Towards a Fuzzy Questionnaire of Felder and Soloman for determining learning styles without dichotomic in the answers

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Abstract
The article shows the development and evaluation of the Learning Styles Fuzzy Questionnaire - FuzzyILS, based on the Felder and Silverman Learning Style Model and as an alternative fuzzy to the ILS Questionnaire created by Felder and Soloman. The FuzzyILS was created as an alternative to the limitation described by students who answered the ILS Questionnaire in previous research and they indicated that the dichotomy of the answers limited them to express their answers. The FuzzyILS has 5 options for each question then we calculate the degrees of membership in the fuzzy sets of the dimensions. Finally, the work shows the FuzzyILS evaluation, carried out in three phases, the first with 132 people in 5 universities in Venezuela and Brazil, the second evaluation with 180 students from the Central University of Venezuela and the third an internal consistency evaluation based on the Cronbach's alpha value.
Keywords: Felder & Soloman Questionnaire, Learning Styles, Felder and Silverman Learning Styles Model, Fuzzy Logic.

Hacia un cuestionario difuso de Felder y Soloman para determinar estilos de aprendizaje sin dicotomía en las respuestas

Resumen
El artículo muestra el desarrollo y la evaluación del cuestionario Fuzzy Learning Styles - FuzzyILS, basado en el modelo de estilo de aprendizaje Felder y Silverman y como una alternativa difusa al cuestionario ILS creado por Felder y Soloman. FuzzyILS se creó como una alternativa a la limitación descrita por los estudiantes que respondieron el cuestionario ILS en investigaciones anteriores e indicaron que la dicotomía de las respuestas los limitaba a expresar sus respuestas. El FuzzyILS tiene 5 opciones para cada pregunta, luego con las respuestas se determinan los grados de membresía en los conjuntos difusos de las dimensiones. Finalmente, el trabajo muestra la evaluación FuzzyILS, realizada en tres fases, la primera con 132 personas en 5 universidades de Venezuela y Brasil, la segunda evaluación con 180 estudiantes de la Uni-

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versidad Central de Venezuela y la tercera una evaluación de consistencia interna basada en el valor del alfa de Cronbach.

Palabras Clave: Cuestionario Felder y Soloman, Estilos de Aprendizaje, Modelo de Estilos de Aprendizaje de Felder y Silverman, Lógica Difusa.

Sumario: 1. Introducción. 2. Fuzzy Questionnaire Proposal. 2.1 The FuzzyILS. 2.2 Learning Style Evaluation Using FuzzyILS. 2.3 Case example. 3. FuzzyILS evaluation. 3.1 The evaluation process. 3.2 The results. 4. Conclusiones. Referencias.

1. Introduction

The learning style is defined as "a set of aptitudes, preferences, tendencies, and attitudes that a person has to do something and that is manifested through a behavioral pattern and different skills that make him distinguish himself from other people under a single etiquette in the way in which one conducts, dresses, speaks, thinks, learns, tells us what style can be defined knows and teaches" (García Cué, Santizo Rincón & Alonso García, 2009).

Thus, as students, depending on their learning style, consciously, controlled and intentionally use procedures (sets of steps, operations or skills) to learn and solve problems, that is, they structure their learning strategy (Díaz-Barriga & Hernández, 2010). The effectiveness of it depends a lot on the instructional technique used by the teacher; in fact, the instructional techniques do not work effectively in any learning situation (Ossandón & Castillo, 2006).

Therefore, Learning Styles are decisive in the teaching and learning process (Paredes, 2008). Felder & Silverman, for example, argue that students with a strong preference for a certain learning style may have difficulty in the process if the learning environment is not suitable for their learning style (Felder & Silverman, 1988), and additionally, few investigations correlate the teaching ways with learning styles of students, and fewer those that propose to interrelate them in the same model (Renes & Martínez, 2016).

To determine learning styles, several researchers have proposed different models, among them:

- Herman Witkin called the Field Dependency and Independence model (Witkin, 1964; Witkin & Goodenough, 1981).
- Rita and Kenneth Dunn (Dunn & Dunn, 1974).
- David Kolb (1976), identifying the main dimensions of learning: perception and processing.
- Peter Honey & Alan Mumford (1986), who started from the Kolb bases.
- Ned Herrmann (1982, 1990), who developed a model inspired by knowledge of brain function.
- Richard Bandler & John Grinder (1982) also known VAK by the initials of visual-auditory-kinesthetic, or Neuro-linguistic Programming model.
- Howard Gardner (1983), who developed the Multiple Intelligence Model.
- Richard Felder and Linda Silverman (Felder & Silverman, 1988) known Felder and Silverman's Model of Learning Styles (FSLSM).
- Elvira Popescu called Unified Learning Styles Model (ULSM) (Popescu, 2010).

A description and comparison of these models are in (Silva, 2018).

This study is based in the FSLSM, specifically, in the Learning Styles Questionnaire (ILS), developed for Felder & Soloman (2007), which has been widely used and widespread when analyzing styles, especially in areas of technology and science. It has even been integrated into platforms for the development of educational resources since instructional techniques can be associated with these styles (Silva, Ponce & Villalpando, 2014).

However, all the answers to this questionnaire are closed and dichotomous, representing a limitation when responding and expressing their opinions (Silva & Ponce, 2015). On this di-

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chotomy, Paul Kirschner (2017) indicates that the student is not associated with a style based on a set of measures in different dimensions, but is classified in a specific group, often exclusive. The first problem here is that people cannot simply group into specific and distinct groups, in fact, most of the differences between people in any dimension one can imagine are gradual and not nominal.

To respect, Litzinger, Lee, Wise & Felder (2007) raised a psychometric study of the ILS to determined if the dichotomous items to reducing the reliability, because two alternatives may be insufficient to discriminate differences consistently (Spector, 1992). This study concluded that the modification of the dichotomous response scale format to a five-option scale did not change the mean scores on the four learning style dimensions, but it did result in statistically significant reductions in the standard deviations of the scores for all scales and in substantial improvements in internal consistency reliability for three of the four scales. Consequently, this study proposes a new ILS with five-option, but these options associated with a fuzzy model, so it was proposed to incorporate fuzzy logic to it.

2. Fuzzy Questionnaire Proposal

One way to break the dichotomy of the ILS responses, and allow the inclusion of intermediate responses, with different degrees of occurrence or different degrees of belonging to the dichotomous sets originally raised, can be through fuzzy logic, originally proposed by Lofti Zadeh (1965).

Fuzzy logic is a multivalued logic, which allows representing mathematically uncertainty and vagueness, and with this allows the degree of gradual belonging of the elements to fuzzy sets (Zadeh, 1965), unlike classical theory, where an element it belongs or not to a certain set (0 or 1), as is the case with the dichotomous responses of the original ILS. Fuzzy logic can classify the elements in a set through the so-called degrees of belonging (values between 0 and 1).

So by incorporating fuzzy logic into the ILS, each person does not belong exclusively to one end of each FSLSM dimension and will belong to all groups and extremes, to different degrees, as indicated by Paul Kirschner (2017).

2.1 The FuzzyILS

The FuzzyILS contains 44 questions, the same being from the ILS questionnaire, but each question now has 5 possible answers, instead of being dichotomous, with only two possible answers (option for extreme A of the dimension and option for extreme B). Option 1 of the proposed FuzzyILS questionnaire matches the option for extreme A of the original ILS, and option 5 of FuzzyILS matches the option for extreme B of the ILS.

Each FuzzyILS option is a linguistic variable, created with the following rule:
a) Option 1: always extreme A
b) Option 2: almost always extreme A and rarely extreme B
c) Option 3: sometimes extreme A and sometimes extreme B
d) Option 4: almost always extreme B and rarely extreme A
e) Option 5: always extreme B

Thus, the 44 questions were developed with the proposed rule, changing the original ILS questionnaire and developing the FuzzyILS. The FuzzyILS questions are shown below:
Question 1, associated with the Active/Reflective dimension, "I understand something better after:"
a) Always practice
b) Almost always practice, and rarely reflect on them
c) Sometimes practice, and sometimes reflect on them
d) Almost always reflect on them, and rarely practice
e) Always reflect on them
Question 2, associated with the Sensing/Intuitive dimension, "I consider myself:"

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
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a) Always realistic
b) Almost always realistic, and rarely innovative
c) Sometimes realistic, and sometimes innovative
d) Almost always innovative, and rarely realistic
e) Always innovative

Question 3, associated with the Visual/Verbal dimension, "When I think about what I did yesterday, I am more likely to do it based on:"
a) Always an image
b) Almost always an image, and rarely words
c) Sometimes an image, and sometimes words
d) Almost always words, and rarely an image
e) Always words

Question 4, associated with the Sequential/Global dimension, "I tend to:"
a) Always understand the details of a topic, but not see its complete structure
b) Almost always understand the details of a topic, but not see its complete structure, and rarely understand the complete structure, but not see the details
c) Sometimes understanding the details of a topic, but not seeing its complete structure, and other times understanding the complete structure, but not seeing the details
d) Almost always understand the complete structure, but not see the details, and rarely understand the details of a topic, but not see its complete structure
e) Always understand the complete structure, but not see the details.

Question 5, associated with the Active/Reflective dimension, "When I am learning something new, it helps me:"
a) Always talk about it
b) Almost always talk about it, and rarely think about it
c) Sometimes talk about it, and sometimes think about it
d) Almost always think about it, and rarely talk about it
e) Always think about it

Question 6, associated with the Sentimental/Intuitive dimension, "If I were a teacher, I would prefer to give a course:"
a) Whenever it deals with facts and real life situations
b) Almost always when dealing with real events and situations in life, and rarely dealing with ideas and theories
c) Sometimes that deals with facts and real situations of life, and other times that deals with ideas and theories
d) Almost whenever he deals with ideas and theories, and rarely deals with facts and real life situations
e) Whenever dealing with ideas and theories

Question 7, associated with the Visual/Verbal dimension, "I prefer to obtain new information:"
a) Always of images, diagrams, graphs or maps
b) Almost always of images, diagrams, graphs or maps, and rarely of written instructions or verbal information
c) Sometimes of images, diagrams, graphs or maps, and sometimes of written instructions or verbal information
d) Almost always written instructions or verbal information, and rarely images, diagrams, graphs or maps
e) Always written instructions or verbal information

Question 8, associated with the Sequential/Global dimension, "Once I understand:"
a) All parties, I always understand the total
b) All parties, I almost always understand the total, and when I understand the total of something, I rarely understand how their parts fit together

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c) All parties, sometimes I understand the total, and when I understand the total of something, sometimes I understand how their parts fit together

d) The total of something, I almost always understand how its parts fit together, and when I understand all the parts, I rarely understand the total

e) The total of something, I always understand how its parts fit together

Question 9, associated with the Active/Reflective dimension, "In a study group that works with a difficult material, it is more likely that:"

a) Always participate and contribute ideas

b) Almost always participate and contribute ideas, and rarely do not participate and just listen

c) Sometimes participate and contribute ideas, and sometimes do not participate and just listen

d) Almost always do not participate and just listen, and rarely participate and contribute ideas

e) Never participate and just listen

Question 10, associated with the Sensing/Intuitive dimension, "It's easier for me:"

a) Always learn facts

b) Almost always learn facts, and rarely learn concepts

c) Sometimes learn facts, and sometimes learn concepts

d) Almost always learn concepts, and rarely learn facts

e) Always learn concepts

Question 11, associated with the Verbal/Visual dimension, "In a book with many images and graphics it is more likely that:"

a) Always check images and graphics carefully

b) I almost always carefully check the images and the graphics and rarely focus on the written text

c) Sometimes I carefully review the images and the graphics and other times I focus on the written text

d) I almost always concentrate on the written text, and rarely check the images and graphics carefully

e) Always concentrate on the written text

Question 12, associated with the Sequential/Global dimension, "When I solve math problems:"

a) I always work on solutions one step at a time

b) I almost always work on solutions one step at a time and rarely know what the solutions are, but then I have difficulty imagining the steps to reach them

c) Sometimes I work on the solutions one step at a time and other times I know what the solutions are, but then I have difficulty imagining the steps to reach them

d) I almost always know what the solutions are, but then I have difficulty imagining the steps to reach them and I rarely work on the solutions one step at a time

e) I always know what the solutions are, but then I have difficulty imagining the steps to reach them

Question 13, associated with the Active/Reflective dimension, "In the classes I have attended:"

a) I have usually come to know how many of the students are

b) Many times I have come to know how many of the students are

c) Sometimes I have come to know how many of the students are

d) I have rarely come to know how many of the students are

e) I have rarely come to know how many students are

Question 14, associated with the Sentimental/Intuitive dimension, "When I read non-fiction topics, I prefer:"

a) Always something that teaches me new facts or tells me how to do something

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
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b) Almost always something that teaches me new facts or tells me how to do something and rarely something that gives me new ideas to think about
c) Sometimes something that teaches me new facts or tells me how to do something and sometimes something that gives me new ideas to think about
d) Almost always something that gives me new ideas to think about, and rarely something that teaches me new facts or tells me how to do something
e) Always something that gives me new ideas to think about

Question 15, associated with the Verbal/Visual dimension, "I like teachers who:"
a) Always use many schemes on the board
b) They almost always use many schemes on the board, and rarely take much time to explain
c) Sometimes they use many schemes on the board, and sometimes they take a long time to explain
d) They almost always take a long time to explain, and rarely use many schemes on the board
e) They always take a long time to explain

Question 16, associated with the Sequential/Global dimension, "When I am analyzing a story or a novel:"
a) I always think about the incidents and try to accommodate them to configure the issues
b) I almost always think about the incidents and try to accommodate them to configure the issues, and rarely do I realize what the issues are when I finish reading and then I have to go back and find the incidents that show them
c) Sometimes I think about the incidents and try to accommodate them to configure the topics, and other times I realize what the issues are when I finish reading and then I have to go back and find the incidents that show them
d) I almost always realize what the issues are when I finish reading and then I have to go back and find the incidents that demonstrate them, and I rarely think about the incidents and try to accommodate them to configure the topics
e) I realize what the issues are when I finish reading and then I have to go back and find the incidents that show them

Question 17, associated with the Active/Reflective dimension, "When I start solving a task problem, it is more likely that:"
a) Always start working on your solution immediately
b) Almost always start working on your solution immediately, and rarely try first to fully understand the problem
c) Sometimes start working on your solution immediately, and other times try first to fully understand the problem
d) Almost always try first to fully understand the problem, and rarely start working on your solution immediately
e) Always try to fully understand the problem first

Question 18, associated with the Sentimental/Intuitive dimension, "I prefer the idea of:"
a) Always certainty
b) Almost always certainty, and rarely the theory
c) Sometimes certainty, and sometimes the theory
d) Almost always the theory, and rarely certainty
e) Always the theory

Question 19, associated with the Verbal/Visual dimension, "I remember better:"
a) Always what I see
b) Almost always what I see and rarely what I hear
c) Sometimes what I see and sometimes what I hear
d) Almost always what I hear and rarely what I see
e) Always what I hear

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
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Question 20, associated with the Sequential/Global dimension, "It is more important to me than a teacher:"
a) Always expose the material in clear sequential steps
b) I almost always expose the material in clear sequential steps, and rarely give me an overview and relate the material to other topics
c) Sometimes expose the material in clear sequential steps, and sometimes give me an overview and relate the material to other topics
d) Almost always give me an overview and relate the material to other topics, and rarely expose the material in clear sequential steps
e) Always give me an overview and relate the material to other topics

Question 21, associated with the Active/Reflective dimension, "I prefer to study:"
a) Always in a study group
b) Almost always in a study group, and rarely alone
c) Sometimes in a study group, and sometimes only
d) Almost always alone, and rarely in a study group
e) Always alone

Question 22, associated with the Sentimental/Intuitive dimension, "I consider myself:"
a) Always careful in the details of my work
b) Almost always careful in the details of my work and rarely creative in the way I do my work
c) Sometimes careful in the details of my work and sometimes creative in the way I do my work
d) Almost always creative in the way I do my work and rarely careful in the details of my work
e) Creative in the way I do my job

Question 23, associated with the Verbal/Visual dimension, "When someone gives me directions to new places, I prefer:"
a) Always a map
b) Almost always a map and rarely written instructions
c) Sometimes a map and sometimes written instructions
d) Almost times written instructions, and rarely a map
e) Always written instructions

Question 24, associated with the Sequential/Global dimension, "I learn:"
a) Always at a constant pace. If I study hard I get what I want
b) Almost always at a constant pace. If I study hard I get what I want, and rarely in the beginning and pauses. I get confused and suddenly I understand
c) Sometimes at a constant pace. If I study hard I get what I want, and other times in the beginning and pauses. I get confused and suddenly I understand
d) Almost always in the beginning and pauses. I get confused and suddenly I understand, and rarely at a constant pace. If I study hard I get what I want
e) Always at the beginning and pauses. I get confused and suddenly I understand

Question 25, associated with the Active/Reflective dimension, "I prefer first:"
a) Always do something and see what happens
b) I almost always do something and see what happens, and rarely think about how I am going to do something
c) Sometimes do something and see what happens, and sometimes think how I am going to do something
d) I almost always think about how I am going to do something, and rarely do something and see what happens
e) Always think about how I'm going to do something

Question 26, associated with the Sentimental/Intuitive dimension, "When I read for fun, I like writers who:"

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
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a) They always say clearly what they want to imply
b) They almost always say clearly what they want to imply, and rarely say things creatively and interestingly
c) Sometimes they say clearly what they want to imply, and other times they say things creatively and interestingly
d) They almost always say things creatively and interestingly, and rarely say clearly what they want to imply
e) They always say things creatively and interestingly

Question 27, associated with the Verbal/Visual dimension, "When I see a scheme or outline in class, I am more likely to remember:"
a) Always the image
b) Almost always the image and rarely what the professor said about it
c) Sometimes the image and sometimes what the professor said about it
d) Almost always what the professor said about her, and rarely the image
e) Always what the teacher said about her

Question 28, associated with the Sequential/Global dimension, "When I face an information body:"
a) I always concentrate on the details and lose sight of the total
b) I almost always concentrate on the details and lose sight of the total, and rarely try to understand the whole before going to the details
c) Sometimes I focus on the details and lose sight of the total, and other times I try to understand the whole before going to the details
d) I almost always try to understand the whole before going to the details, and rarely do I focus on the details and lose sight of the total of it
e) I always try to understand the whole before going to the details

Question 29, associated with the Active/Reflective dimension, "I remember more easily:"
a) Always something I have done
b) Almost always something I've done, and rarely something I've thought about a lot
c) Sometimes something I've done, and sometimes something I've thought about a lot
d) Almost always something I've thought about a lot, and rarely something I've done
e) Always something I've thought about a lot

Question 30, associated with the Sensing/Intuitive dimension, "When I have to do a job, I prefer:"
a) Always master a way of doing it
b) Almost always master a way of doing it, and rarely try new ways to do it
c) Sometimes master a way of doing it, and sometimes try new ways to do it
d) Almost always try new ways to do it, and rarely master a way to do it
e) Always try new ways to do it

Question 31, associated with the Verbal/Visual dimension, "When someone teaches me data, I prefer:"
a) Always graphics
b) Almost always graphics, and rarely summaries with text
c) Sometimes graphics, and sometimes summaries with text
d) Almost always summaries with text, and rarely graphics
e) Always summaries with text

Question 32, associated with the Sequential/Global dimension, "When I write a paper, I am more likely to do it (think or write):"
a) Always from the beginning and advance
b) Almost always from the beginning and advance, and rarely in different parts and then order them
c) Sometimes from the beginning and advance, and sometimes in different parts and then order them

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
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d) Almost always in different parts and then order them, and rarely from the beginning and advance

e) Always in different parts and then order them

Question 33, associated with the Active/Reflective dimension, "When I have to work on a group project, I first want to do:"

a) Always a "brainstorm" where everyone contributes ideas

b) Almost always a "brainstorm" where everyone contributes ideas, and rarely the "brainstorm" personally and then join the group to compare ideas

c) Sometimes a "brainstorm" where everyone contributes ideas, and sometimes the "brainstorm" personally and then join the group to compare ideas

d) Almost always the "brainstorm" personally and then join the group to compare ideas, and rarely a "brainstorm" where everyone contributes ideas

e) Always the "brainstorm" personally and then join the group to compare the ideas

Question 34, associated with the Sensing/Intuitive dimension, "I consider:"

a) Whenever it is better praise to call someone sensing

b) Almost always it is better to praise calling someone sensing, and rarely is it better to call it imaginative

c) Sometimes it is better to praise to call someone sensing, and other times to call it imaginative

d) Almost always it is better to praise calling someone imaginative, and rarely calling him sensing

e) Whenever it is better praise to call someone imaginative

Question 35, associated with the Verbal/Visual dimension, "When I meet people at a party, I am more likely to remember:"

a) Always their appearance

b) Almost always their appearance, and rarely what they say about themselves

c) Sometimes what their appearance looks like, and sometimes what they say about themselves

d) Almost always what they say about themselves, and rarely how is their appearance

e) Always what they say about themselves

Question 36, associated with the Sequential/Global dimension, "When I am learning a subject, I prefer:"

a) Always stay focused on that topic, learning as much as I can from him

b) I almost always stay focused on that topic, learning as much as I can from it, and rarely make connections between that topic and related topics

c) Sometimes I stay focused on that topic, learning as much as I can from it, and other times make connections between that topic and related topics

d) I almost always make connections between that topic and related topics, and rarely stay focused on that topic, learning as much as I can from it

e) Always make connections between that topic and related topics

Question 37, associated with the Active/Reflective dimension, "I consider myself:"

a) Always open

b) Almost always open, and rarely reserved

c) Sometimes open, and sometimes reserved

d) Almost always reserved, and rarely open

e) Always reserved

Question 38, associated with the Sentimental/Intuitive dimension, "I prefer courses that give more importance to:"

a) Always concrete material (facts, data)

b) Almost always concrete material (facts, data), and rarely abstract material (concepts, theories)

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

c) Sometimes concrete material (facts, data), and sometimes abstract material (concepts, theories)
d) Almost always abstract material (concepts, theories), and rarely concrete material (facts, data)
e) Always abstract material (concepts, theories)

Question 39, associated with the Verbal/Visual dimension, "To have fun, I prefer:"
a) Always watch television
b) Almost always watch television, and rarely read a book
c) Sometimes watching television, and sometimes reading a book
d) Almost always read a book, and rarely watch television
e) Always read a book

Question 40, associated with the Sequential/Global dimension, "Some teachers start their classes by outlining what they will teach. Those sketches are: "
a) Always something useful for me
b) Almost always something useful, and rarely very useful for me
c) Sometimes something useful, and sometimes very useful for me
d) Almost always very useful, and rarely useful for me
e) Always very useful for me

Question 41, associated with the Active/Reflective dimension, "The idea of doing a group task with only one qualification for all:"
a) It always seems good to me
b) It almost always seems good to me, and rarely
c) Sometimes it seems good to me, and sometimes it doesn't
d) It almost never seems good to me, and rarely does it
e) It never seems good to me

Question 42, associated with the Sentitive/Intuitive dimension, "When I do large calculations:"
a) I always tend to repeat all my steps and check carefully
b) I almost always tend to repeat all my steps and carefully review my work, and rarely do I get tired of doing their review and I have to make an effort to do it
c) Sometimes I tend to repeat all my steps and carefully review my work, and other times I get tired of doing its review and I have to make an effort to do it
d) I almost always tend to repeat all my steps and carefully review my work, and rarely do I tend to repeat all my steps and carefully review my work
e) I always get tired of doing his review and I have to make an effort to do it

Question 43, associated with the Verbal/Visual dimension, "I tend to remember places where I have been:"
a) Always easily and quite accurately
b) Almost always easily and quite accurately, and rarely with difficulty and without much detail
c) Sometimes easily and quite accurately, and sometimes with difficulty and without much detail
d) Almost always easily and fairly accurately, and rarely easily and fairly accurately
e) Always with difficulty and without much detail

Question 44, associated with the Sequential/Global dimension, "When I solve problems in a group, it is more likely that I:"
a) Always think of the steps to solve problems
b) Almost always think about the steps for solving problems, and rarely think about the possible consequences or applications of the solution in a wide range of fields
c) Sometimes think about the steps to solve the problems, and sometimes think about the possible consequences or applications of the solution in a wide range of fields

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
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d) Almost always think about the possible consequences or applications of the solution in a wide range of fields, and rarely think about the steps to solve the problems

e) Always think about the possible consequences or applications of the solution in a wide range of fields

Each option has an evacuation or degree of belonging in each fuzzy set. The two fuzzy sets are the two extremes of the question dimension. For example questions 1, 5, 9, 13, 17, 21, 25, 29, 33, 37 and 41 are related to the Active/Reflective dimension so that the two fuzzy sets are Active (extreme A) and Reflective (extreme B).

Figure 1 shows the two fuzzy sets for each question. The two extremes A and B, the 5 options and the degrees of belonging in the set are shown.
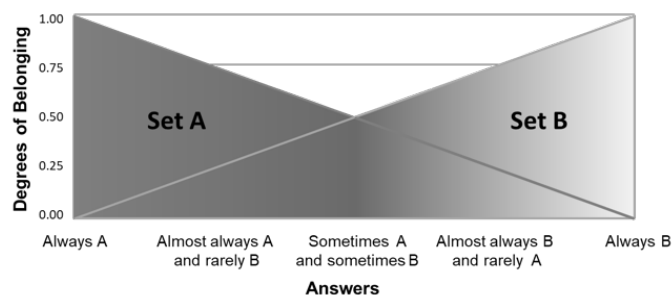

Figure 1. FuzzyILS fuzzy sets for each question.

In such a way that a possible evaluation, where the person answers a question belonging to the Active extreme in the Active/Reflective dimension, but their selection is not totally at the extreme, and their answer corresponds to option 2 (almost always option A and rarely option B), and the degrees of belonging of 0.75 to the set A (extreme A of the dimension and 0.25 to the set B (extreme B), as shown in Figure 2.
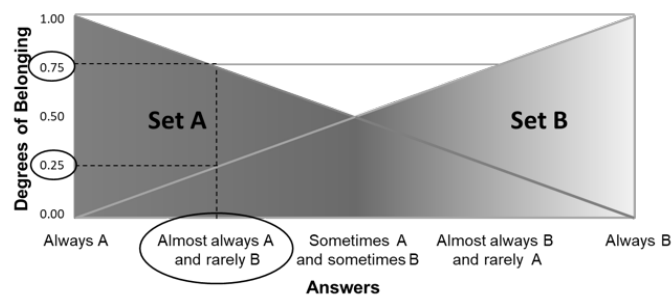

Figure 2. Degrees of belonging of fuzzy sets.

So if the person answers most of the questions related to the Active/Reflective dimension, as the case indicated above, the values of the FuzzyILS questionnaire in the Active/Reflective dimension could be as shown in Table 1.

Table 1.
Example of the FuzzyILS questionnaire values for the Active/Reflective dimension, where the Active extreme prevails.

Question	Active	Reflexive
1	0.75	0.25
5	0.75	0.25
9	0.75	0.25
13	0.75	0.25

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

Question	Active	Reflexive
17	0.75	0.25
21	0.75	0.25
25	0.75	0.25
29	0.75	0.25
33	0.75	0.25
37	0.75	0.25
41	0	1
Total	**7.5**	**3.5**

2.2 Learning Style Evaluation Using FuzzyILS

Before the evaluation of the Learning Style, the values of the extremes of each dimension should be obtained, using the FuzzyILS questionnaire, such as the values shown in Table 1, where the Active extreme obtained the value 7.5 and the extreme Reflective value 3.5.

It is important to note that in FuzzyILS the difference of the major extreme minus the minor extreme is not calculated, but both extremes must be evaluated in their respective fuzzy sets.

Each extreme of the 4 Dimensions of the FSLSM, has a fuzzy set definition in the FuzzyILS, defined according to the intervals indicated in (1):

$$\mu(x) \begin{cases} \frac{1}{16}x \, , & 0 \leq x < 2 & \text{Weak degree} \\ \frac{1}{8}x - \frac{1}{8} \, , & 2 \leq x < 9 & \text{Moderate degree} \\ 1 \, , & 9 \leq x \leq 11 & \text{Strong degree} \end{cases} \tag{1}$$

Based on the μ (x) function, the value of belonging to the weak, moderate and strong sets, corresponding to each extreme of each dimension, is obtained. X corresponds to the value of the extreme of the dimension obtained with the FuzzyILS questionnaire.

Figure 3 shows the fuzzy assembly used for all the extreme of the FSLSM Dimensions, created for the FuzzyILS questionnaire.
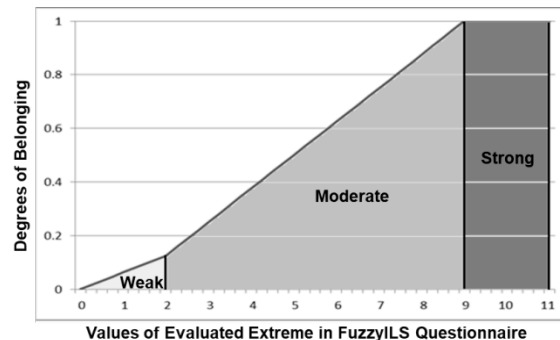

Figure 3. Fuzzy sets to obtain the degree of belonging for
each extreme in the FSLSM Dimensions.

For values between 0 and 2, the evaluated extreme has a weak degree, between 2 and 9, it has a moderate degree, and finally, values between 9 and 11, has a strong degree.

It is important to highlight that fuzzy sets were defined with the help of a professional in cognitive psychology and pedagogy, using a knowledge education technique called Protocol Analysis, where multiple values are offered and it is requested that they be included within pre-established sets and that additionally assign membership values between 0 and 1.

According to the fuzzy sets defined, the values in Table 2, corresponding to 7.5 for Active and 3.5 for Reflective, it is concluded that the person has a Moderate membership of 0.81 to the Active, and Moderate set from 0.31 to Reflective, being naturally more Active than Reflective.

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

Figure 4 shows the degrees of membership of the FuzzyILS questionnaire values, in the fuzzy sets of the Active/Reflective dimension, of the example in Table 1.
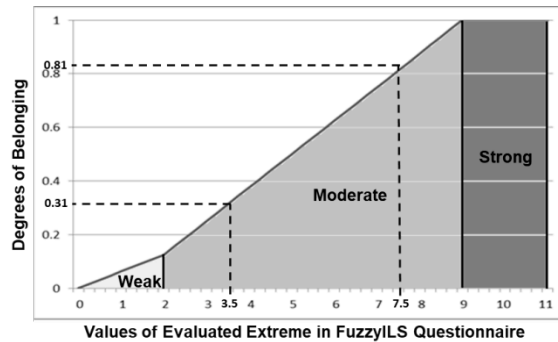

Figure 4. Degrees of membership of the FuzzyILS questionnaire values in the fuzzy sets of the Active/Reflective dimension, from the example in Table 1.

2.3 Case example

The following example shows the values of the answers given by a student of the Bachelor of Computer Science, from the Central University of Venezuela, who was asked to answer the FuzzyILS, obtaining the values shown in Table 2 for each of the dimensions of the FSLSM.

Table 2.
Fuzzy evaluations of each question, using FuzzyILS, showing the values for each extreme of each dimension of the FSLSM Model.

Dimension 1				Dimension 2		
Question	Active	Reflexive		Question	Sensing	Intuitive
1	0.75	0.25		2	0.25	0.75
5	0.50	0.50		6	0.25	0.75
9	0.50	0.50		10	0.5	0.5
13	0.75	0.25		14	0.75	0.25
17	0.75	0. 5		18	0.5	0.5
21	0.25	0.75		22	0.25	0.75
25	0.50	0.50		26	0.25	0.75
29	0.75	0.25		30	0.25	0.75
33	0.50	0.50		34	0	1
37	0.75	0.25		38	0.75	0.25
41	0	1		42	0	1
Total	6.0	5.0		Total	4.75	6.25

Dimension 3				Dimension 4		
Question	Visual	Verbal		Question	Sequential	Global
3	1	0		4	0.75	0.25
7	0.75	0.25		8	1	0
11	1	0		12	0.75	0.25
15	0.75	0.25		16	1	0
19	0.75	0.25		20	0.75	0.25
23	0.5	0.5		24	1	0
27	0.75	0.25		28	1	0
31	0.75	0.25		32	0.75	0.25

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

35	1	0		36	0.5	0.5
39	1	0		40	0.5	0.5
43	0.75	0.25		44	0.75	0.25
Total	**9**	**2**		**Total**	**8.75**	**2.25**

Once all the questions asked with the FuzzyILS were evaluated the dimensions were evaluated using the fuzzy functions of Equation 1.

Figure 5 shows the fuzzy evaluation of the Active/Reflective dimension where it is observed that the values of the responses of the dimension were 6 for the Active extreme corresponding to a moderate degree of membership of 0.625 and with a value of 5 for the reflexive extreme corresponding to a moderate degree of belonging of 0.5. In this way, the student is Moderate Active with a degree of membership of 0.625 and is Moderate Reflective with a degree of membership of 0.5.
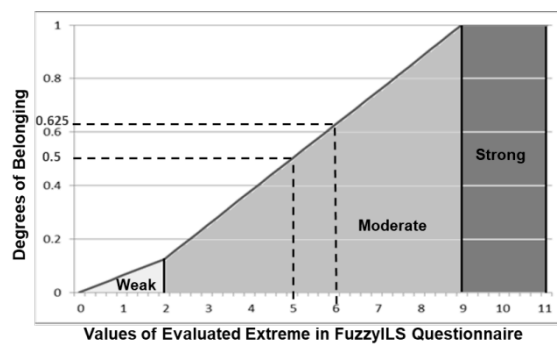

Figure 5. Evaluation of the Active/Reflective dimension in fuzzy sets.

Figure 6 shows the fuzzy evaluation of the Sensing/Intuitive dimension. where it is observed that the values of the responses of the dimension were 4.75 for the Sensing extreme corresponding to a moderate degree of membership of 0.468 and with a value of 6.25 for the Intuitive extreme. This corresponding to a moderate degree of membership of 0.666. Thus the student is Moderate Sensing with a membership degree of 0.468 and is Intuitive Moderate with a membership degree of 0.666.
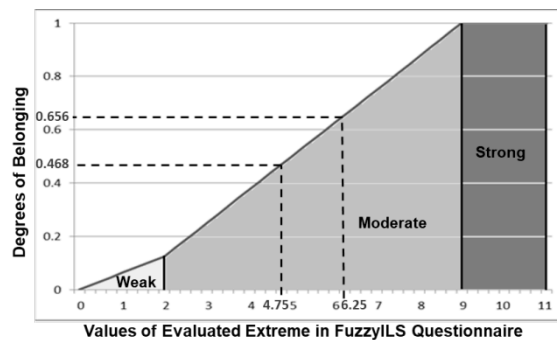

Figure 6. Evaluation of the Sensing/Intuitive dimension in fuzzy sets.

Figure 7 shows the diffuse evaluation of the Visual / Verbal dimension where it is observed that the values of the responses of the dimension were 9 for the Visual extreme corresponding to a strong degree of belonging of 1 and with a value of 2 for the Verbal extreme corresponding to a moderate degree of belonging of 0.125. In this way, the student is Strong Visual with a membership degree of 1 and is Verbal Moderate with a membership degree of 0.125. Here we observe that the Verbal extreme is in the Weak and Moderate limit having the minimum possible value within the Moderate set.

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
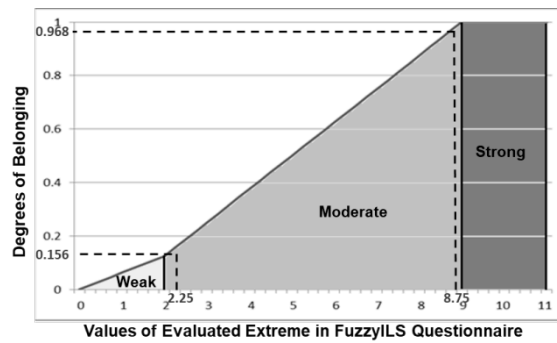www.revistaestilosdeaprendizaje.com

Figure 7. Evaluation of the Visual/Verbal dimension in fuzzy sets.

Figure 8 shows the fuzzy evaluation of the Sequential/Global dimension. where it is observed that the values of the responses of the dimension were 8.75 for the Sequential extreme. corresponding to a moderate degree of membership of 0.968 and with a value of 2.25 for the Global extreme corresponding to a moderate membership of 0.156. In this way, the student is Moderate Sequential with a membership degree of 0.968 and is Global Moderate with a membership degree of 0.156. Here we observe that the Sequential extreme is very close to being strong and the Global extreme is very close to being weak.
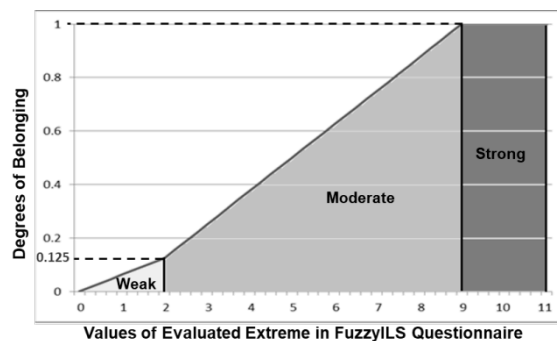

Figure 8. Evaluation of the Sequential/Global dimension in fuzzy sets.

3. FuzzyILS evaluation

To evaluate the FuzzyILS we completed three processes. These and the results obtained are described below.

3.1 The evaluation process

First, we did an online test with the 44 questions of the original ILS and their corresponding 44 questions of the FuzzyILS, and we asked in each of the questions: Do you consider the FuzzyILS a better way to evaluate the Learning Style than the ILS Questionnaire? The possible answers were (Yes/No). This test was completed by 132 people from the Central University of Venezuela, the Federal University of Rio Grande do Sul (UFRGS, Brazil), the Federal University of Pelotas (UFPEL, Brazil), the Federal University of Pampa (Unipampa, Brazil) and the Federal University of Alagoas (UFAL, Brazil).

The second evaluation process was also an online test applied to 180 students of the Bachelor of Computing of the Central University of Venezuela, where we show them the original ILS and the FuzzyILS, and then we ask them the following: Is FuzzyILS a better way to evaluate the Learning Style than the ILS Questionnaire? Here we used the Likert scale with five options: totally agree, agree, neither agree nor disagree, disagree and **totally disagree. In**

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

this test, it was not necessary to answer the questionnaires ILS, neither the original nor the FuzzyILS.

The last one was an internal consistency analysis of the FuzzyILS, about the 132 answers of the first process. The internal consistency reliability refers to the consistency of results across items within a test and is assessed by checking for correlated answers for multiple questions designed to test the same construct. This can be assessed using Cronbach's alpha which is a classic test on psychometric scales (Kline, 1993) that assesses the consistency of the survey as good when the results for each scale are between 0.7 and 0.9 (Troiano, Breitman & Gete-Alonso, 2004).

Some previous works have carried out similar analyzes in the ILS questionnaire using Cronbach's alpha. Table 3 shows some previous evaluations.

Table 3.
Some previous evaluations of the ILS questionnaire, using Cronbach's alpha.

Authors	N	Cronbach's alpha				
		Sensing	Visual	Sequential	Active	Mean
Van Zwanenburg, Wilkinson & Anderson (2000)	279	0.65	0.56	0.41	0.51	0.53
Livesay et al. (2002)	255	0.72	0.60	0.54	0.56	0.61
Zywno (2003)	557	0.70	0.63	0.53	0.60	0.62
Troiano, Breitman & Gete-Alonso (2004)	414	0.62	0.57	0.44	0.51	0.54
Felder & Spurlin (2005)	584	0.76	0.69	0.55	0.70	0.68
Felker & Gosky (2015)	145	0.81	0.67	0.56	0.51	0.64
Brito-Orta & Espinosa-Tanguma (2015)	265	0.58	0.61	0.38	0.42	0.50
Mean	357	0.69	0.62	0.49	0.54	

The best evaluation was obtained by Felder & Spurlin (2005), where Sensing and Sequential were the second-best results, and Visual and Active were the best results. Also, these authors work with the greatest sample. The dimension best evaluated was Sensing and the worst was Sequential.

3.2 The results

In the first process, the results were: 73.09% of affirmative answers and 26.91% of negative responses. Being question 19 the best evaluated (90.91% of affirmative answers) and question 16 the worst evaluated (62.12% of affirmative answers).

Below we show the questions 16 and 19, in their ILS version and the FuzzyILS version.

Question 16, corresponding to the Sequential/Global Dimension: "When I am analyzing a story or a novel:"
Options of the original ILS version
  a) I think about the incidents and try to accommodate them to configure the issues
  b) I realize what the issues are when I finish reading and then I have to go back and find the incidents that show them
Options of the FuzzyILS version
  a) I always think about the incidents and try to accommodate them to configure the issues

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

b) I almost always think about the incidents and try to accommodate them to configure the issues. and rarely do I realize what the issues are when I finish reading and then I have to go back and find the incidents that show them

c) Sometimes I think about the incidents and try to accommodate them to configure the topics. and other times I realize what the issues are when I finish reading and then I have to go back and find the incidents that show them

d) I almost always realize what the issues are when I finish reading and then I have to go back and find the incidents that demonstrate them and rarely do I think about the incidents and try to accommodate them to configure the topics. and rarely

e) I always realize what the issues are when I finish reading and then I have to go back and find the incidents that show them

Question 19, corresponding to the Visual/Verbal Dimension: "I remember better:"
Options of the original ILS version
a) What I see
b) What I hear
Options of the FuzzyILS version
a) Always what I see
b) Almost always what I see and rarely what I hear
c) Sometimes what I see and sometimes what I hear
d) Almost always what I hear and rarely what I see
e) Always what I hear

Figure 9 shows the results of the first evaluation process, where all FuzzyILS questions had better results than the ILS questions.
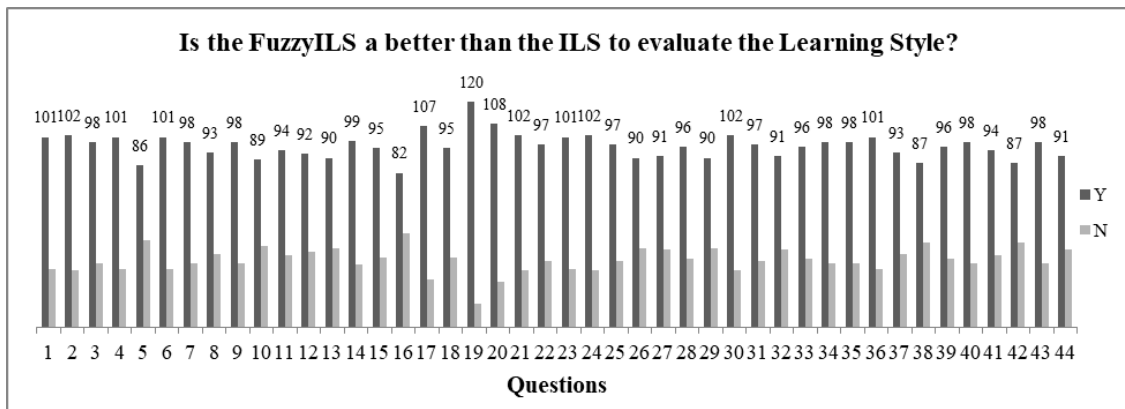

Figure 9. Results of the question "Do you consider the FuzzyILS proposal a better way to evaluate the Learning Style than the ILS Questionnaire?" for each question.

The second evaluation process was also an online test applied to 180 students of the Bachelor of Computing of the Central University of Venezuela, where we were only one question: Do you consider the FuzzyILS a better than the ILS Questionnaire to evaluate the Learning Style? Here we used the Likert scale with five options: totally agree, agree, neither agree nor disagree, disagree and totally disagree.

In the second evaluation, we obtained favorable results, with a total of 162 students (90%) who responded totally agree and agree; the other 18 students (10%) responded neither agree nor disagree o responses disagree. Figure10 shows the totals results of each option.
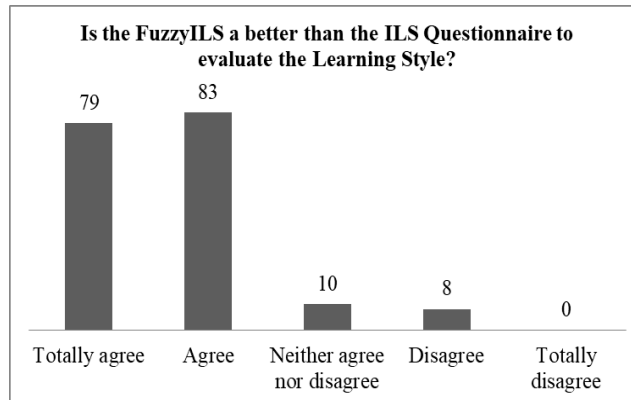
Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

Figure 10. Results of the question "Is the FuzzyILS is a better than the ILS Questionnaire to evaluate the Learning Style?".

The third evaluation was internal consistency reliability, that is to say, the consistency of results across items within a test and this is assessed by checking for correlated answers for multiple questions designed to test the same construct. Table 4 shows the Cronbach´s alpha for all dimensión.

In the FuzzyILS the students are associated with both extremes of dimension, in fact, the mean of Sensing is 4.62 and the mean of Intuitive is 6.37 because the persons are Sensing with the value what after representing a degree in the set weak, moderate and strong. The standard deviation is the same in both extremes, then it is only one for dimension, and de variance and Cronbach´s alpha too.

Table 4.
Cronbach's alpha for four dimensions of FuzzyILS.

Dimension	N	Σ var	Mean	Std. Dev.	Cronbach´s alpha
Sensing/Intuitive	132	0.51	4.62 / 6.37	2.04	0.88
Visual/Verbal	132	0.51	5.69 / 5.30	1.67	0.82
Sequential/Global	132	0.61	8.10 / 2.89	1.67	0.78
Active/Reflexive	132	0.67	6.03 / 4.96	2.03	0.84

These results are better values than previous analysis, showed in table 3, and they are also bigger than 0.7, in fact, three dimensions are bigger than 0.8. The dimension best evaluated is Sensing and the worst Sequential, like the previous works.

According to these results, there is evidence that the FuzzyILS is a better alternative than the traditional ILS Questionnaire.

4. Conclusions

In FuzzyILS each question has 3 more answers options than ILS, which expanding the possibilities of responses and not using only dichotomous responses (such as ILS). This development allows determining the learning styles with the halftones that real life the persons have because it is not common a person with a very marked learning style since people generally have combinations of styles in different degrees.

ILS have three degrees (strong, moderate and balance), now the FuzzyILS have three too, but they are strong, moderate and weak. The weak when the value obtained in the FuzzyILS Questionnaire is greater than or equal to 0 and less than 2 at the extreme of the Dimension; the moderate state when the value is equal or greater than 2 and less than 9 for the extreme evaluated, and finally strong when the value is between 9 and 11.

Revista de Estilos de Aprendizaje / Journal of Learning Styles Vol. 13 Núm. 25, 146-166
ISSN: 1988-8996 / ISSN: 2332-8533
www.revistaestilosdeaprendizaje.com

The evaluation of the proposal was carried out in the first instance on 132 people obtaining a majority of favorable responses towards FuzzyILS (on average 73.09% of affirmative answers).

A second evaluation was carried out on 180 students obtaining 90% of positive responses. Specifically that they totally agree and agree that the FuzzyILS proposal is a better way to evaluate the Learning Style than the traditional ILS Questionnaire.

The last evaluation presents higher values than previous works, where the internal consistency of the ILS was analyzed, that is, the FuzzyILS proposal shows greater internal consistency than the ILS, determined with a sample of 132 students, evidencing that FuzzyILS is a valid proposal, although It is recommended to continue the tests, and to analyze greater consistency through larger samples of people and other additional techniques.

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