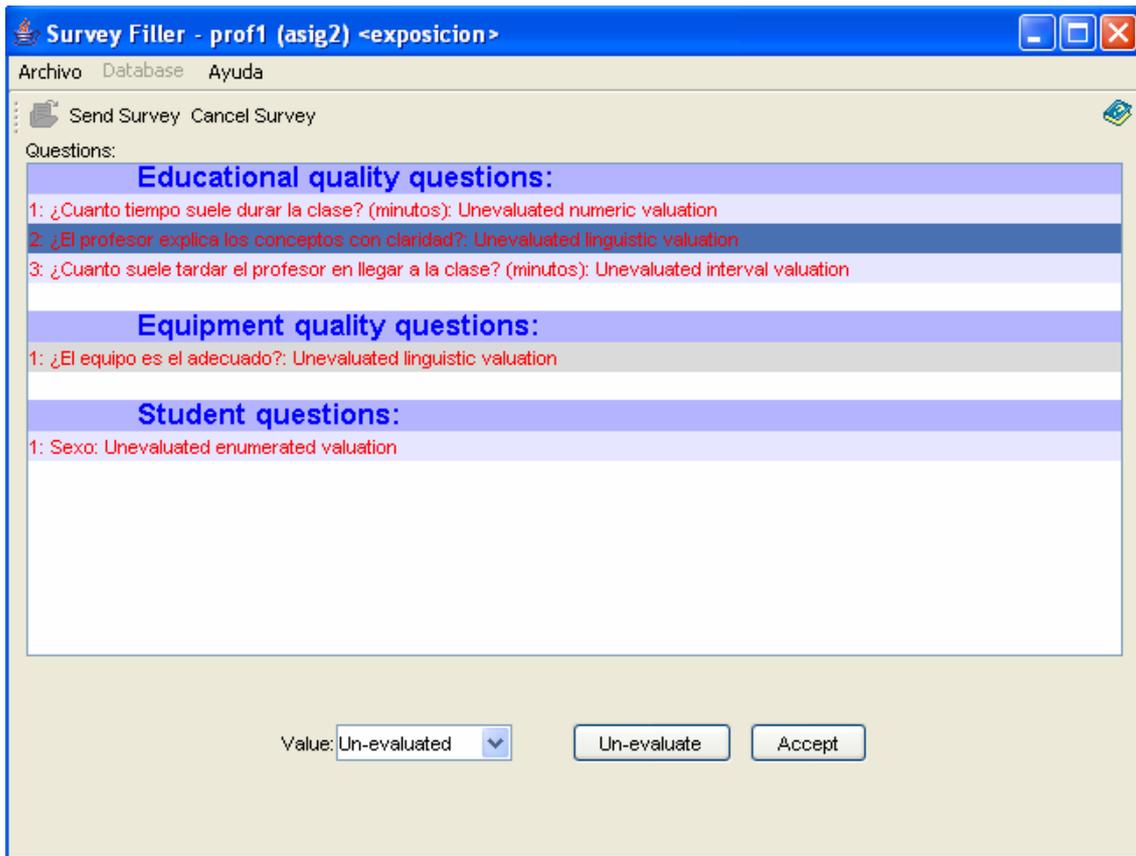


Figure 16: Survey Filler Window with Survey

In figure 17 we can see the window that shows to the content of the survey as well as a serie of buttons. In this window we can identify three different zones:

Buttons to send (to store it in the base of data) or to cancel a survey.



Figure 17: Survey Filer Options

They are in the top of the window and as their name indicate are used for once answered all the questions of the questionnaire, this information is sent(Send Survey). In opposite case it is possible to cancel this survey and to return to fill up it at another moment(Cancel Survey).

b) Questions to fill up. In the middle of the window the different questions of the survey are enumerated in different categories.

c) Evaluation of the questions. Located in the bottom of the window, it appears a select box list and two buttons to each question. After the student selects the evaluation value according to the type of question which it is answering, the user must press the button "Accept" so that its valuation has effect. If he wishes do not evaluate a question, has to press in the "Un-evaluate button".



Figure 18: Survey Filler evaluate question

Depending on the nature of the questions, in the survey they can be used up to four types of answers: numeric, interval, linguistic or enumeration. When the user selects a question that hasn't been answered (she appears outstanding in red color), the application identifies the type of question and presents/displays in the take offable list "Value" the rank of suitable answers this question, that can be one of the following ones:

#### 8.1. Answer numerically evaluated question

In the bottom of the window it will appear a graphical representation of the question domain. it will appear an interval where the limits represent the allowed values minimum and maximum for answering the question. The user will use the mouse to mark a specific value within the interval or the keyboard to introduce a valid numerical value in the field "Value" (figure 19). The button "UN-evaluate" will allow us to eliminate the value for the question that appears in the field "Value".

The screenshot shows the 'Survey Filler' application window. The title bar reads 'Survey Filler - prof1 (asig2) <exposicion>'. The menu bar includes 'Archivo', 'Database', and 'Ayuda'. Below the menu bar, there are buttons for 'Send Survey' and 'Cancel Survey'. The main area is titled 'Questions:' and contains three sections:

- Educational quality questions:**
  - 1: ¿Cuanto tiempo suele durar la clase? (minutos): Unevaluated numeric valuation
  - 2: ¿El profesor explica los conceptos con claridad?: Unevaluated linguistic valuation
  - 3: ¿Cuanto suele tardar el profesor en llegar a la clase? (minutos): Unevaluated interval valuation
- Equipment quality questions:**
  - 1: ¿El equipo es el adecuado?: Unevaluated linguistic valuation
- Student questions:**
  - 1: Sexo: Unevaluated enumerated valuation

At the bottom of the window, there is a numeric scale from 0.0 to 90.0. A vertical red line indicates the current value of 52.688. Below the scale, there is a text input field labeled 'Value:' containing '52.688'. To the right of the input field are two buttons: 'Un-evaluate' and 'Accept'.

Figure 19: Answer numeric question

Finally, it will have to press the button "accept" to assign the selected value to the question. If we saw the question that we have answered, it is possible to be verified since it has changed of color and at the end of the statement of the same one to the selected value and the valid rank have been added.

## 8.2. Answer a question evaluated with intervals

The answer of this type of questions is characterized because the user settles down a rank of values, characterized by his minimum and maximum value, as answer to a specific question. This type of answer is used for quantitative indicators on which the knowledge is not precise, and the user feels more comfortable expressing it of this form.

Figure 20: Answer interval question

In the button "accept" to assign the selected value to the question. The evaluated button will not allow us to eliminate the value for that question.

### 8.3. Answer an evaluated linguistic question

For this type of questions, the window will show in the bottom a take offable list with the possible valid linguistic values for the selected question (Figure 21). The user will select the wished value and will press the button "Accept" so that it is registered. Also he will be able to establish the answer like not evaluated pressing the buttons "Un-evaluate" and "Accept".

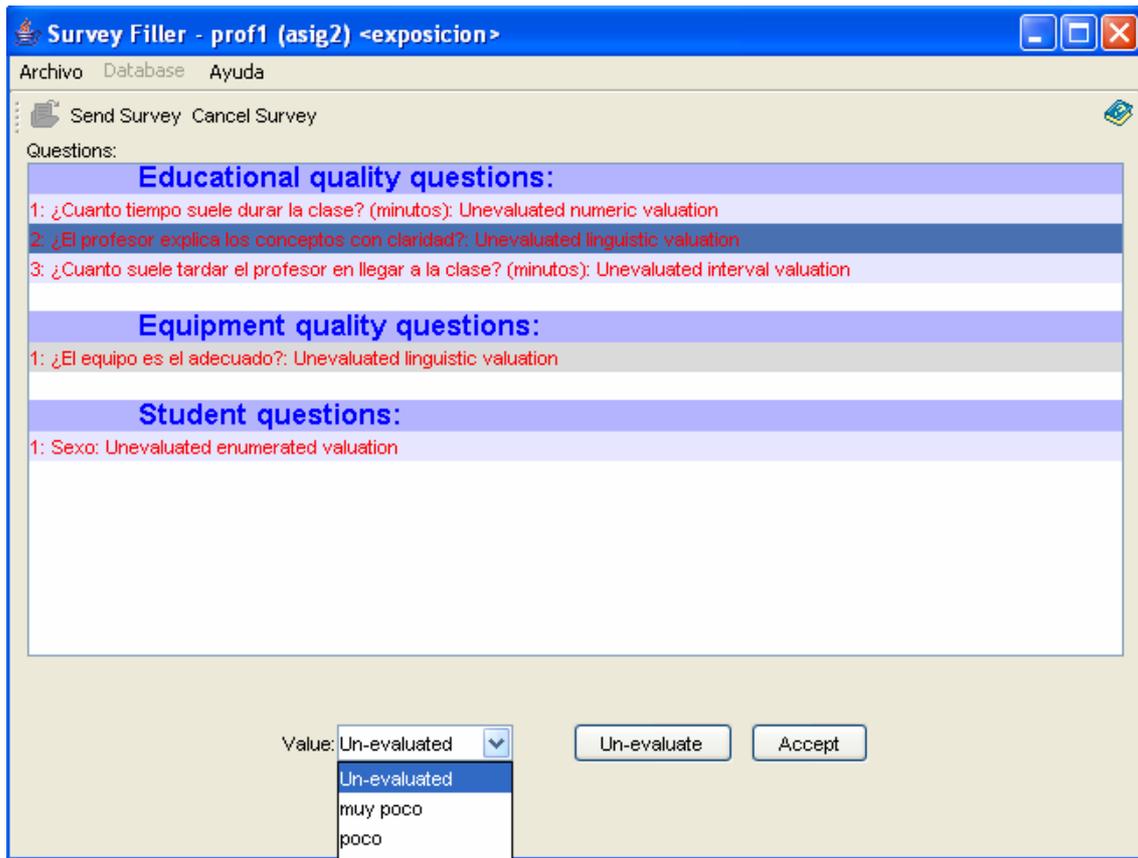


Figure 21: Answer linguistic question

#### 8.4. Answer an enumerated question

The last class of the type of answers that can be used in a questionnaire is the enumerated ones. This case is similar to the questions linguistic with the difference that they only admit two possible answers of the type True/False or Yes/No. In the inferior part of the window we can see the possible values, selecting itself one of them. Like for the rest of answers, it is necessary to press the button "Accept" so that the answer is registered. Also the question can be left like not evaluated pressing the buttons consecutively "UN-evaluate" and "Accept".

#### 8.5. Send or cancel the survey:

Once we have filled to all the questions, we must keep the results in the database, pressing the button "Send survey". If by some reason the user tries to leave this module without sented the survey, will appear a message informing this situation and asking the student if he wants or not to send the survey (Figure 22).



Figure 22: Sending Survey

## 9. Results Evaluation

The objective of this module of the application is the calculation of the survey results filled up by the students. We can see different views or forms from presentation of the results. The person or groups of people in charge to analyze the results of the surveys has a very useful tool to know general or specific values of the evaluation. Next we will describe the different options and operations related to the results from the surveys. In order to enter this module of the application, the user has to press the button "Aggregated results" that appears in figure 1, appearing the following screen (Figure 23):

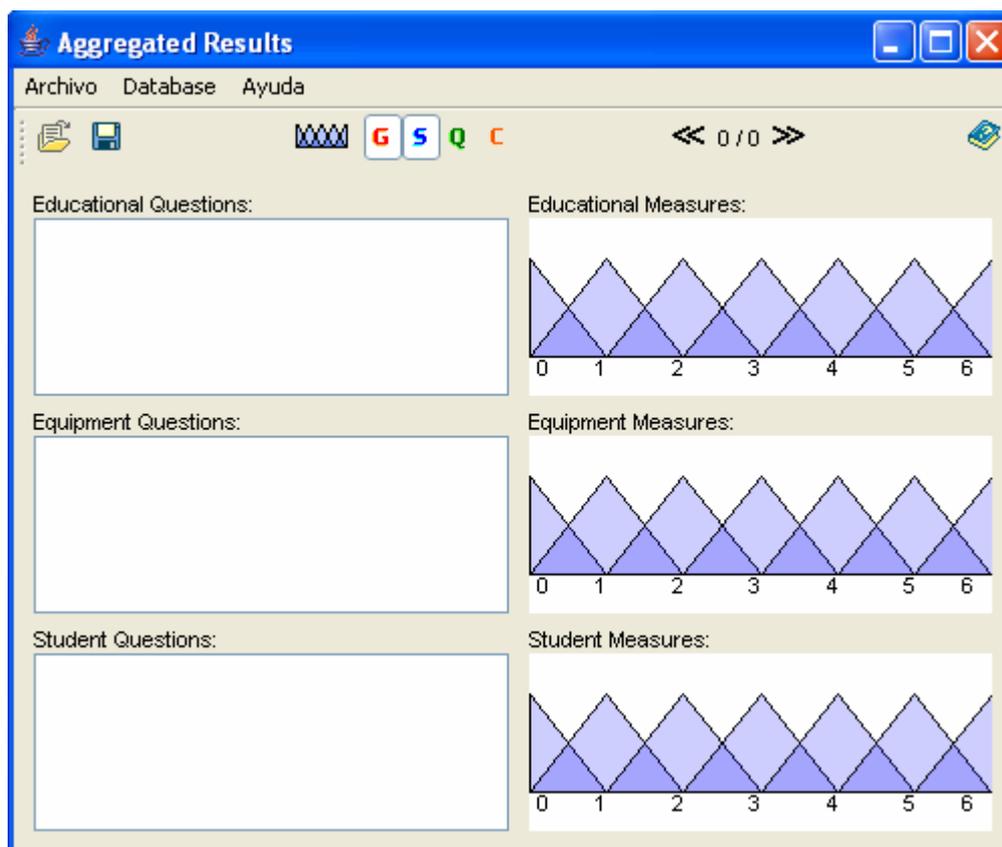


Figure 23: Aggregated Results Window

## 9.1. Open Survey

The first operation to make is open the survey model that we wish to consult. We have to consider that each model of survey is identified from three fields : subject, teacher and the name of the survey. When pressing on the icon "Open file" , the application visualizes a window (Figure 24) where the user must select the values of the previous fields.



Figure 24: Open Survey

If for the combination of the values of these three fields surveys answered by the students exist, will appear the window of figure 25 with all the information referring to this survey.

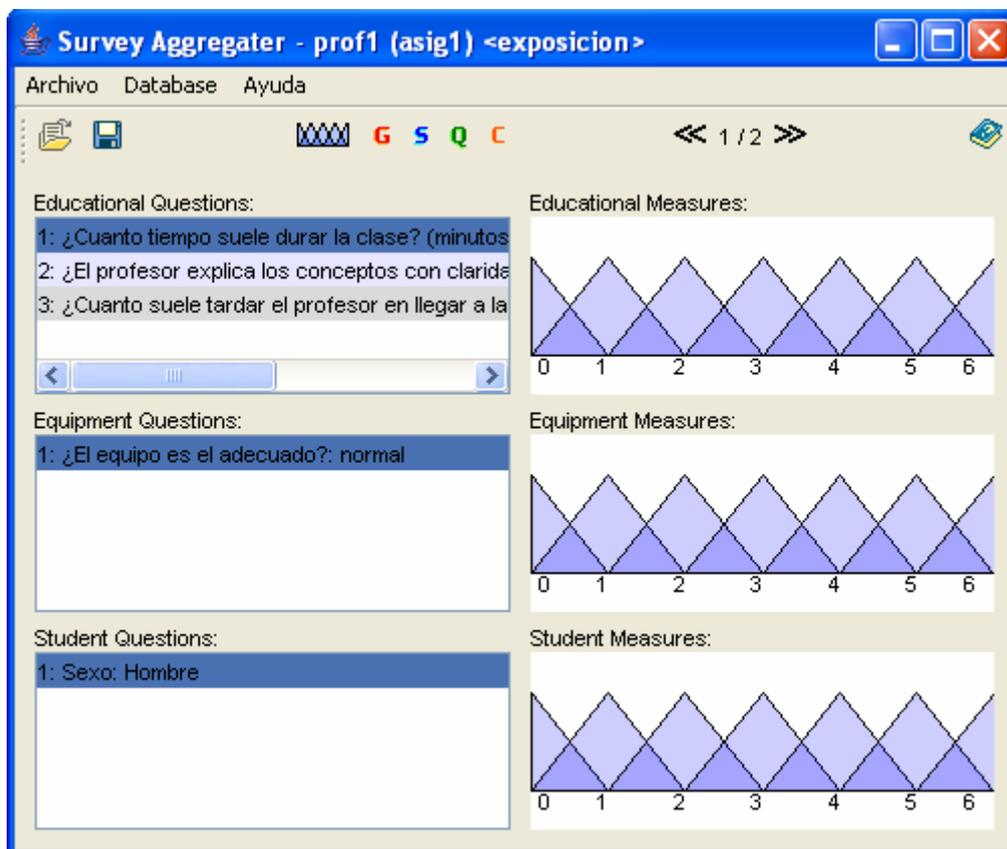


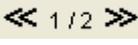
Figure 25: Aggregated Results Window with Survey

In this window we can emphasize two parts:

a) Selection of criteria to visualize: In the top of the window they appear several icons that allow to select the type of information that we want to consult.

b) Presentation of results: The middle of the window composes by a side the questions that part of the survey model forms that is being consulted next to a graphical representation in which the different values obtained from the selected criteria will appear visible. The details of each one of these parts will be commented in the following sections.

Present survey/number of total surveys

In the bottom of the window, they appear the icons , that they indicate the number of survey we can see at this moment in the window as well as the total number of surveys available for the subject - to teacher that we are evaluating.

Criteria Selection

The set of icons  allows to visualize the results of the surveys from different points of view.

Global valuation of the survey : It represents the global value of each one of the sections that compose the model of survey obtained from all the surveys. It does not depend the present survey neither the question selected then.

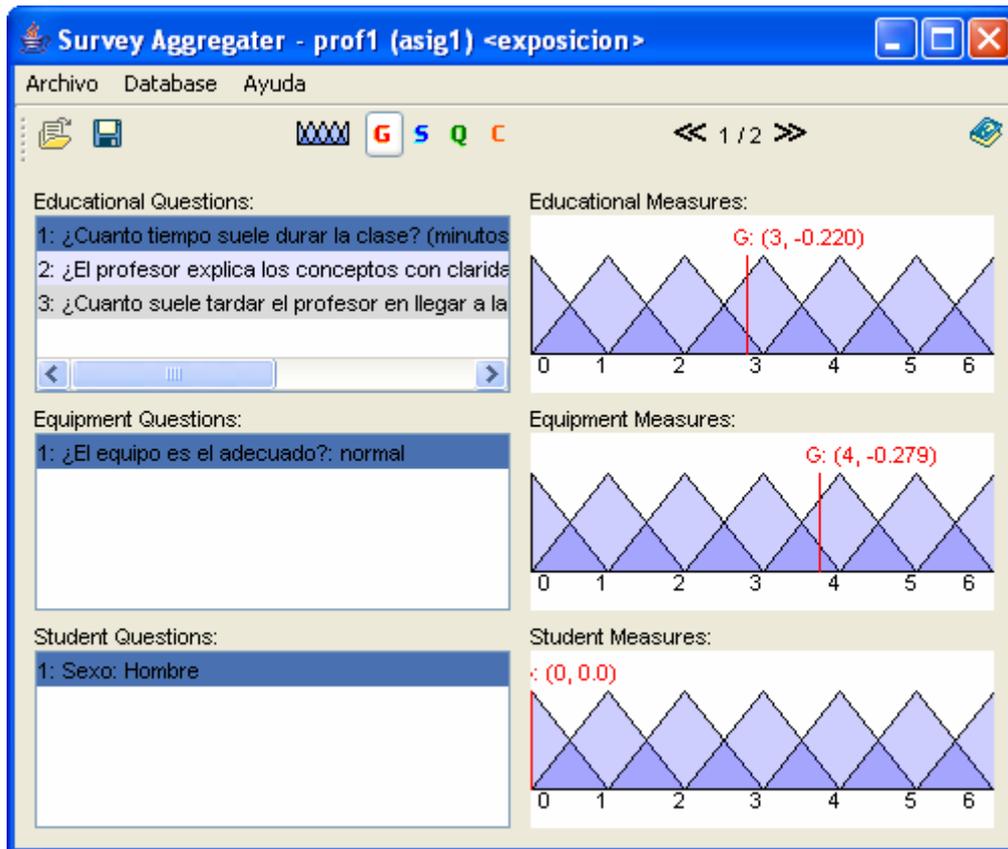


Figure 26: Survey Aggregator Global Results

Valuation of the present survey **5**: It only shows the global measurement but considering a single survey. The one that appears then. It does not depend on the question selected. In order to consult the rest of answered surveys, it can use the buttons respectively "previous Survey" and "next Survey".

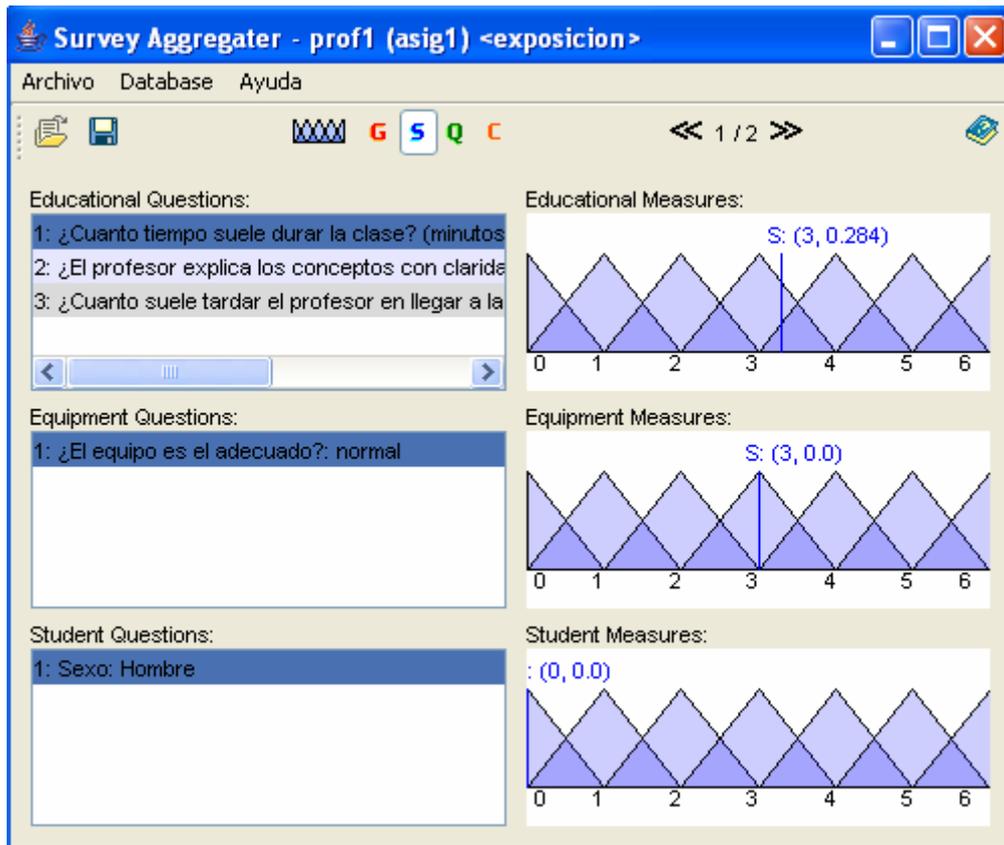


Figure 27: Survey Aggregator Survey Results

Global valuation of each question (added all the surveys) **Q**: It represents the global value of each question that composes the different sections obtained from all the surveys. It does not depend on the present survey. Selecting each question will be visualized the corresponding global values.

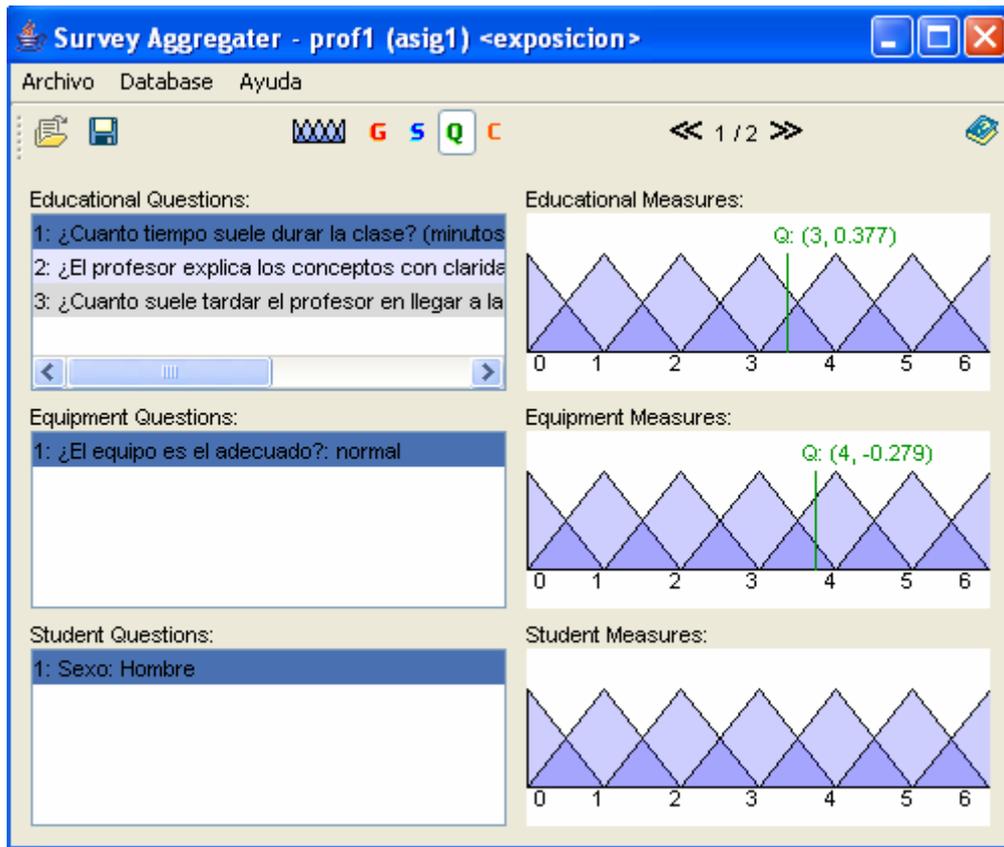


Figure 28: Survey Aggregator Question 1 Results

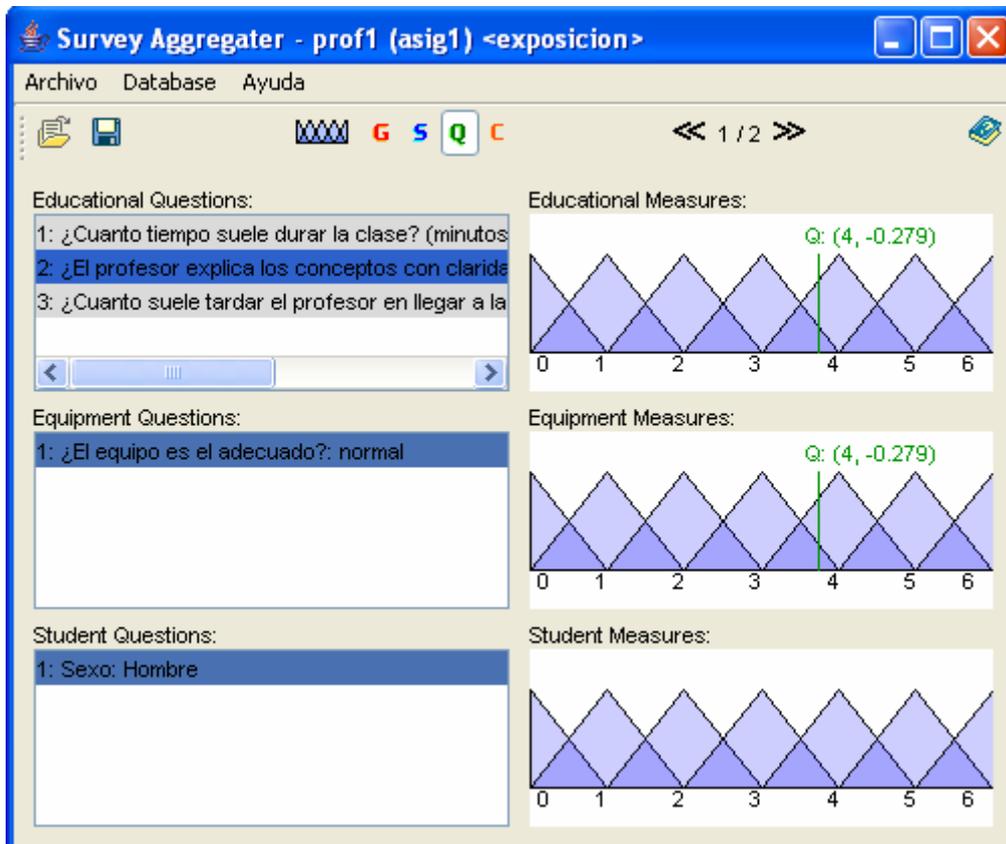


Figure 29: Survey Aggregator Question 2 Results

Local valuation of a question **C**: It represents the value of each one questions of the present survey. Selecting each one of the questions they will be visualized the corresponding local values.

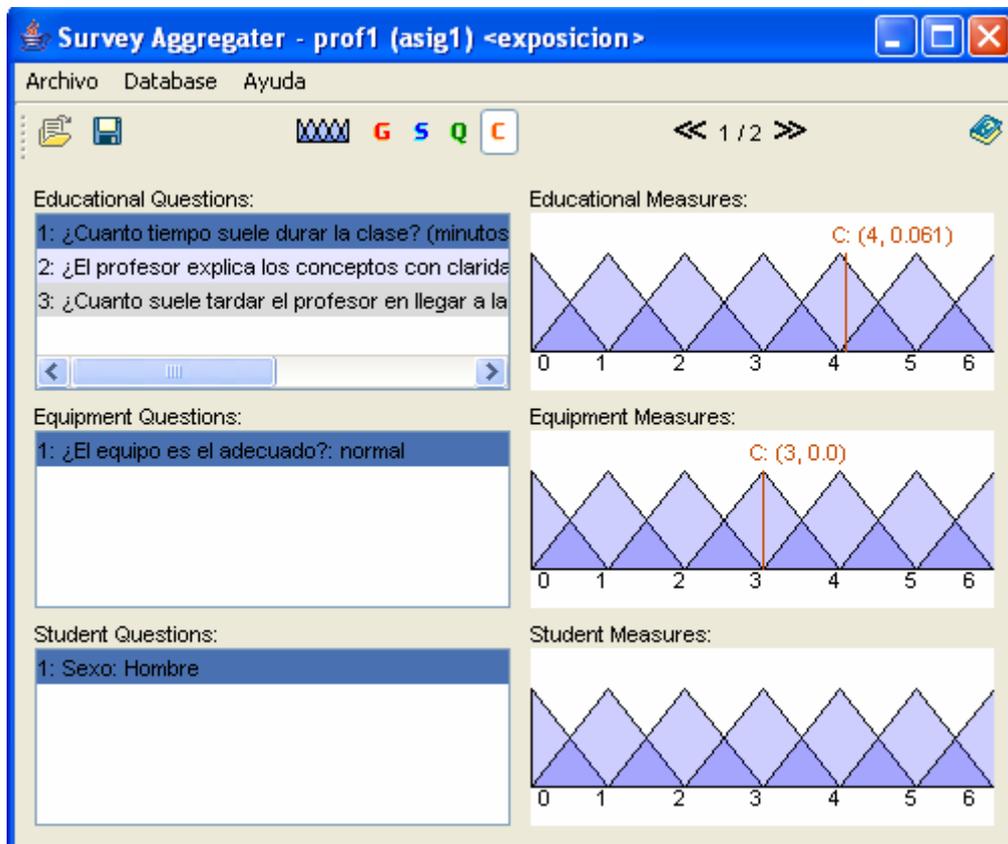


Figure 30: Survey Aggregator Current Question Results

### Change of the basic set labels

If the user wishes, is possible to change the basic set of labels, for example it can interest to him to use another type of labels such as: very bad, bad, average, good, very good.

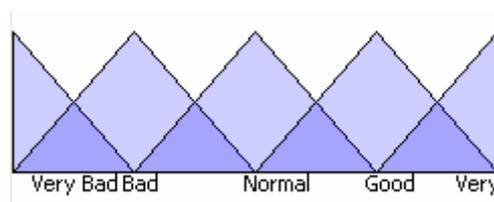


Figure 31: BLTS

This operation is carried out pressing in the icon of the window top of the window (figure 32).

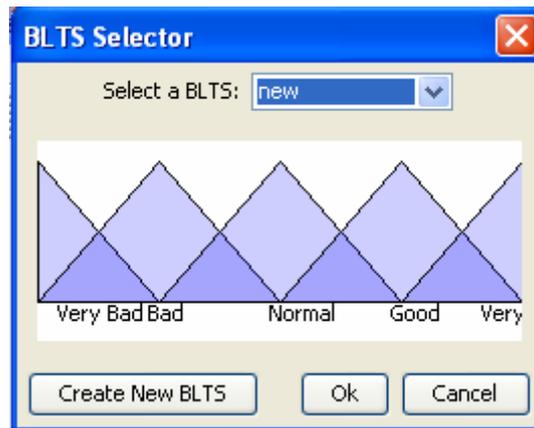


Figure 32: BLTS Selector Window

From this window we will press the button "create new BLTS" and will indicate in the number and name of each one of the new wished labels.

## 10. Statistic Valuation

The objective of this module of the application is the calculation and presentation of aggregated and standard deviation of the results filled up by the students. This presentation is made in two ways: table of averages and standard deviations, and a graphic comparing the different averages of the three kind of questions.

To enter this module of the application, we have to press the button "Average Results" that appears in figure 1, appearing the following screen(Figure 33).

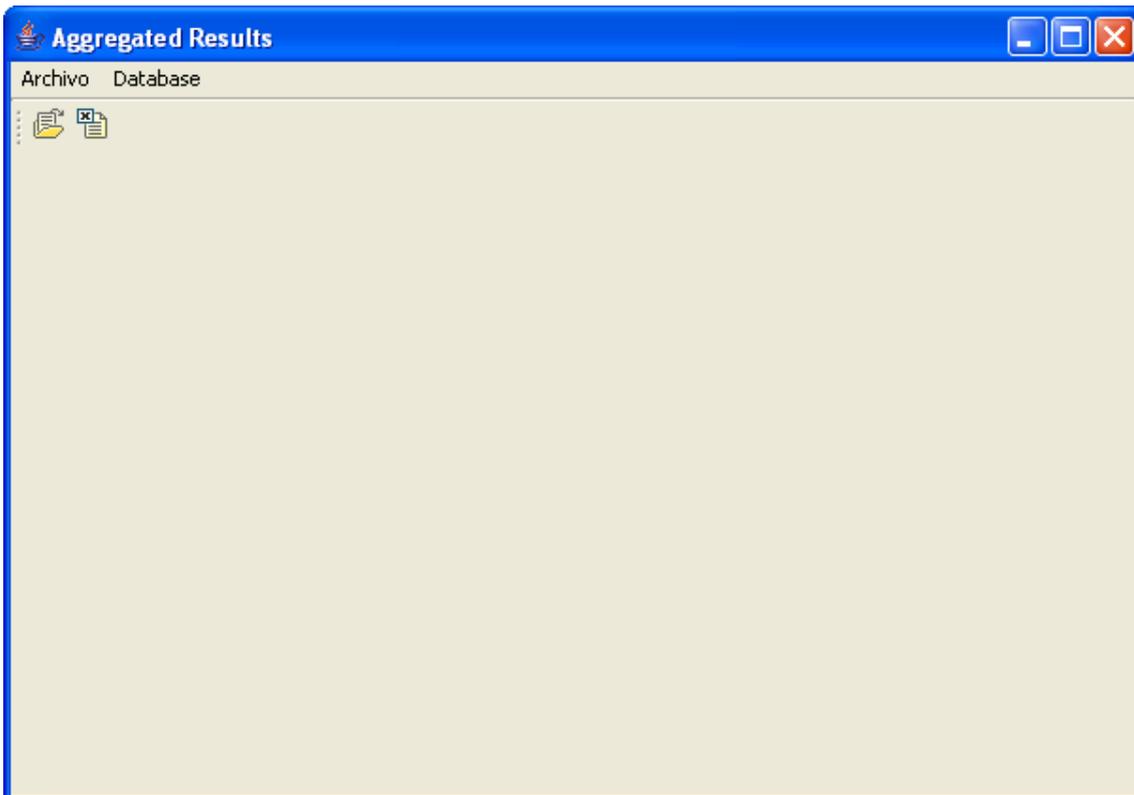


Figure 33: Aggregated Results Window

The first operation to make is open the survey model that we wish to consult. We have to consider that each model of survey is identified from three fields : subject, teacher and the name of the survey. When pressing on the icon "Open file" , the application visualizes a window (Figure 34) where the user must select the values of the previous fields.



Figure 34: Open Survey

If for the combination of the values of these three fields surveys answered by the students exist, will appear the table in the window of figure 35 with all the information referring to this survey.

QUESTIONS	AVERAGE VALUES	STANDARD DEVIATION
1 - EDUCATIONAL QUESTIONS	3.116	0.9397563180535254
Educational Question 1	2.65	3.2940355562733803
Educational Question 2	3.285	0.5013194572530868
Educational Question 3	3.117	2.0055683622233578
2 - EQUIPMENT QUESTIONS	3.392	0.3441560299119446
Equipment Question 1	3.392	4.155482097464429
Equipment Question 2	Enumeration Question	
3 - STUDENT QUESTIONS	2.82	0.4842180412286197
Student Question 1	2.77	3.458600109212982
Student Question 2	2.84	0.8883452392953762

Figure 35: Aggregated Table Results

As we see in the figure, there are just one table with three columns:

- Question names
- Aggregated Value
- Standard Deviation

The table rows have three kind of questions. First we have the Educational questions, then the Equipment Questions and finally the Student questions. In front column of this kind of questions, we have the respective aggregated value and standard deviation for all questions of that kind.

In front of which question, we have the value of aggregated result and standard deviation.

In the top of the window we can see a icon like this , that have access to the graphic panel. In this panel we have a bar chart (figure 35). This chart have the aggregated results of the different kind of Questions(Educational, Equipment and student questions). This different questions are separated by bars with different colors: Educational with pink bar, Equipment with orange bar and students with a yellow bar.

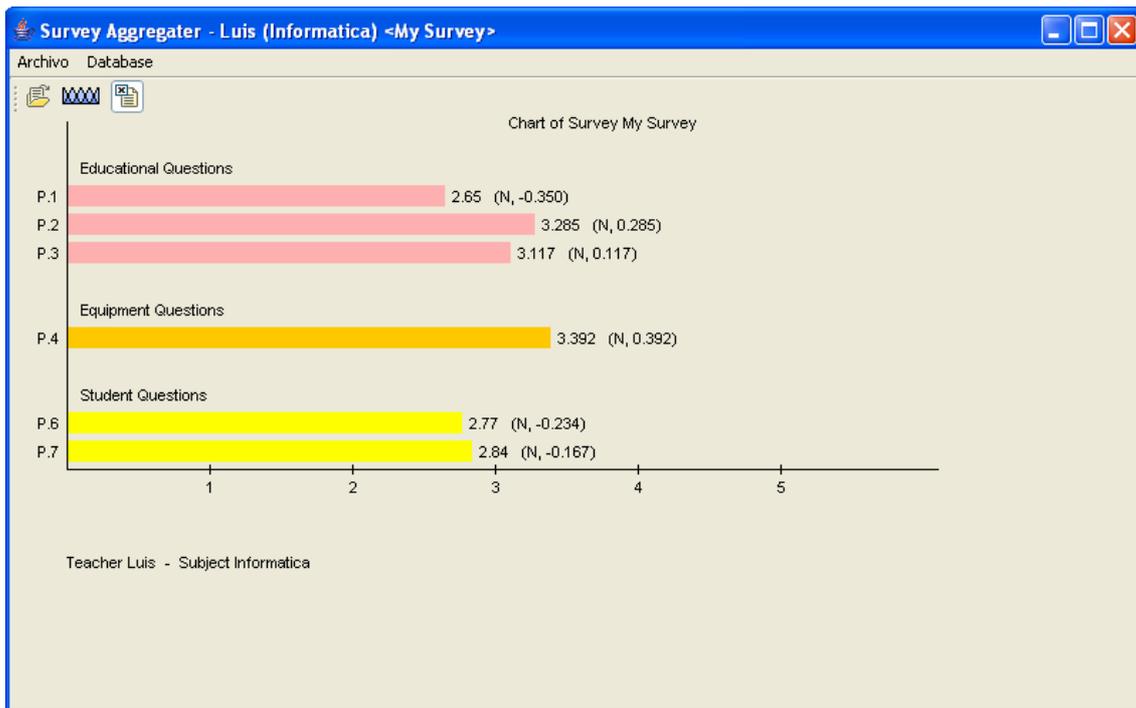


Figure 35: Aggregated Results Chart

## Appendix I

# AN AUTOMATIC EDUCATIONAL QUALITY EVALUATION FUZZY SYSTEM

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## Abstract

*The surveys about educational quality in the University have become really relevant for institutions and Government recently. However, current surveys are not flexible at all, due to the fact that all the questions are assessed in the same domain despite that they are not related to or they have different nature. The aim of this paper is to present an evaluation approach for educational quality more flexible than current ones that can manage heterogeneous information (numerical, interval valued and linguistic) and afterwards it will be outlined two Unified Modelling Language (UML) schemes that will facilitate its implementation in a JAVA based system. To do so, the evaluation approach will be based on fuzzy decision and evaluation models presented in the literature [4,5,8]. The UML schemes will be the basis to develop an object oriented evaluation system implemented in JAVA. This system will offer a great flexibility to the users (students who answer the pool) because they could provide their responses in different domains according to the nature of the questions used to evaluate the educational quality. In addition this software system improves the process of obtaining the final results about the qualification obtained by each lecturer or professor due to it is an automatic system and the pools can be filled, processed and stored in a automatic manner.*

## Keywords

Fuzzy system, heterogeneous information , quality evaluation.

## 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. Currently, 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. Hence, the results obtained by the current survey can be not accurate due to fact that the users (students) can not express their knowledge in a natural a proper way. Because some aspects evaluated by them cannot have a quantative nature either be evaluated in a precise manner but rather than may have a qualitative nature or the knowledge about them could be vague or imprecise. The use of fuzzy techniques have provided good results for dealing with this type of information in different evaluation problems [3,5,10].

The aim of this contribution is to show the basis to implement a JAVA based system that implements an evaluation model designed to carry out the evaluation of the educational quality dealing with non-homogeneous information (numerical,inteval valued, linguistic). To do so, we shall review in short the evaluation scheme we have designed to evaluate processes in which the information provided by the experts may be assessed with information of different nature or different domains and it is based on a decision making model able to manage with non-homogeneous information [5,6,8] by menas of the linguistic 2-tuple representation model [7]. Afterwards, we shall present the UML schemes of the JAVA based system we are developing for the *Office of Quality for the Universities of Andalucía* (South of Spain) that facilitates, improves and automatizes its current evaluation processes. This system will offer a greater flexibility and better rapport with reality to face this type of evaluation problems than the current ones Due to the fact, each question could be assessed in the more adequate domain that will be chosen after a pshycologist study.

This contribution is structured as follows: in the section 2 we review briefly the evaluation process that has been used to design the UML schemes for the implementation of the evaluation JAVA system dealing with heterogeneous information, in the section 3 we shall present the UML schemes of the evaluation JAVA system. Eventually some concluding remarks and future works are pointed out.

## 2. THE EVALUATION SCHEME

Our aim is to evaluate the educational and research skills of the lecturers and professors in the University. On many occasions, evaluation processes have been solved in the literature by means of decision analysis tools [2,3]. In our evaluation problem we have to evaluate different aspects that may have different nature (quantitative, qualitative) or the knowledge about them can be vague or imprecise. Therefore, these aspects could be assessed in different domains. Our proposal for solving this evaluation process is based on the decision making processes presented in [6,8] that follow a common resolution decision process scheme [13] but slightly modified due to the input information is non-homogeneous:

1. *Aggregation phase*: it obtains a collective value for each aspect of the lecturer evaluated according to the students opinions that will be assessed with heterogeneous information. This phase is carried out in a two-step process:
  - a) *Make uniform the information*. 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 [6]. Afterwards numerical, interval valued and linguistic input information is transformed into fuzzy sets in  $S_T$ ,  $F(S_T)$ , using the transformation functions presented in [6].  
Once all the input information has been expressed by means of fuzzy sets to facilitate the computations with this information we shall transform it into linguistic 2-tuples [7] using the function presented in [8].
  - b) *Aggregation process*. Now, the input information is expressed by means of linguistic 2-tuples assessed in the BLTS. In [7] we can find several 2-tuple aggregation operators based on classical aggregation operators to aggregate the linguistic 2-tuples and obtain the collective values we are looking for. The aggregation operator will be chosen depending on if all the aspects evaluated have the same importance or not.
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 [11,12]. However, in this evaluation problem it will compute an overall value [5] expressed by means of a linguistic 2-tuple. This overall value expresses a measurement of the quality about the skills of the lecturer or professor evaluated.

## 3. THE UML SCHEMES OF THE EVALUATION JAVA SYSTEM

UML is a graphic language to visualize, specify, build and document the elements of a system independently of the software used to its implementation [1,9]. UML provides a standard way to write the schemes for a computer system, we just use the diagram of classes to present the most important elements for the design of an automatic educational quality evaluation system based on the proposal presented in the section 2. The UML scheme in the Fig. 1 shows the classes that allow us to deal with the heterogeneous information in our problem. Now we shall describe the main characteristics of each one of the current classes in this UML scheme:

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METODOS.  
EN LAS EXPLICACIONES SI QUIERES UTILIZA LO DEL ARTICULO PARA DSS SOBRE ERP  
DE 30 PAGINAS

- Valuations.** Each question in the quality survey will be assessed by a student. In our problem the valuations can be assessed in different domains of the information but all they share common methods that will be contained in these abstract classes for their later implementation in each one of their subclasses. This class have an important method that will be able to work with heterogeneous information:
  - unification:** it unifies the different valuations assessed in the different domains of information into a fuzzy set in the BLTS,  $S_7$ . This method will have a particular implementation depending on the type of information that is becoming unified (numerical, interval valued or linguistic) [6].
- Numeric, Interval Linguistic.** These three classes inherit of **Valuations** and represent the three domains of information that we work in our application (heterogeneous information). As these three classes inherit of **Valuations** it allows us to use the property of the polymorphism to be able to decide in execution time what a method it will be executed in each moment (according to the class that belongs the object). Being this an efficient form to work with heterogeneous information.
- TwoTuple.** This class contains the necessary methods to implements the 2-tuple linguistic representation model presented in [7]. Also this will be the domain of the information where the results are assessed.
- FuzzySet.** This class is used to represent the domain of information used to unify the heterogeneous information.
- Label.** This class is used to represent the syntax of a linguistic label and its semantics given by fuzzy number defined in the  $[0,1]$ .

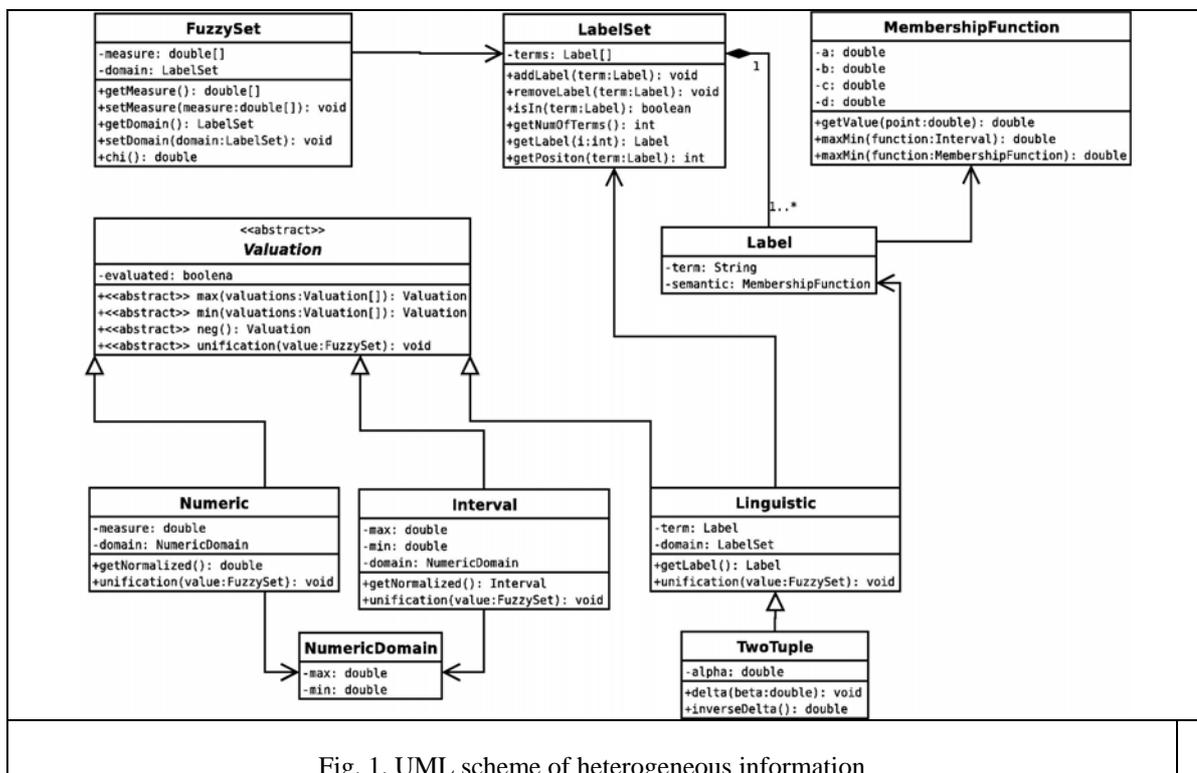


Fig. 1. UML scheme of heterogeneous information

- LabelSet.** This class is used to represent linguistic term sets that can be used by the students to assess their linguistic assessments related to the factors evaluated linguistically.
- NumericDomain.** The numeric information as the intervals should be expressed using

numbers that belong to range  $[0,1]$ . But to offer a greater flexibility to the student to answer the survey we should allow that the numeric information and interval-value can be assessed in any range. A numeric object or interval object have associate an object **NumericDomain** that allow us to indicate the range of permitted values and implement a normalization method into the range  $[0,1]$  in the classes **Numeric** and **Interval**.

- **MembershipFunction**. This class represents the parametric representation achieved by a 4-tuple  $(a,b,c,d)$ , where  $b$  and  $d$  indicate the interval in which the membership value is 1, with  $a$  and  $c$  indicating the left an right limits of the definition domain of the trapezoidal membership function.

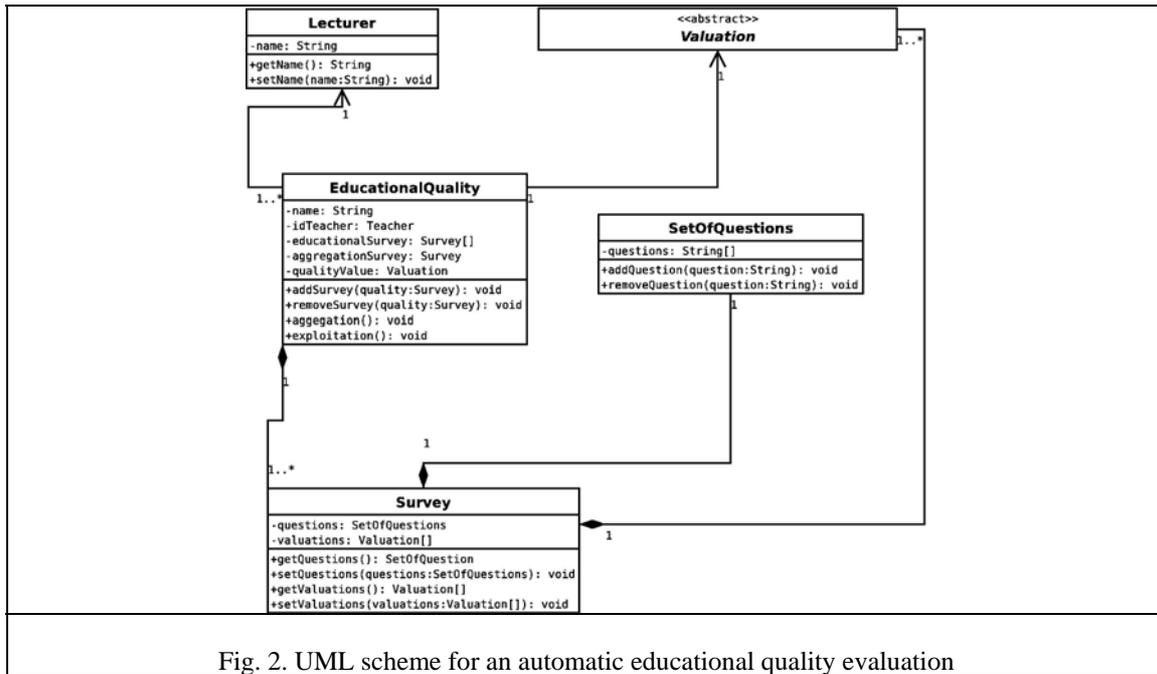


Fig. 2. UML scheme for an automatic educational quality evaluation

We have presented an UML scheme to deal with heterogeneous information now we shall present the UML scheme for an automatic educational quality evaluation system, shown in the Fig. 2. Now we describe the main characteristics of each class of this UML scheme:

- **Lecturer**. The final objective of the survey is to obtain a measure of lecturer's educational skills. Therefore we need to know the lecturer's identity that teaches the subject.
- **SetOfQuestions**. This class allows us to store the questions of the survey. As the questions of all the surveys are the same ones we just need to create an only object of this class for each given object of **EducationalQuality**.
- **Survey**. Each survey belongs to an **EducationalQuality** object shares the same **SetOfQuestions** object that are the questions used to evaluate all the quality surveys. We should have for each survey a utility vector that will represent the answers given by the students to the survey. The utility vector are **Valuation** objects that allow us to represent the heterogeneous information (numerical, interval valued and linguistic).
- **EducationalQuality**: It is the main class of our proposal. We store the name of the subject object of the educational survey, the lecturer's name and the surveys answered by the students for each subject. This is the necessary information to solve our problem of quality evaluation. The main methods to carry out this task are:

- **aggregation:** In this problem the aggregation method must aggregate educational quality questions with heterogeneous information (numerical, interval valued, linguistic). To do so, we shall use the aggregation process:
  1. *Making the information uniform.* The heterogeneous information is unified using fuzzy sets in the BLTS.
  2. *Aggregating individual educational survey.* For each question of survey, a collective value is obtained by means of an aggregation operator obtaining the *aggregationSurvey.Selección del operador*
  3. *Transforming into 2-tuple.* The *aggregationSurvey* of the survey expressed by means of fuzzy sets are transformed into linguistic 2-tuple in the BLTS.

*PEDRO NO CUADRA CON LO EXPLICADO ANTES CAMBIALO CON RESPECTO AL DE ANTES ME DA IGUAL CUAL DE LOS DOS DEJES PERO TIENEN QUE SER COINCIDENTES*

- **exploitation:** Once it has been completed the aggregation method and we have obtained a collective survey the exploitation method for this problem computes an overall value expressed by means of a linguistic 2-tuple. Qué usa para obtener el valorThis overall value expresses a measurement of the lecturer's educational quality, *qualityValue*.

#### 4. CONCLUDING REMARKS AND FUTURE WORK

So far, we have presented the UML schemes to the theoretical background developed in [5, 6, 8] of a JAVA 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 Andalucía (Spain). But in the future we want to apply similar methods to the study of quality of textile products.

In addition as we have aforementioned (donde) 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.

Poner que en la presentación presentarás una primera versión del JAVA system

#### 5. ACKNOWLEDGEMENTS

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# A JAVA Based System for Evaluating Educational Skills

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**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  $s_i \in S = \{s_0, \dots, s_g\}$  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  $\{0, \dots, g\}$  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  $(r_i, \alpha_i)$ ,  $r_i \in S$  and  $\alpha_i \in [-.5, .5)$ .  $r_i$  represents the linguistic label center of the information and  $\alpha_i$  is the Symbolic Translation.

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

**Definition 2.** *Let  $S = \{s_0, \dots, s_g\}$  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  $\beta$  is obtained with the following function:*

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

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

where  $\text{round}(\cdot)$  is the usual round operation,  $s_i$  has the closest index label to " $\beta$ " and " $\alpha$ " is the value of the symbolic translation.

**Proposition 1.** *Let  $S = \{s_0, \dots, s_g\}$  be a linguistic term set and  $(s_i, \alpha)$  be a linguistic 2-tuple. There is always a  $\Delta^{-1}$  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:

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

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  $X=\{x_1, \dots, x_m\}$  that are evaluated by  $n$  students  $E=\{e_1, \dots, e_n\}$  providing their evaluations in different domains,  $D^k$ , according to the nature of the evaluated aspect by means of utility vectors:

$$\{p_{il}^k, \dots, p_{im}^k\}$$

Let  $p_{ij}^k$ ,  $i \in \{1, \dots, m\}, j \in \{1, \dots, n\}, k \in \{N, I, L\}$  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: Numerical, Interval-valued and Linguistic.

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]:

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

Once the BLTS has been chosen each numerical, linguistic and interval-valued evaluation,  $s_{ij}^k$ , 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,  $p_{ij}^N \in [0, 1]$ , into  $\mathbf{F}(S_T)$ :**

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

**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,  $p_{ij}^L \in S$ , into  $\mathbf{F}(S_T)$ :**

$$\begin{aligned} \tau_{SS_T} : S &\rightarrow F(S_T) \\ \tau_{SS_T}(p_{ij}^L) &= \{(s_k, \gamma_k)/k \in \{0, \dots, g\}\}, \forall p_{ij}^L \in S \quad (2) \\ \gamma_k^i &= \max_y \min\{\mu_{p_{ij}^L}(y), \mu_{s_k}(y)\} \end{aligned}$$

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

- (c) **Transforming interval values,  $p_{ij}^I \in [0, 1]$ , into  $\mathbf{F}(S_T)$ :** Let  $I = [\underline{i}, \bar{i}]$  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]:

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

The transformation function is:

$$\begin{aligned} \tau_{IS_T} : I &\rightarrow F(S_T) \\ \tau_{IS_T}(p_{ij}^I) &= \{(s_k, \gamma_k)/k \in \{0, \dots, g\}\} \quad (4) \\ \gamma_k^i &= \max_y \min\{\mu_{p_{ij}^I}(y), \mu_{s_k}(y)\} \end{aligned}$$

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

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:

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

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

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

Being  $\mu$  an *aggregation operator* and  $i$  the number of students.

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

$$\Delta(\chi(\tau(\vartheta))) = \Delta(\beta) = (s, \alpha) \quad (5)$$

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  $\chi$ :

$$\begin{aligned} \chi : F(S_T) &\rightarrow [0, g] \\ \chi(\tau(\vartheta)) &= \chi(\{(s_j, \gamma_j), j = 0, \dots, g\}) = \frac{\sum_{j=0}^g j \cdot \gamma_j}{\sum_{j=0}^g \gamma_j} = \beta \end{aligned} \quad (6)$$

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

$$\Delta(\chi(\tau(\vartheta))) = \Delta(\beta) = (s, \alpha) \quad (7)$$

### 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.

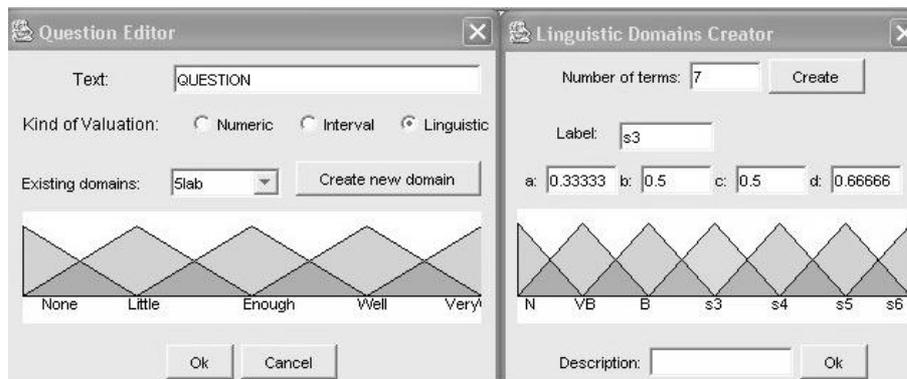


Figure 1: Adding questions and creating term sets

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.

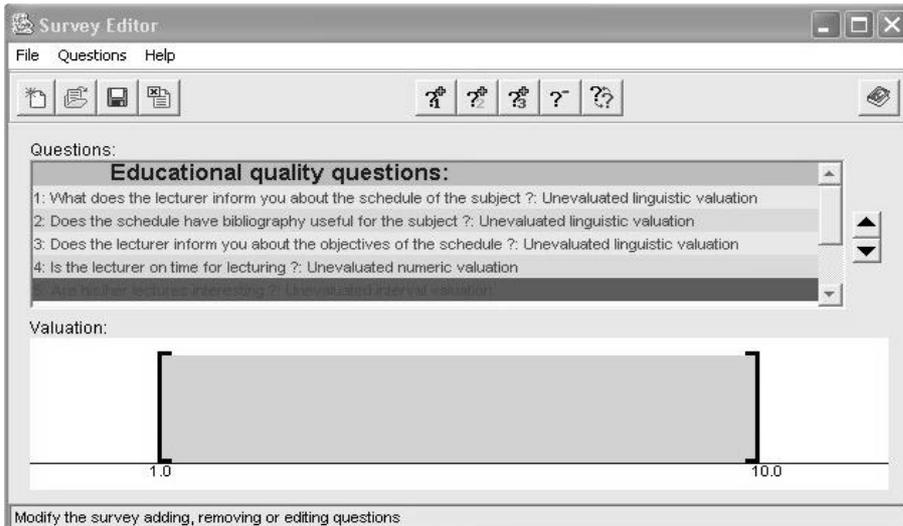


Figure 2: Module to design surveys

#### 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:

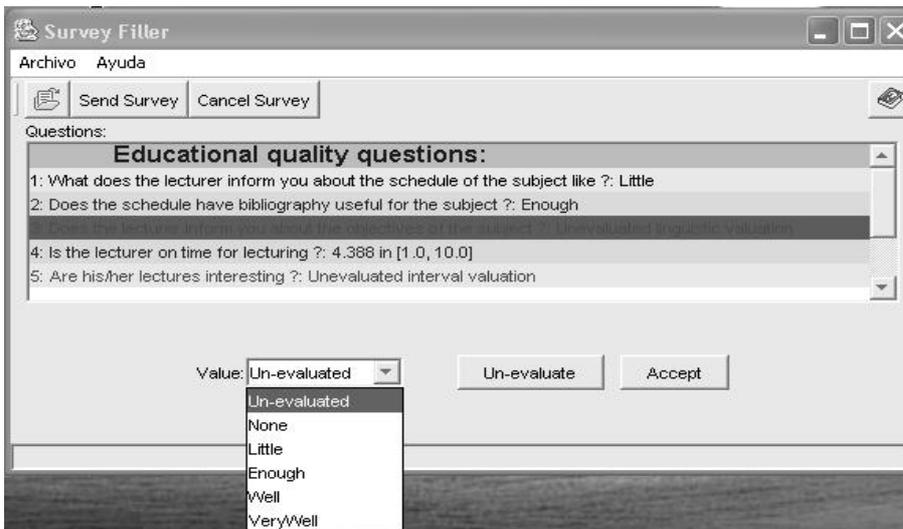


Figure 3: Answering a question assessed in a linguistic term set

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.

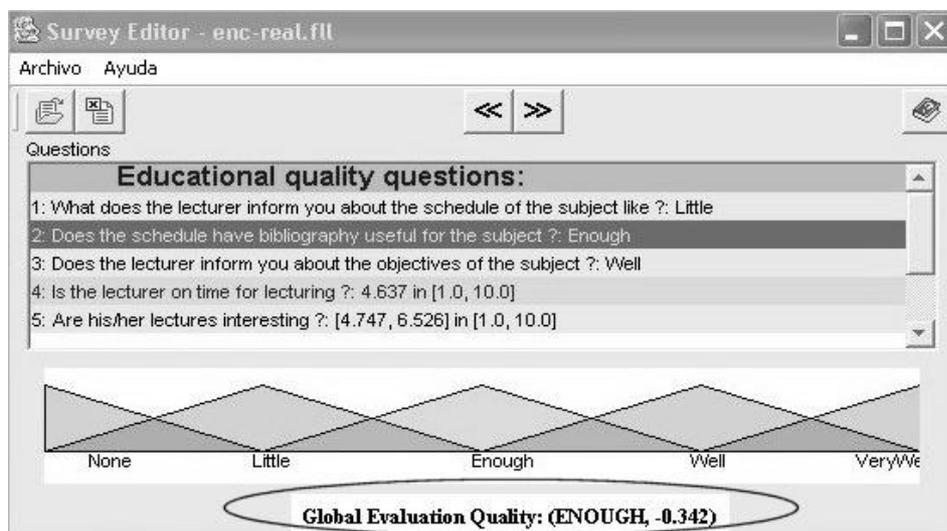


Figure 4: UML scheme for an automatic educational quality evaluation

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 Andalusia* (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.

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