

Fuzzy Logic Techniques (FLT) in the Interpretation of the Responses Given to a Questionnaire Filled out by Professors in Spain

Francisco Gómez Gómez

María del Pilar Munuera Gómez

Antonio García Gans

Social Work and Social Services Department
Social Work Faculty, Universidad Complutense de Madrid
Spain

Abstract

This article tackles the study conducted through the application of Fuzzy Logic Techniques (FLT) to the responses given by the professors from Universidad Complutense de Madrid (UCM) and other Spanish faculties. The questionnaire employed for this purpose was elaborated with the professional competences that are basic for Social Work performance in Spain. Its results confirm the principal hypothesis about how to make easier the decision-making that is provided by the method applied and, additionally, some of the differences with respect to the conceptions that professors hold in relation with competences towards Social Work are described herein.

Key Words: Fuzzy Logic Techniques (FLT), Universidad Complutense de Madrid (UCM), Spanish faculties, Social Work.

1. Background and Current State of the Matter

Some of the notions and data about addressing questionnaires with Fuzzy Logic Techniques (FLT), as well as the guidelines of the new method of addressing the questionnaires through the abovementioned FLT (Gómez and García, 2007), with which the equivalent group response is obtained, as well as the membership and indecision of the latter, reduces the subjective interpretation of the pollsters and favors decision making.

The previous results to this study herein obtained in respect of the acquisition of professional competences for the performance of Social Work (Gómez, 2010) in which FLT were applied to the processing of the data from the questionnaires handed to students of different subjects of Social Work degree, highlighted the differences that exist when it comes to college degrees, based on the responses given by the students, between Social Work subjects and those that coming from matters different from Social Work included scholarships in their syllabus and those that coming also from matters different from Social Work did not include scholarships in their syllabus. The Fuzzy Logic created by Zadeh (1965) from the Fuzzy Set Theory has been fully spread among technological fields such as engineering, computing and robotics, and among various industries, i.e. refrigeration industry, however its spread among other investigation fields such as humanities and social areas has become mere approaches, sometimes even speculations.

Notwithstanding this, it shall be marked out examples of the abovementioned approaches such as some of the attempts, performed in our country, to explain the methodological adaptation of Fuzzy Logic to education (Ballester and Colom, 2006), Law (Esparza, 2003), Politics (Felizzola, 2007), Psychology (Prieto and San Luís, 1992), economy (Pecha & Villamil, 2002 and Fuentes & Lozano, 2003) and to Social Work (Gómez & Herrador, 2008). Nevertheless everything that has been published to this respect evidences the explanatory approaches, which do not go far beyond in relation with its practical applications. In our country there are some investigation groups that have performed studies and applications related to Fuzzy Logic, such as the group led by professor Galindo Gómez, J., from Universidad de Málaga Computing Engineer Faculty. Which it has originated multiple investigation works and thesis, but applied to computing and other technical fields.

This as well can be acknowledged in respect of other scientific fields, based on the review of the works written in English about this matter, which show as well the same conditions of technical application. The method of processing questionnaires with Fuzzy Logic Techniques (FLT) and its guidelines are the subject introduced and approved at the official announcement executed by Universidad Complutense de Madrid Social Work and Social Service Department. Fuzzy Logic is applied to fuzzy sets and systems in a way that any element from the data universe may belong to a set with a certain degree of membership. The application of this mathematical theory smoothes a lot the rigidity of the quantification values of the responses that takes place with the traditional processing of the data from questionnaires (Gómez & García, 2010).

As a consequence of the UCM Investigation Group works (940102) the initial guidelines from 2007 year have evolved to the following guidelines of 2010 year. This method of data processing based on Fuzzy Logic can be summed up in the following steps:

1. An interval of real numbers $[0, 100]$ is established as the discourse universe.
2. For each question, a frame of knowledge is defined, composed of as many fuzzy sets- linguistic label as responses the question may have. All the elements from the frame of knowledge have the same domain $[0, 100]$.
3. The membership functions of each linguistic label are curves, in a way that the values corresponding to membership 1 are uniformly distributed throughout the domain, including the extremes, and each function has two values of membership 0 in the domain extremes, except for the extreme labels which shall have a single value of membership 0 that shall be located on the other extreme of the interval.
4. Responses in blank from a question shall form part of the data set to be processed, but they shall form a disjoint subset in respect of the subset of chosen responses. For this reason, to these responses any linguistic label is not assigned, although a membership function is defined for them that shall determine the value of the discourse universe that shall correspond to them.
5. The membership functions of the responses in blank from each question are curves, in a way that they shall have two values of membership 1 in the domain extremes and one value of membership 0 corresponding to the average value of the linguistic labels from the question.
6. The membership of the value corresponding to each question is equal to its percentage obtained in the questionnaire expressed in per one units.
7. A “weighted set of points” is determined so that to each question corresponds one point whose abscissa is the value of its “maximum” in the membership function and whose ordinate is its membership.
8. For the extreme linguistic labels it is determined, in the line of its membership function, the point that has such membership and its abscissa shall be the value of the abovementioned response in the Fuzzy Set. This function has been chosen for being similar to the rest but defining one “minimum” of membership, due to the fact that responses in blank form a disjoint subset with the chosen responses. And then the percentage is divided by 100.
9. For intermediate linguistic labels the procedure is the same but two points are derived from the function (each in each line of the membership function’s curve). The value of the point whose sum of distances to the “weighted points” is the lowest, shall be taken.
10. The average value of the values corresponding to all the responses from the question shall be calculated.
11. To the responses in blank a membership is assigned equal to the percentage obtained expressed in per one units. For each membership two values are possible (each in each line of the membership function’s inverted curve). The value of the point located in the farthest distance from the “weighted points” shall be taken.
12. The overall value of the question shall be the average value of those obtained in its responses and of the responses in blank, in the cases where they happen to exist.
13. To the overall value corresponds the membership of the point of the gradient that shall exist on its vertical line. The membership defines the linguistic label of the overall value. The mathematical concept of distance in two dimensions is applied herein. If there are no responses in blank the numerical overall value is the one obtained in step 10.

The studies developed by the members of the research group called UCM 940102 “Observatory for Social Intervention in Organizations” and of others in execution, are the ones which permit that we can currently have some of the previews of the results in order to share them in this article before the processing of the results of this study is done.

The publication of the work about “Acquisition of professional competences for the performance of Social Work” (Gómez, 2010), where it is reflected a study in which the initial version of the guidelines above described is applied, is the most important study of reference because it supposed the validation of the questionnaire applied.

Additionally we will quote the works done by the Research Group UCM (940102) and also those in execution about the subject matter:

1. One -unpublished- titled: “Study of the evolution of the impact of the psychosocial factors over the students of military education of improvement at Superior Technical College of the Army” (García, 2009).
2. Others already designed to be applied in Superior Technical College of the Army, in Universidad Complutense de Madrid, in Technical University of Ambato (Ecuador) and in University of Tarapacá (Arica, Chile), among those activities which are characteristic of the abovementioned educational and research institutions, which are:
 - a) García Gans PhD Thesis which currently it is in a very advanced state of composition, titled: “Adjustment of qualitative characteristics through Fuzzy Logic Technics”.
 - b) One final work from the Master of European Community Social Work: Management and Evaluation of Social Services applied the abovementioned method to the employees at Madrid care centers for people affected by social exclusion, titled: “Study about the psychosocial risks which the professionals who work with Homeless People in Madrid municipality are subject to” (Cubero, 2009, 2011). And,
 - c) A study about psychosocial risks in the Technical University of Ambato (Ecuador) and other in the University of Tarapacá (Arica, Chile) about the same subject, promoted by Cajamadrid Foundation.

2. Methodology and Research Hypothesis

The population subject to this questionnaire is composed by professors, educators and professional educators, from Universidad Complutense de Madrid and other Spanish universities. The data processing has been done with the following partitions of the polled sample:

- The whole the questionnaire (All)
- First binary partition:
 - Educators.
 - Professional educators.
- Second binary partition:
 - Employees at Social Work Faculties (SW).
 - Employees at other Faculties and Schools (non SW).
- Third binary partition:
 - Employees at Universidad Complutense de Madrid (Spanish acronym, UCM).
 - Employees at other Spanish Universities (non UCM).

2.1. Traditional Processing.

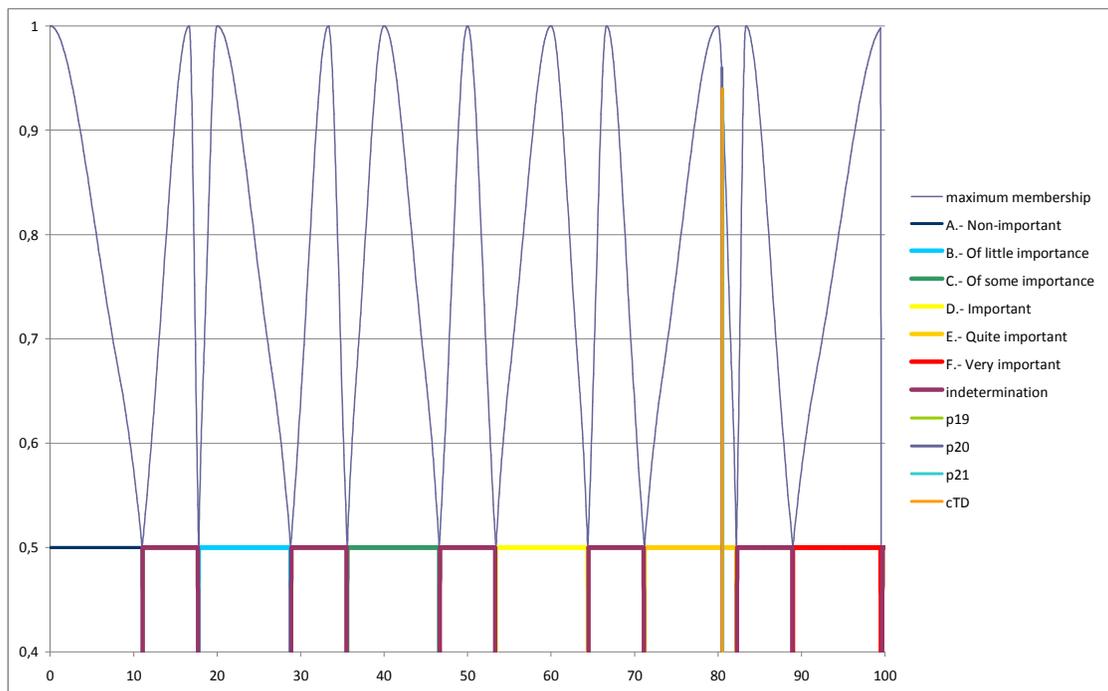
It is indicated by diagrams for each question the percentage of the choices of the responses from each of the sets of the abovementioned partitions. The response in blank is assumed as though it was an additional response. For each response, it is assigned, as a class mark, a numerical value, resulting in a discrete data set from the questionnaire. The numerical value of each response is obtained by processing the discrete data from the questionnaire: the adjusted average is calculated from the class marks and the resulting value is assigned to the response whose class mark is more proximate (check graph 4).

2.2. Processing with FLT

Since 2010 the guidelines have keep evolving until nowadays. The FLT method is applied for the processing of questionnaires with linguistic values, developed by one of the members of the Research Group in his PhD thesis (García, 2012). It is used by the other members of the abovementioned Research Group in other studies and related researches. The method applies membership functions for each of the responses, having all of them the same numerical domain (each function determines a fuzzy set) and also to the responses in blank it associates them a fuzzy set.

For each value of the numerical domain is matched with as many points as responses the question may have plus the point corresponding to the response in blank, becoming different from its response due to its membership to the fuzzy set; one of such points shall have the maximum value of membership.

With the maximum points of membership of each value from the numerical domain, a function defined in pieces is established with a maximum for each fuzzy set (evenly distributed over the domain) and with as many maximum values for the fuzzy set of the responses in blank as successive changes of response it may have (one maximum value for each two consecutive maximums). Each “piece” of the abovementioned function determines an interval of the domain and the changes of interval always take place in a point whose membership is 0,5, moving from the fuzzy set of a response to the fuzzy set of “indetermination” (the one that belongs to responses in blank). The union of all the intervals corresponding to the “indetermination” is equivalent to the fuzzy set of responses in blank, and all of its points of maximum membership represent a single multiple point (this implies that its function of membership is multiform). This function composed of values of maximum membership has the following looks (the following is an example for questions of six responses):



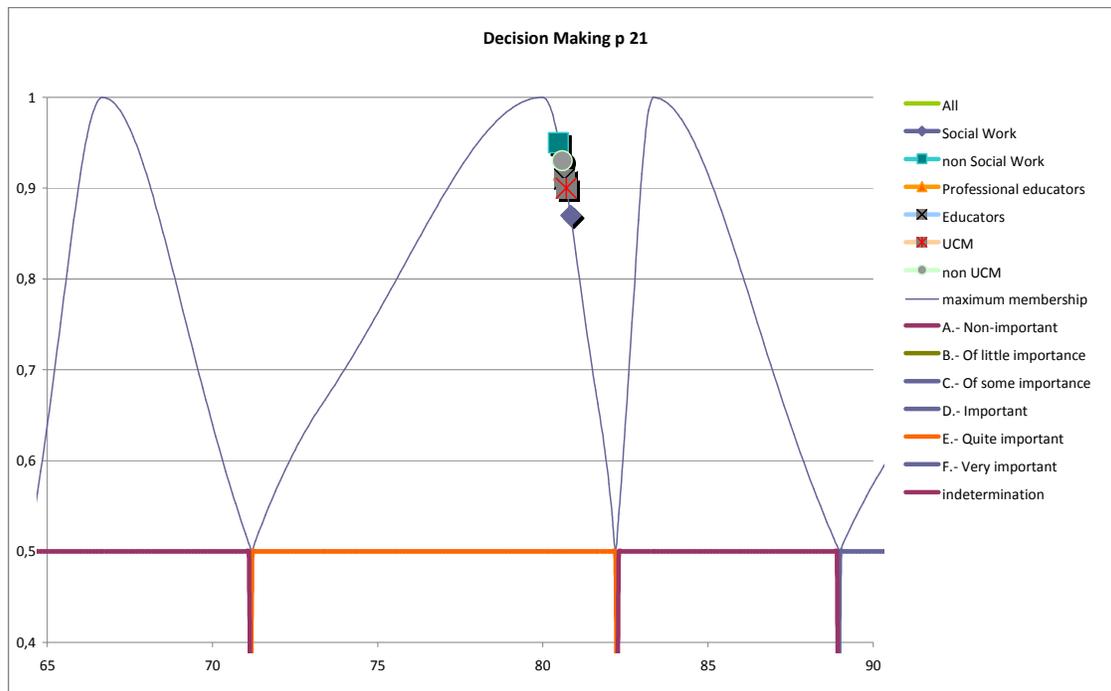
Graph 1

For each of the questions from the questionnaire the method assigns a fuzzy point to each of its possible responses, with the condition that the points corresponding to the same question ought to be grouped together. The average value of the obtained fuzzy values indicates the group response, becoming the one with the highest membership for the abovementioned average value.

The main conceptual differences between FLT and the processing of discrete data from the traditional logic are the following: the values corresponding to the responses from the questionnaire, including the responses in blank, may be located in any place of the domain and they may have a membership between 0 and 1; the questions not answered influenced the final result; the assignation of a response to each value is defined by the interval of the domain to which it belongs, but in accordance with FLT the intervals located between two successive responses are separated by an interval of “indetermination”.

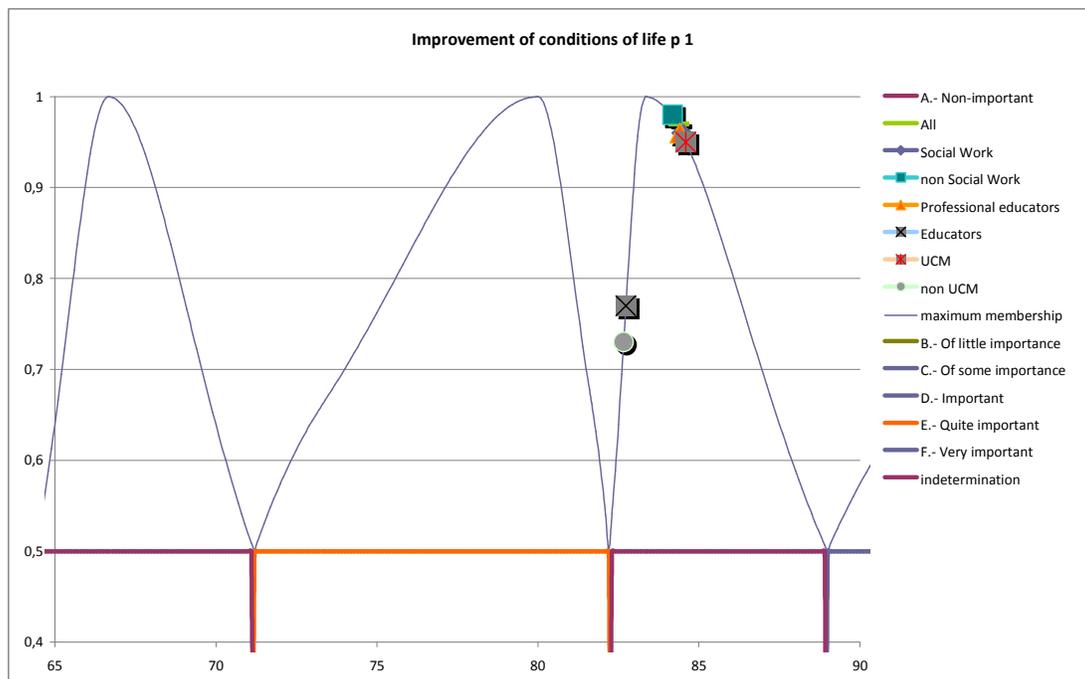
When the method is applied to the study of the responses from each of the sets of the abovementioned partitions, the following possibilities may exist:

- The values distributed in the same side in respect of a maximum or a minimum: these values evolve in the same way when the membership increases or decreases.



Graph 2

- The values distributed in both sides in respect of a maximum: these values evolve approximating when the membership of them all increases; in the opposite case, they get separated.



Graph 3

- The values distributed in both sides in respect of a minimum: these values evolve approximating when the membership of them all decreases; in the opposite case, they get separated.
- We consider that the points whose membership is between 0,75 and 1, are far out of the zone of change.
- We consider that the points whose membership is between 0,5 and 0,75, are proximate to the zone of change.

- The Graphs: horizontal bar graphs indicating the numerical values (without membership) and dispersion graphs indicating the points of response (value, membership) have been built over the discontinuous function of the maximums of membership (in addition to the already mentioned vertical bar graphs corresponding to the % of the responses) (check graphs 6 and 7).

3. Hypothesis and Objectives of This Research

The main hypothesis of this project sets out that the processing of the data obtained from the research questionnaires through FLT makes decision taking easier, especially for those decisions competence of the teaching staff, in comparison with the traditional data processing. The objectives of this project represent the empowerment of the research guidelines of the group and the empowerment of the activities on execution, above indicated. On the other hand, the specific objective is to apply the data processing using FLT in order to detect the most appropriate for the development of the professional competences in the education of Social Work students through their teaching staff.

4. Data Analysis

Due to the space required for this work, we have only gathered some of the most significant data and graphs when demonstrating the confirmation of the main hypothesis of this study, as well as for extracting some of the most relevant conclusions of the same that comply with the proposed objectives. Table 1 gathers the total data obtained from the questionnaire filled by UCM professor and non UCM as well and processed using Classical Logic and Fuzzy Logic.

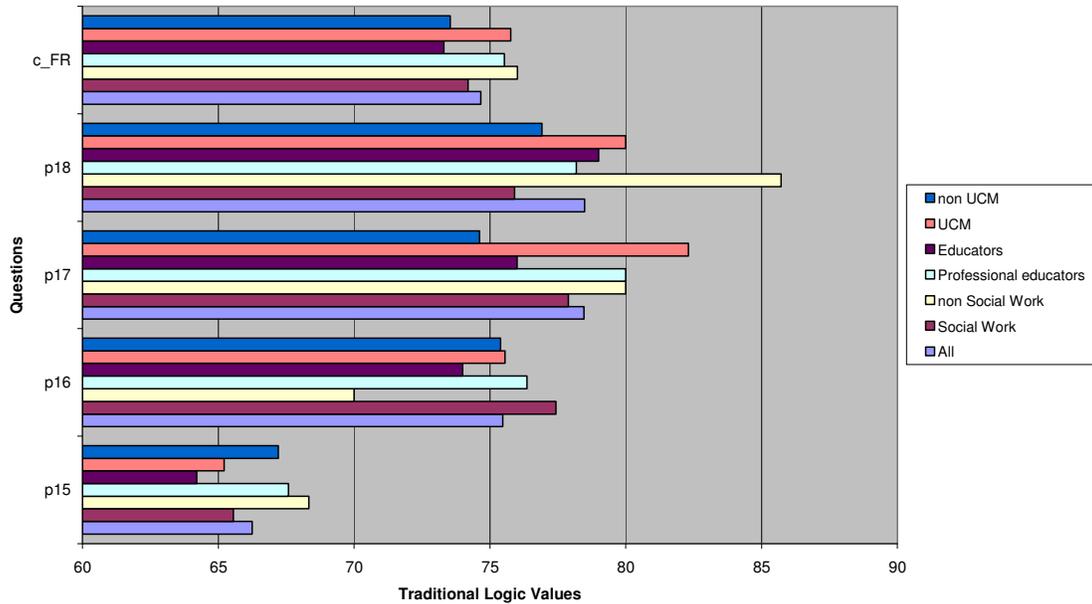
As it can be observed, the results of the questionnaires obtained through both Logics do not differ too much as a whole, but the data processing with FLT refines much more when remarking out those that may result more significant in decision making. This way, questions 19, 20 and 21 related to decision making offer a global response more adjusted to their data, which represents a valid indicative for the abovementioned decision making. Something similar happens with questions from 1 to 7 and those from 11 to 14 related to the improvement over the conditions of life, as well as with those from 15 to 18 about the end of a relationship in a proper way and those questions from 8 to 10 and 22 about how to cope a crisis.

		Group1	All	Group1	All
Linguistic Value		FL Value	Membership	TL Value	Standard Dev.
E.- Quite important	p19	80,6	0,9	86,9	17,2
E.- Quite important	p20	80,5	0,9	84,1	16,4
E.- Quite important	p21	80,6	0,9	83	16,1
High	c_TD	80,6	0,9	84,6	16,6
Does not know, Does not answer	p1	84,3	0,9	94,3	19
E.- Quite important	p2	80,8	0,8	87,1	17,1
E.- Quite important	p3	82,5	0,6	86,4	16,9
E.- Quite important	p4	80,7	0,9	85,4	16,8
E.- Quite important	p5	80,6	0,9	86	16,8
Does not know, Does not answer	p6	82,5	0,6	91,7	16,3
Does not know, Does not answer	p7	80,7	0,8	87,3	17,3
E.- Quite important	p11	80,8	0,8	80	15,7
E.- Quite important	p12	80,7	0,8	82,3	16,1
E.- Quite important	p13	81,1	0,8	78,4	15,4
E.- Quite important	p14	80,8	0,8	81,9	16,2
Very High	C_MCV	81,4	0,7	85,5	16,9
D.- Important	p15	61,4	0,8	66,2	13,5
D.- Important	p16	81,2	0,7	75,4	14,4
D.- Important	p17	80,8	0,8	78,4	15,2
E.- Quite important	p18	80,7	0,9	78,4	15,1
Does not know, Does not answer	c_FR	76,1	0,8	74,6	14,6
E.- Quite important	p8	80,7	0,9	82,3	15,9
E.- Quite important	p9	80,8	0,8	81,2	16
D.- Important	p10	80,8	0,8	76,9	14,7
E.- Quite important	p22	80,6	0,9	86,8	17,5
High	c_AC	80,7	0,9	81,8	16,1

Table 1

The processing of the data through FLT groups such data in a way that offers the global response, which becomes useful when obtaining evidences over a group response, which is different from a grouping of data via standard deviations, which is offered by the processing of data with Traditional Logic. This represents more objectivity in the interpretation of the data. The numerical values obtained through Traditional Logic (graph 4), previous to the assignation of a class mark, indicate a lot of dispersion, making the drawing of conclusions much difficult.

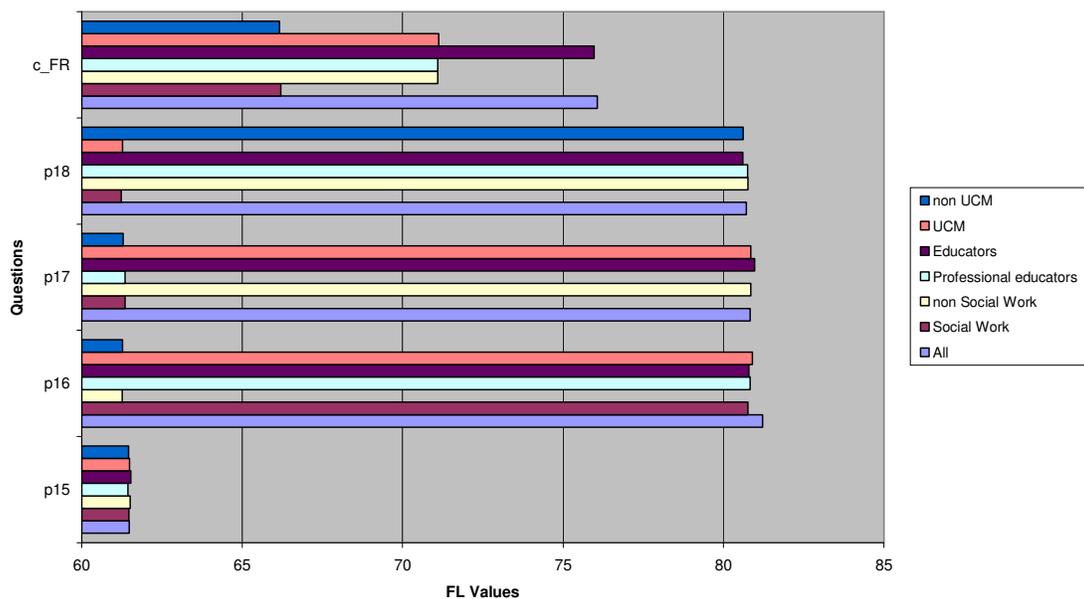
Ending the relationship in a proper way – Traditional logic processing



Graph 4

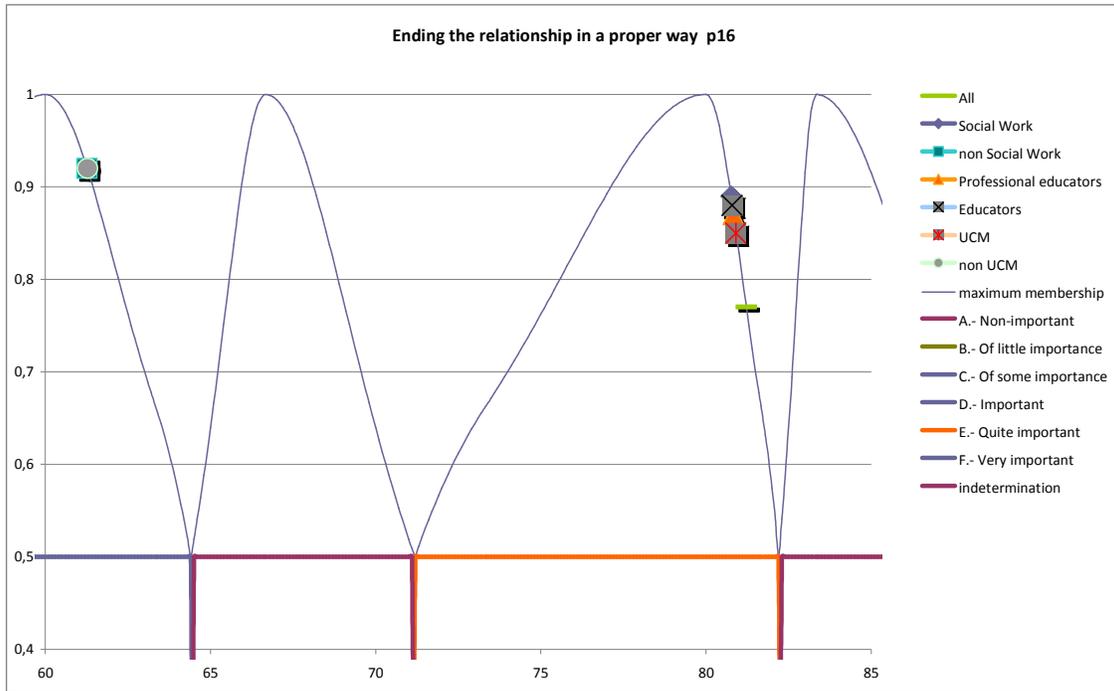
Once assigned the mark of class most of the values match the same group response, consequently the method discriminates a little bit. Notwithstanding this, the numerical values obtained through FLT are different even though they may belong to a same group response, despite the fact they might be similar. A simple look at graph 5 allows us to distinguish different group responses:

Ending the relationship in a proper way – FLT processing



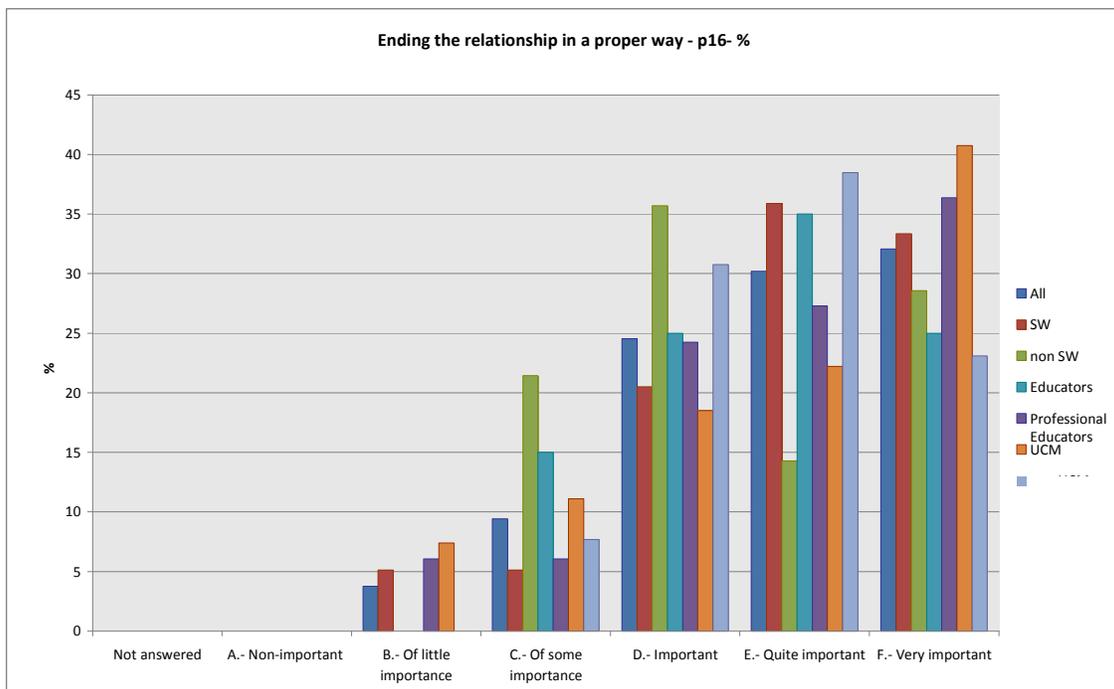
Graph 5

Even if the most important characteristic of the method is the membership of the value. This can be observed in the dispersion graphs, as it is shown in the following graphs 6 and 8:



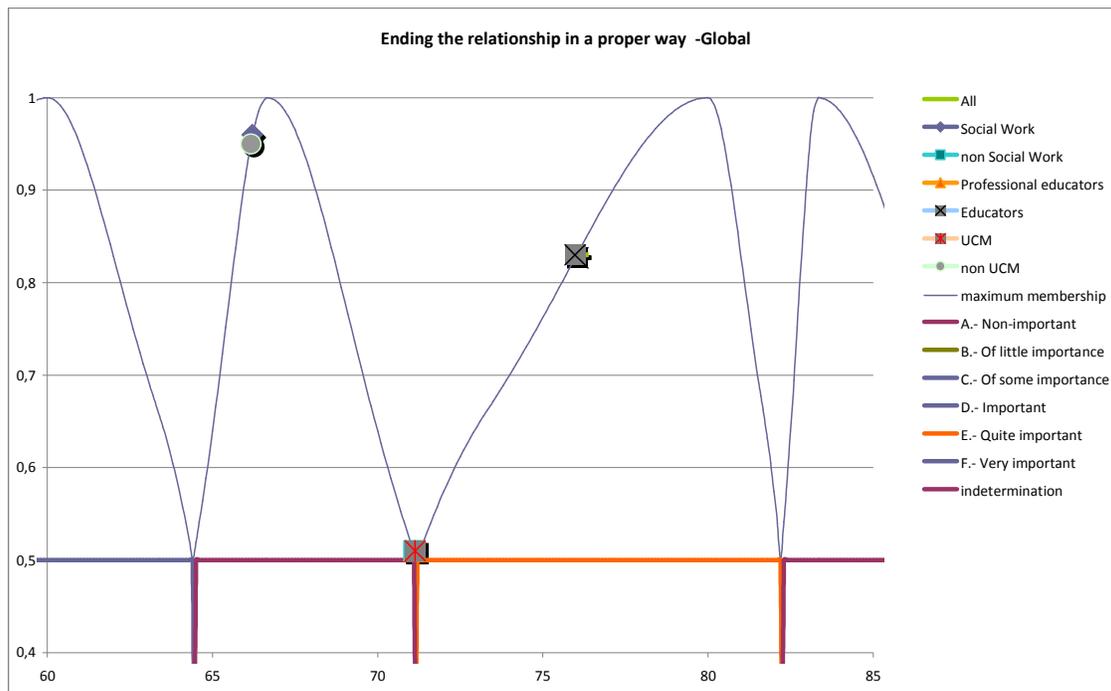
Graph 6

As it can be observed in the previous graph 6, from the seven analyzed groups two are located in the zone corresponding to the “Important” response and five are located in the zone corresponding to “Quite important”; both zones are separated by a zone of “indetermination” in which, in this case, there is no group analyzed. All of the memberships are above 0,75 so that these groups are far out of the zone of change.



Graph 7

In bar graph 7, which reflects the % of the responses from the question “Ending a relationship in a proper way”, they do not become easy to be interpreted through this form of representation of the data.



Graph 8

In this graph 8 the sets “Social Work” and “non UCM” are approximate to the maximum of indetermination. This means that they “belong” with much certainty to the fuzzy set of “indetermination” and consequently they are certain that their response is not any of the two laterals (nor “Important” neither “Quite important”). In these conditions such groups may be inclined, in the future, for any of the responses (let us remind you that points with a membership of 1 from this set represent one single multiple point).

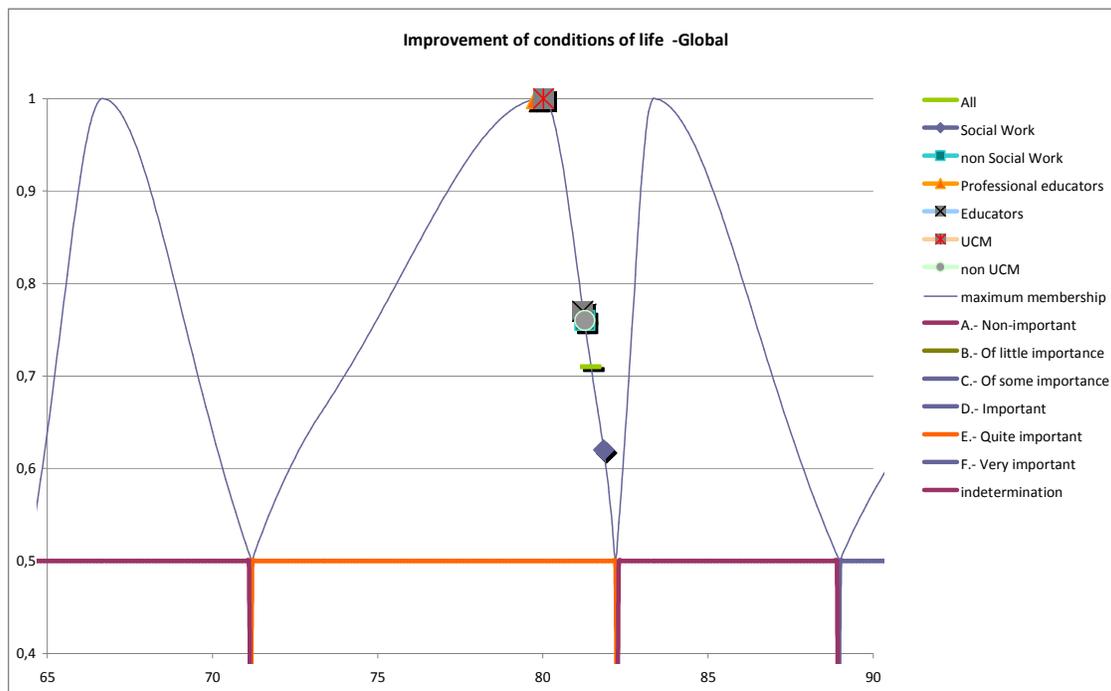
The sets “Educators” and “All” are located in the zone “Quite important” with memberships above 0,75. We can establish they are very certain about their response. The sets “Non Social Work”, “Professional educators” and “UCM” have memberships very proximate to 0,5 which is the zone of change between the response “Quite important” and “Indetermination” towards the response “Important”. Situations like this make possible to make decisions so that, in the future, their response may incline towards the zone of “Quite important”.

It must be observed that the graph shows us positions almost coincident among these three groupings of sets, this suggests that their opinions in respect of the importance of this concept are similar. This has to be confirmed with each of the questions related to the concept.

Another of the characteristics to be pointed out from this method is the possibility of obtaining the response from a concept integrated by several questions. We will comment farther ahead in this text briefly Graph 9, obtained through FLT for the concept “End a relationship in a proper way”.

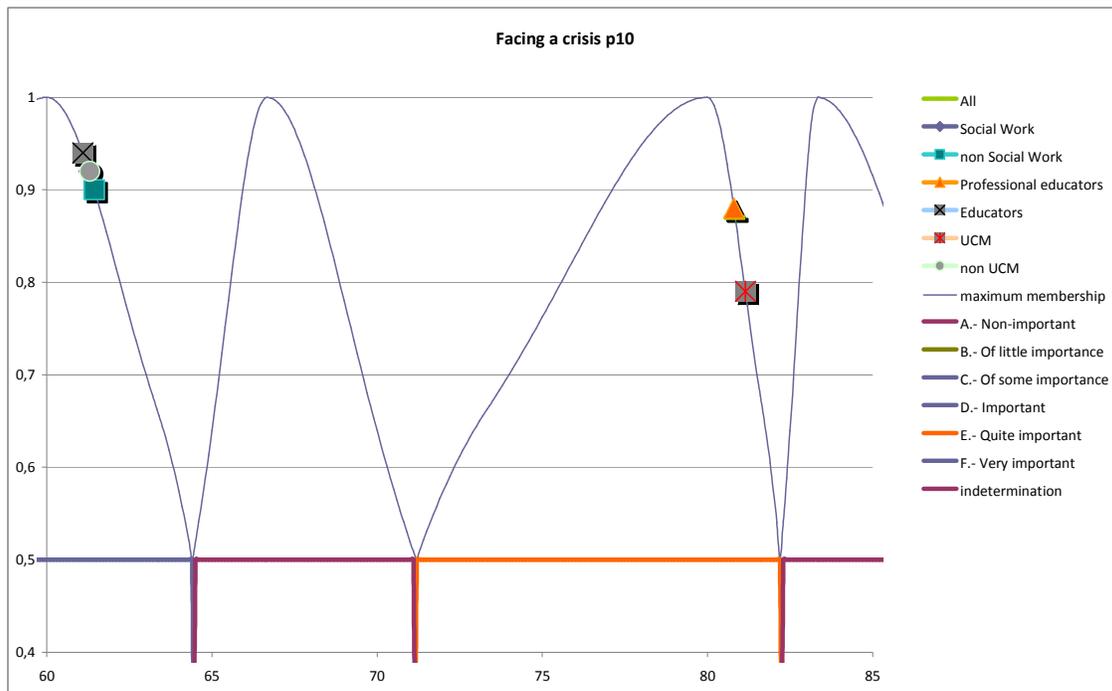
5. Conclusions

1. This study offers some ideas that result quite interesting in relation with the processing of the data derived from the questionnaire handed to the professors who educate the Social Work students at Universidad Complutense de Madrid and at other Spanish universities, and in relation with the professional competences of the social workers whom through FLT their decision making becomes easier, decreasing the subjectivity of the interpretations in comparison with the traditional processing of data.
2. The processing of the data, in other words of the responses given by the professors, using FLT offers a greater approximation to the group response than the processing of the data derived from questionnaires with CL (Traditional Logic).
3. The processing of the data, offered by the responses from the research questionnaires, using FLT shows the membership of the polled professors to each of the possible responses.
4. The processing of the responses given by the professors using FLT makes possible the measurement of the group indetermination from each of the questions, which may become very useful in the decision making.
5. FLT makes it easier for us the establishment of relationships between the memberships and the indeterminations of a response. The higher the grade of membership in the indetermination, the lower the possibility of change, whereas the lower the grade of membership in the indetermination, the higher the possibility of change.
6. All the polled professors, independently of the group they belong to, consider that the decision making as a professional competence of the social workers is important, that it is an intermediate response among those possible, among non-important, of little importance, of some importance, important, quite important and very important.
7. As Graph 9 demonstrates, all the professors place themselves in a scope of indetermination with respect to the question related to the improvement of conditions of life, notwithstanding this, professional educators and UCM are proximate to the value 1 of membership, which is the multiform point where changes to any of the other possible responses can be produced. Whereas the response of all of them is located below the 0,75 of membership, which indicates it is more proximate to the change towards “Very important”.



Graph 9

8. In relation with the importance of the professional competence of PLANNING when and how to reduce and end the relationships (contacts and services) in a proper way, non-Social Work professors distinguish themselves from all the others (Graph 6), whereas in the global response given to the end of a relationship in a proper way issue, they agree with professional educators (Graph 8) with a membership proximate to 0,5 which is the one where the change is produced; the response of all of them coincides with the UCM professors' in "Quite important" and non-UCM coincide with Social Work professors in an indetermination with a membership value of over 0,75, which is the zone of no change.
9. As Graph 10 shows, the importance of the professional competence of INFORMING OR CONTACTING with organizations and self-help groups that may encourage the change to cope with the problems and conflicts in order to prevent situations of crisis, resulted in the same response for the UCM and for the professional educators, coinciding with everyone, and, on the other hand, educators offer a different response in respect of this professional competence, coinciding with non-Social Work and non-UCM.



Graph 10

10. The study has empowered and continued with the research actions in execution by the UCM Research Group (940102) "Observatory for Social Intervention in Organizations", which the authors of this work belong to.

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7. Annex

Questions from the questionnaire (All of them had as responses: non-important, of little importance, of some importance, important, quite important and very important)

Question 1.

Mark the importance of the professional competence of INTERACTING with people, families, groups, organizations and communities for achieving changes, promoting the development of the same and improve the conditions of life through the use of Social Work methods and models.

Question 2.

Mark the importance of the professional competence of DEVELOPING and KEEPING intentioned relations among people, families, groups, organizations and communities taking on account ethnical, genre, age, disabilities, religious and sexual aspects.

Question 3.

Mark the importance of the professional competence of EXPLAINING the professional role of a social worker, their duties towards the organization they work for and the right of every user to confidentiality and to get to know about the current state of their case in every moment.

Question 4.

Mark the importance of the professional competence of PROVIDING emotional and material support that may make possible that people express, explore and value their emotions and feelings.

Question 5.

Mark the importance of the professional competence of COMFORTING people throughout the process of change by means of a supporting and helping relationship.

Question 6.

Mark the importance of the professional competence of LISTENING with efficacy, giving a constructive, useful and understandable feedback to people.

Question 7.

Mark the importance of the professional competence of IDENTIFYING the areas of intervention in order to establish the best line of action with people, families, groups, organizations, communities and others.

Question 8.

Mark the importance of the professional competence of MEDIATING and NEGOTIATING when people have different point of views with the intention to prevent situations of crisis and face the problems and conflicts.

Question 9.

Mark the importance of the professional competence of IDENTIFYING how to face current or potential problems should be done with the view to prevent situations of crisis and confront conflicts.

Question 10.

Mark the importance of the professional competence of INFORMING or CONTACTING with organizations and self-help groups that may support the change in order to deal with the problems and conflicts with the view to prevent situations of crisis.

Question 11.

Mark the importance of the professional competence of GIVING SUPPORT to families, people, groups, organizations or communities so that they may perform their own supervision, review and evaluation of every change over their needs and circumstances, and about the effectiveness of social work.

Question 12.

Mark the importance of the professional competence of COLLECTING, GATHERING, ANALYSING and EVALUATING the feedback received from all the sources about the changes over the needs and circumstances.

Question 13.

Mark the importance of the professional competence of IDENTIFYING and JUSTIFYING any necessary alteration on the services provided in order to evaluate the changes over the needs and circumstances.

Question 14.

Mark the importance of the professional competence of REGISTERING and USING the review of the results to evaluate the changes over the needs and circumstances.

Question 15.

Mark the importance of the professional competence of VALUING the separation between one encounter and another in order to reduce the contacts and end the relationship in a proper way.

Question 16.

Mark the importance of the professional competence of PLANNING when and how to reduce and end the relationships (contacts and services) in a proper way.

Question 17.

Mark the importance of the professional competence of REACHING A CONSENSUS over a set of additional supports that may become necessary after the intervention by a social worker before ending the relationship.

Question 18.

Mark the importance of the professional competence of INFORMING and REGISTERING matters not resolved, needs not covered and any risk that may come up from them, after ending the relationship.

Question 19.

Mark the importance of the professional competence of INTERVENING with people, families, groups, organizations and communities to help them make sound decisions about their needs, circumstances, risks, preferential options and resources.

Question 20.

Mark the importance of the professional competence of ANALISING if the strategy selected is feasible considering all the possible determinants (legal requirements of access, availability of posts, time of wait, etc.).

Question 21.

Mark the importance of the professional competence of PROMOTING the growth, development and independence of the persons identifying the opportunities to educate and create groups, using planning and role playing for the individual growth and the empowerment of the abilities.

Question 22.

Mark the importance of the professional competence of RESPONDING to situations of crisis valuing the urgency of such situations, planning and developing actions to face them and reviewing the results.