International Journal of Innovative
Computing, Information and Control
Volume **15**, Number **2**, April **2019**

 ISSN 1349-4198
pp. **681–695**

A MULTIPOLAR-VALUED FUZZY SETS APPROACH TO TEACHING PEOPLE WITH DISABILITIES

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Received June 2018; revised October 2018

Abstract. *Focused on deaf students, this paper approaches a new method of instruction through computer software that is able to instruct in a particular way the students with special needs. This approach is fully implemented and evaluated in an educational application model, called model of Digitized Mental Architecture – DMA. Particularly, DMA performs user modeling by dynamically identifying and updating a student's knowledge level of all the concepts of the domain knowledge. The concept of DMA is based on Multipolar-Valued Fuzzy Set (MVFS) that is used to represent the dependences among the domain concepts. DMA uses fuzzy sets to represent a student's knowledge level as a subset of the domain knowledge. Thus, it combines fuzzy theory with the overlay model. Moreover, it employs a novel inference mechanism that dynamically updates user stereotypes on fuzzy sets. The gain from this novel combination is as significant as a student level of knowledge is represented in a more realistic way by automatically modeling the learning process of a student the system can provide individualized adaptive advice. The repeatability of your applications builds a solid foundation for education, according to behavioral standards set. This cognitive ability to infer on what we observe and perceive, regarded as intrinsic human beings, does not depend of their physical capacity. This article allows reproducing inferences about sensory stimuli of deaf, focused on the implementation of DMA. In this proposal, we evaluate the contextual aspects experienced by learners during the interactions between the constituent elements of a study session, based on experiments on a public school with a teacher and two deaf students enrolled in high school. Therefore, this model constitutes a novel fuzzy tool, which offers dynamic adaptation to deaf users' needs and preferences of adaptive systems, providing expansion of the possibilities of social inclusion.*

Keywords: Fuzzy sets, Fuzzy systems and their applications, Knowledge discovery

1. **Introduction.** The ideas about intelligence have been expanded to become the part emotions of intelligent systems. The books "Emotional Intelligence" by D. Goleman [1] and "Descartes' Error" by A. R. Damasio [2] have greatly influenced this current view of intelligence. Goleman found that only associating intelligence with IQ (Intelligence Quotient) and genetic factors is a narrow view of reality.

Damasio has shown that the reasoning is inseparable emotion because the neuronal circuits, responsible for both, operate together. Based on his extensive knowledge of the brain, he presented a clear explanation of how reason and emotion interact to create decision-making processes, plan to act, etc. Emotion and reasoning are adaptive mechanisms responsible for social adaptation of persons.

Since ancient Greece, Aristotle (384-322 B.C.) in "Prior Analytics", clearly states that everything based on a syllogism, is some kind of identity. Even syllogisms that result

DOI: 10.24507/ijicic.15.02.681

from contrary terms or not applicable to the same individual are reducible to a syllogism figure, in which there is a minimum identity [3].

From that philosophical sustention, it can be inferred about the existence of this intrinsic cognitive faculty of human beings, to create such relationships and map their respective universes, finites, hitched to the tangency or intersection with the world that surrounds them. The process that appropriates the language, for example, is essential in human development, when it allows the appropriation of World Reference Systems, considering that cognition and language are processes which overlap the constitution of the subject [4].

Gardner [5], in his theory of multiple intelligences, argues that intelligence has many facets. The most relevant, for the present work is the "intrapersonal". The "intrapersonal intelligence" is related with self-knowledge skills, understanding of their own feelings and social value. According to Gardner the development of this type of intelligence is as important as the development of those more privileged traditional teaching, linguistic and logical-mathematical. It could be considered as a facet of "emotional intelligence" proposed by Goleman.

From the point of view of people with disabilities, to notice these tangencies or intersections assumes greater or lesser degree of difficulty depending on the nature and severity of sensory losses: motor, visual, auditory, tactile and gustatory. It is remarkable the communication deficit in these cases, when interacting, normally one of the subjects involved will fail in the construction and understanding of senses and meanings expressed in the form of language.

The Alternative Communication (AC) may become a possibility that provides subsidies of supplement, complement or construction in the communication process [6]. In the case of deafness, several authors [7-9] realize the existence of this communication deficit and suggest an AC to support the possible interaction of the subjects with the disability.

The primary function of perspective of the Technologies of Information and Communication of this research, is to develop one Computational Model of the universe of these people, receiving as answers how they would interpret and would apply the concepts in their daily life, according to the adequacy and applicability thereof in the relationship with the tangible phenomena that surround.

A development constituted from a historical social vision, whose focus is not only in the subject, but in relation with the cultural context, defined as a social movement formed from a linguistic minority opposite to dominant ideology, in which people are immersed, constituted and submitted the conditions of such concepts [10].

This study aimed to investigate the improvement of the teaching learning process of people with disabilities through the construction of a Digitized Mental Architecture – DMA, sustained in the study of human behavior in the face of uncertainty and ambiguity of boundary conditions that surround this type of learner.

This model can help in forecasting, analysis and planning the emotional and motivational aspects in school contexts. Such psychological aspects strongly influence human relations and the power to act and, consequently, affect the production system and student performance. Therefore, it is essential to understand and know how to deal with these problems, to improve human performance, optimizing efforts in performing the tasks.

The paper is organized as follows. Section 2 begins with a short review of the literature regarding the fuzzy logic in different areas of education, then presents a theoretical foundation and finally talks about the scientific research. Section 3 is the main part of this study, in which the details about MVFS for support of DMA are presented. The structure of the DMA is presented in Section 4. Section 5 discusses the application of a real case. Finally, we make some conclusions.

2. **Related Works.** This section begins with a short review of the literature regarding the fuzzy logic in different areas of education, then presents a theoretical foundation and finally talks about the scientific research.

2.1. **Literature review.** Various researchers have applied fuzzy logic in different areas of education and others fields. Lassibille and Gomez [11] presented an integrated fuzzy set approach to assess the outcomes of a student learning. They exploited fuzzy set principles to represent the imprecise concepts for subjective judgment and applied a fuzzy set method to determining the assessment criteria and their corresponding weights. Reasoning based on fuzzy approaches has been successfully applied for inference of multiple attributes containing imprecise data. Biswas [12] proposed an application of fuzzy sets to student academic evaluation. The reasons behind the use of the fuzzy approach are that an educational grading system involves substantial amounts of fuzziness and that fuzzy theory can provide a model of subjective judgments. Chen and Lee [13] proposed a method for the evaluation of student answer scripts. The purpose of their study was to counter some drawbacks of the method proposed by Biswas. The method proposed by [13] is similar to the method of [14] which applies fuzzy membership function values and probability theory.

It is known that expert fuzzy scoring systems [15] help teachers to make assessment in less time and with a level of accuracy that compares favorably to the best examiner. Tinto's model [16] is the predominant theoretical framework for considering factors in academic success. He considered the process of student attrition as a socio-psychological interplay between the characteristics of the student entering university and the experience at the institute. Many studies included a wide range of variables, including personality factors, intelligence and aptitude tests, academic achievement, previous college achievements, demographic data, etc. [17-19] for assessing academic performance of students.

It is universally acknowledged that vague information exists in human thinking and natural language. Fuzzy set proposed by Zadeh [20] is a powerful tool to capture imprecision. In the past few decades, fuzzy set theory has been successfully applied to various fields, such as control, decision making, and image processing [21-27].

2.2. **Theoretical foundation.** The world is moving towards technology at a breakneck pace. With the growth of technological possibilities that deal with the virtual world sustained for hardware and software increasingly sophisticated, broaden up the horizons for socio-economic and cultural inclusion of people with disabilities, in order to meet the provisions of the Convention on the Rights of People with Disabilities, defining that they have the right to develop their skills and abilities to the maximum [28].

Noteworthy is also, the document establishing the National Policy on Special Education in the Perspective of Inclusive Education of MEC [9], which argues that the preferential enrollment of students with disability, pervasive developmental disorders and high skills/giftedness must be made exclusively at common class of mainstream schools, at detriment of services segregated, considering this as: political action, cultural, social and pedagogical, triggered in defense of all students being together, learning and participating without any discrimination.

The inclusive education constitutes an educational paradigm grounded at the conception of human rights, combining equality and difference as inseparable values, advancing towards the idea of formal equality to contextualize at the historical circumstances of the production of exclusion, in and out of school [29]. This denotes unmistakably, that society has evolved and the perception of usefulness in human beings, distances itself of the restriction evolutionary of the people advocated since antiquity.

Although educators seek to improve the teaching and learning process through teaching resources, they leave to be desired when a person with disability is related to such resources. There are many teachers and institutions who claim to have better ways of accessing new sources of information, as the development of science on applied artificial intelligence [30]. This distance can be attributed to the ignorance of how behaves a person with disability and then they really need to know and learn in front of their challenges and perception capabilities. Thus, some researches become alternative solutions such as recommendation systems [31] and software aids [32].

This study seeks to investigate the improvement of the learning process of people with disabilities through the construction of a DMA.

2.3. **Scientific research.** According to the opinion sustained by Clancey [33], such DMA must be able to represent the human behavior, especially when it refers to transmission of knowledge, which will impose changes on the behavior of an apprentice, especially when it presents some kind of disability, psycho-emotional or motor, albeit temporary. Every human being, on a condition of permanent learner, is susceptible to present certain disabilities either temporary or permanent difficulties, not meaning in this way, restrictions for better or worse performance on a socioeconomic or cultural activity.

According to the theory of learning of Piaget et al. [34], the cognitive development of learners is associated to the four factors: biological maturation; experience with the physical environment; experience with the social environment; and balance. The balance is an attempt to bring a stability condition between the first three factors and the reality associated with the external environment. During each phase of the development, the people lead themselves through certain logical peculiar, mental structures that provide them accordingly, make sense of the world. This occurs even more strongly in people with disabilities, due to their sensory and cognitive restrictions.

In this context of possibilities, these symptoms signal that process of learning to the learner, when it is challenged to question and needs to think to express their doubts [35].

This work is based mainly in cognition from the perspective of cognitive psychology. This view provided the theoretical support for the implementation of the computational model set. From this perspective, this processes/operates the external and internal stimuli of your body and its mental representations. The excitement and motivation are just aspects forming part of a complete system information processing.

The human being deals with three categories of information: bottom-up, top-down and mental representations. The first category – bottom-up – corresponds to all sensory information going from the body to the brain. The second category – top-down – corresponds to all information ranging from the brain to the body – nerve impulses and pituitary hormones – promoting the movement and body fit. And the third category corresponds to a set of "cognitive constructs". Such constructs are "knowledge structures", representing previous experiments organized at different levels of abstraction.

From this point of view, emotion and motivation is information related to body adaptations that are part of the "cognitive constructs". The "cognitive constructs" or "mental representations" add a lot of information or knowledge about actions, body signals, linguistic categories, goals, plans, and so on.

Some cognitive approaches to memory and mental representation, as well as cognitive theories of emotion and motivation were analyzed in order to meet its potential for computer modeling. The model of Atkinson-Shiffrin [36], the levels of processing [37], the model of Tulving [38] and the parallel processing approach distributed – PDP [39] are examples of theories studied and cited by various authors [40-42].

The related processes at the five senses of the human being, directly linked to learning, are interpreted a particular subject area located in the cerebral cortex. According to McCrone [43], the brain contains specialized areas in various activities, as to plan movements, make judgments or map the visual scenery.

The way proposed in this paper, to interpret this function "speculate" was to build one Model of Mental Architecture Scanned, based on a concatenated structure of the modeling the five senses associated the each of its attributes, their respective transience and relationships [44].

Figure 1 presented below, represents the class diagram [45] of the DMA.

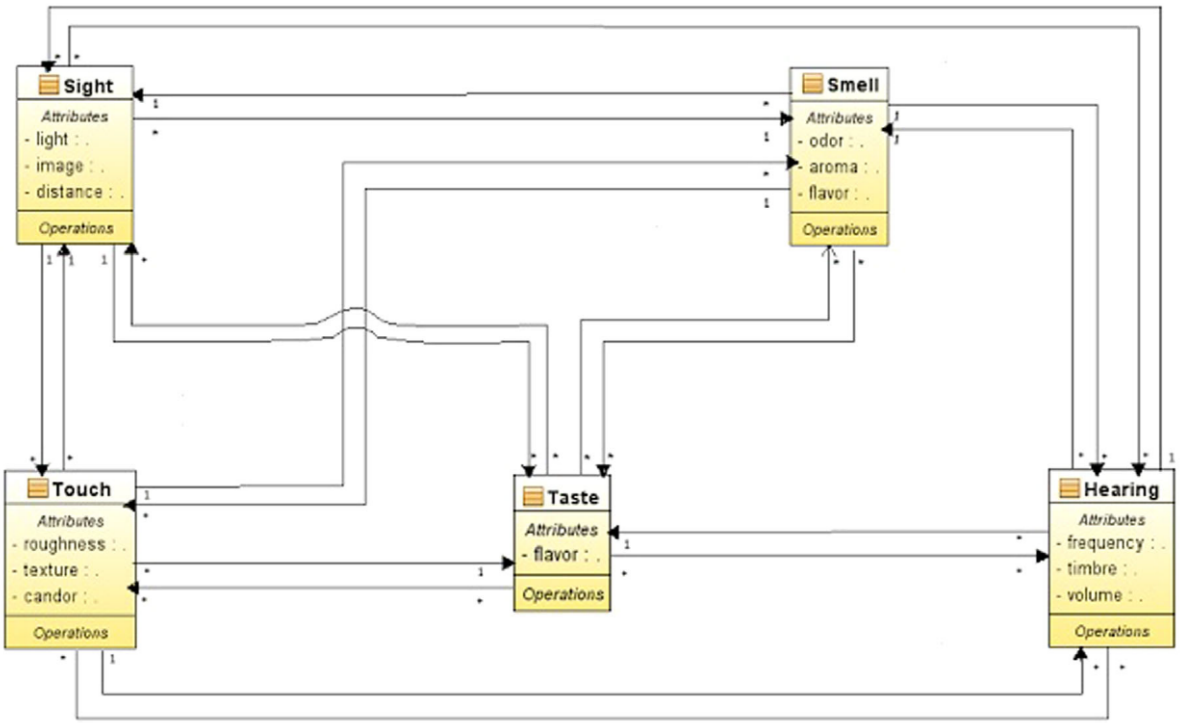

FIGURE 1. Class diagram of the DMA

The model conceived a computerized system that applied at the pedagogical context, had as input parameters the stages of a course, the nature of the information and their respective values of the initial state, calculated according to the value of the constant "k", by the neural network specific. As the course progressed, there was a calculation of the state values as a result of your events.

From a training database, was set up the relationship matrices with collected data, from where were calculated the values of the evolution of the apprentice. These calculations come from the determinant of the relationship matrix and of division of the multiplications of the main diagonal and secondary.

The tally sheet indicated, what lines of action should be taken by the educator to improve the teaching and learning process. Thus, it can be established the sufficiency level of transmission of a knowledge or content, as well as the importance of the consolidation of learning and its application in daily life.

This computational model gave rise to the structure of DMA, that applied to education, allowed to be obtained the maximum of each of the five senses according to their minimum of the skill, to provide a more appropriate response for the relationship "Machine-Man" in the sense of support of the teaching and learning process.

3. **Approach of Multipolar-Valued Fuzzy Sets for Support of DMA.** In this research, the practice of Multipolar-Valued Fuzzy Sets evolved into an interactive application with the aim to help people with disabilities attain the education they richly deserve.

The approaches adopted to view this perspective, when associated at the development of a pedagogical model, propitiated a better understanding of needs of a teaching program for the people with disabilities. Also it enabled an instant analysis of occurrences throughout its application, planned or not at the initial programming.

Multipolar-Valued Fuzzy Set – MVFS has been proposed by Guimarães et al. [46] based on the work of Han et al. [47]. Han et al. developed two new operations to the rough set theory and solved the widely existing information losing problem in the computation process, among other things. Multipolar-Valued Fuzzy Set represents an extension of a Bipolar-Valued Fuzzy Set – BVFS, which on the other hand had integrated the Interval-Valued Fuzzy Set – IVFS and Rough Set – RS. MVFS deals with ambiguities that can create similar processes as executed by our brains.

MVFS is a good way to represent complex systems that are not well defined. They combine some of the advantages of modeling through neural networks and fuzzy logic. The linguistic concepts are represented by fuzzy sets. Each of information reported is associated to a numerical weight, representing a fuzzy variable related to the level of causality between the concepts.

MVFS such as Fuzzy Cognitive Maps – FCM has many advantages in modeling of cognitive processes because this tool is able to simulate parallel operations (feature of neural networks) and deal with misconceptions by fuzzy logic [48].

A concept linguistic may represent a "mental structure of knowledge" ("mental representation") by aggregating various types of information and it does not have a precise limit. Therefore, a fuzzy set, due to its characteristics, can be a good option to model mental structures.

The approach of cognition through multipolar-valued fuzzy sets has great potential for modeling of psychological processes.

The information reported represents concepts expressed by a word or verbal expression. This paper proposes a model for the cognitive processes. Therefore, the chosen concepts are linguistic expressions about this reality. At the mental level, such processes activate various knowledge structures or of the information highly interconnected. Here, all "knowledge structures" present in the mind of an individual will be the set universe of their "mental representations". This set universe is composed of many subassemblies, according with a particular characteristic or considered organization.

Thus, an example of restrictive analysis would be: considering an individual with a certain level of math instruction, may be considered as its universe set of numbers, the set of complex numbers, which presents various subsets. These subsets could be of the following numbers: reals, integers, prime, irrationals, multiples of two, etc.

In the example, there are many subsets and intersections between them. The same elements may belong to different sets, or between some sets, there is no intersection. This is a typical case of classic sets (crisp sets) where the elements belong or do not to a certain set. Already in fuzzy sets, the relevance of an element set is a function, so, the degree of membership of an element to a set can vary continuously between belonging and non-belonging. So there is not a limit well-defined of set.

Returning the "mental structures" or "mental representations", they will be taken here as knowledge organizations. Such structures ranging from sensory representations up to complex structures and abstract, as for example, the semantic memory, the memory of

procedures, the episodic memory (model of Tulving), the goals, the model of the I, the model of the others, the model of the world, the emotional reactions, etc.

In modeling proposed here, these structures are subsets of the universe set of all "mental representations" in the mind of an individual. Such subsets are fuzzy, because they do not have a limit well-defined and have many intersections (common information) each other. They are quite comprehensive and represent "class of concepts". Such concepts will represent some emotional aspects, motivationals, of personality, of the goals, of the I, etc., present in the "knowledge structures" to an individual or a group of individuals.

These concepts form small networks that add various types of information (sensory, episodic, linguistic, etc.), but are identified by means of a word or linguistic expression. They are highly interconnected forming a wide network of information [49].

Concepts were defined for being information reported. They are based mainly in the memory model of Tulving [50], in the model SPAARS of Dalgleish and Power [51], in studies of Reeve [52] and in the basic needs of the human being defined by Murray [53]. Each concept is an instance belonging to one of seven classes of concepts: emotions, aspects of personality and motivationals, meta-goals, meta-actions, aspects of "I", expectation, and aspects of working environment/school. The definition of a context is fundamental to strengthen the extension of the meanings of the concepts.

According to Xavier and Zen [54], for to consider students' knowledge is necessary propose situations where they can show their knowledge, their assumptions during the implemented activities, so that, provide clues to continue the work and for the planning of future actions.

In this work, for the efficient use of teaching program, some steps were defined targeting, according to the concept presented below. The phases of a teaching program, were divided into the following four: Educational Structure, Temporal Distribution, Application and Consolidation.

Initially, design a teaching program based on the finding of a need and utility for a person with disability. Generate it then, a set of goals and targets of idealization. Soon after, the Temporal Distribution transformed the results of Pedagogical Structuring Phase in idea that supported to the Executive Planning of the activities, related to the chosen methods and processes. Once planned, we moved on to phase of the Application DMA, which also controlled up all phases of activities. In the consolidation, all material was elaborated, which was then delivered to the Pedagogic Body.

The development along the stages of the teaching program generated a set of information, which was dealt with an appropriate manner, to resolve conflict situations, both predictable and unpredictable. This distribution of phases, which supported the preparation of a teaching program was transferred to the DMA's job for a particular student, being their follow-up made on a daily basis and represented by a monotonic curve upward, as a way to assess its performance in a given segment of knowledge. This assessment was based on the concept that the senses are the gateway to learning in the human body, they assist in the capture of the most varied contents. According to [55], the ability of learning is accomplished by sensory cells, highly specialized, across the body or concentrated in so-called sense organs, forming what is known by senses of the human body.

The stimuli are captured by these sensory cells and taken to the brain via nerve impulses. On reaching the brain, the nerve impulse is interpreted as a visual sensation, aural, olfactory, gustatory or touch.

All of the DMA worker process was developed through the treatment of information. They were generated, internally or externally, at the process in which they were inserted. This set of information has been rendered as "inputs" and generated of the "exit" informations processed by a process. In any process of development or implementation, the

basic raw material, looked after, is the information. They are able to indicate and change the behavior of various segments of the project of any action, in the case of this survey, the Pedagogical.

Through its structure DMA provides results of information analysis, which promotes the monitoring and consolidation of the learning of people with disabilities.

4. **The DMA: Structuring and Application.** The DMA structure integrates at the context of computational systems as the central fundament of cognitive modern science [56].

For the processing of data, the system performs the following tasks:

1) input of data;
2) correction of data and definition of the numerical equivalent for diffuse gradations;
3) statistical calculations; and
4) simulation of the psychological process through FCM.

As with any computational implementation of a complex system, some choices have to be made, resulting in inevitable restrictions in addressing the problem. The appearance of restrictions is inherent the modeling process due, in this case, the need to transform the qualitative values in numerical values for your processing and, in sequence, returning the numerical values obtained in qualitative information. The various numerical combinations proposed by the system aim to minimize the restrictions imposed by the numerical processing. For this, it allows the user to define the numeric parameters that best fit your needs.

Figure 2 presents the data entry main interface of the system. This is a WEB application, where it presents a main form with logical arguments supporting all inference rules of natural deduction.

The process of analysis of information, according to the MVFS methodology, that allows to evaluate the cognitive development of a people with disability, occurs from the following

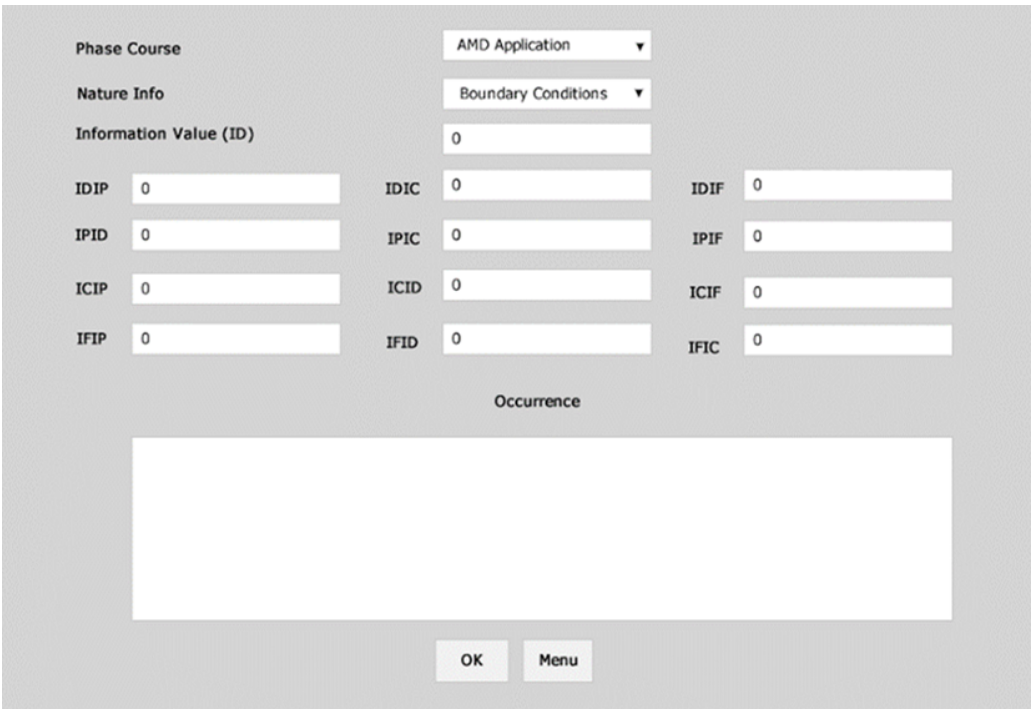

FIGURE 2. Data entry for the processing of DMA

data entry: Phase of Course (or Pedagogical Project); Nature of the Information; and Values of Information.

A course can be divided into the following phases: Pedagogical Structure, Temporal Distribution, Application of DMA and Consolidation.

During a process of teaching and learning, it may occur a series of information perceived and assimilated by apprentices, which improve or worsen the quality of the assimilation of knowledge. Such information shall be classified according to the following natures: Condition Psycho-Emotional, Doubt of Content, Boundary Conditions and Physical Capacity. This classification is defined in terms of the point reached by the apprentice during a study session. It determines where the analysis process will begin, based on the nature of the perceived information and communicated, which originated analysis process.

The education vision built through integration of the phases of a course, of information and their natures and of direct and reciprocal influence factors, transferred to the process proposed in this work, positioned the computational resources, responsible for the treatment of ambiguities and uncertainties pertinent to information and their influences, direct and reciprocal.

The very identification and measurement of information, by itself, can be considered within an ambiguity, because it depends on the particular perception and momentary each educator. These opportunities, the cross-functional communication can minimize the ambiguity by sharing the responsibility in the decision on the classification.

In entire and any info is assigned a direct Influence Factor on the other, and also, one Reciprocal Influence Factor, representing the response, favorable or unfavorable, according to their pertinence inserted in a global context. It should be noted that the influence factors are one of the fundamental elements of the MVFS methodology.

It is considered Direct Influence Factor – F_I, the pressure that the finding of an information has on other information, in a relationship biunivocal. This relationship creates the possibility of a Reciprocal Influence Factor – F_{Ir}, which measures the response of the affected information, related to that which generated the information communication process, introduced into the system and that serves as an instrument for a systemic view, dynamics and adaptive, of relevance of information perceived and communicated for the assessment of set apprentice and machine.

According to the data entry example shown in Figure 2, to any stages of course informed, when selecting a nature of information and indicated the value of information (an indication of perception of educator), the system automatically prompts the introduction of values relating to factors of influence, direct and reciprocal.

The Influence Factors feature the following nomenclature:

ICIP – Influence of the Information of boundary conditions on the Information Psychoemotional;

ICID – Influence of the Information of boundary conditions on the Information of Doubts of Content;

ICIF – Influence of the Information of boundary conditions on the Information of Physical Capacity;

IPID – Influence of the Information Psychoemotional on the Information of Doubts of Content;

IPIC – Influence of the Information Psychoemotional on the Information of boundary conditions;

IPIF – Influence of the Information Psychoemotional on the Information of Physical Capacity;

IDIP – Influence of the Information of Doubts of Content on the Information Psychoemotional;

IDIC – Influence of the Information of Doubts of Content on the Information of Doubts of Content;

IDIF – Influence of the Information of Doubts of Content on the Information of Physical Capacity;

IFIP – Influence of the Information of Physical Capacity on the Information Psychoemotional;

IFID – Influence of the Information of Physical Capacity on the Information of Doubts of Content; and

IFIC – Influence of the Information of Physical Capacity on the Information of boundary conditions.

The Factors of Influence can then assume values, since highly negative, going through neutral, until highly positive, according to the information perceived and assimilated by the user. This track should vary from the value of -1.00 (one negative), for the first case, passing by "zero" until $+1.00$ (one positive), in the latter case. These values may be informed to the process with up to two decimal places.

Define the values of the F_I, and it evaluated the condition of the information communicated that can be considered "very bad", "bad", "correct", "good" or "very good". Table 1 presents the values assigned to each of the tracks and their respective pertinence. The latter have the function to set the intervals that generate the plans created by applying to the treatment of information by the system.

Table 1. Condition, value and pertinence of the information

Condition	Range Value	Pertinence
Very Bad	0 to 0.245	1.00 to 0.5
Bad	0.245 to 0.49	0.5 to 0
Correct	0.49-0.5 and 0.51	0-1.00 and 0
Good	0.51 to 0.755	0 to 0.5
Very Good	0.755 to 1.00	0.5 to 1.00

The collection of data, supplied to the system by educators (Teachers, Pedagogical Advisors, among others) and supervised by Care Professionals Specialized Educational – AEE, are obtained through the factors that characterize the profile of cognitive ability of apprentices, such as: of relationship, of vocation, of functional degradation, among others.

From the figures given, are built the fuzzy logic machines, of which the results are extracted of analysis, communication and information, in an integrated manner, linking up all natures and their interdependencies. These results are used to calculate the value of states. The machine receiving the data, makes "fuzzification", "defuzzification", and presents the results for each one of natures information, based on a knowledge base.

After completing this phase, the classified information is passed on to the analysis and interpretation processing, about what they represent for the course or Pedagogical Project in question, according to an overall view of the situation.

The results generated by DMA provide subsidies for a better approach of content presented to learners with disabled, signaling for expansion of possibilities for inclusion of these people.

As a way of applying the proposed model, was created an instance in a specific domain knowledge. In this article, we present experiments with deaf students of a high school class included in the educational context that used a system based on the model of DMA in order to support the process of teaching and learning.

5. **Case Study.** In this paper was held a case study on "Cognitive Development for teaching People with Disabilities". A prototype of the DMA was experienced in some instances, in the field of knowledge of history. Rules of logical were built responsibles by the treatment of ambiguities and uncertainties arising from any external information perceived by apprentices with disabilities, that might change your behavior on the study of a particular programmatic content.

For each apprentice inserted in the system, was assigned a variable to represent your initial conditions, calculated according to some factors that characterized their respective profiles of cognitive ability, of relationship, of vocation and sensory degradation. This factor was monitored along the transmission of a specific knowledge according to the evaluation of the informations natures perceived over a period and their respective impacts on an apprentice. With that, the educator was able to establish changes or adjustments in his conduct, as well as in its evaluation criterion.

Each apprentice assigned itself a curve of assessment and control, distributed in 4 phases (Pedagogical Structure, Temporal Distribution, Application of DMA and Consolidation), that cumulatively added a state value to according with each phase, until the final limit value, established in the beginnings of a period of knowledge transmission, treated as value of state final, which represented the potential expected of the apprentice.

The experiment was accomplished in the State College Baron of Aiuruoca, in Barra Mansa, by one of the institution's history teachers. In carrying out this experiment were watched 2 deaf students, representing the size of a sample, which according to [57], it is enough to obtain meaningful results and satisfactory.

The application of DMA for students assisted, signaled for the use of certain pedagogical strategies needed for best performance of learning. The use of video-lessons as learning support tool [58] was adopted, because it verified the need of to exploit the visual potential of the students. At certain times of the lessons, the contents presented emphasized items of greater relevance for apprentices, according to the assessment of their cognitive abilities, making flexible the learning differences. A differentiated assessment for apprentices was used. An evaluation object [59] was applied, making it possible and feasible the treatment of the contradictions [60], enabling the scope of expected capability of apprentices.

At all stages of the teaching and learning process, the professor followed interacting with the prototype of DMA stating the following: the values for phases of the course; the nature of the information; and the factors of influence. The system has calculated the values of the evolution of the apprentice and also indicated which lines of action should be taken.

The process of learning assessment occurred in two periods, only in the second was utilized the DMA. It applied the technique of hypothesis tests [61] for analysis of the results of this work. The average allocated to students after each evaluated period are shown in Table 2.

Table 2. Notes regarding the assessment of students

Students	Averages 1o period	Averages 2o period
Student 1 – Class 1001	55	75
Student 2 – Class 1001	75	90

It appears from Table 2, the results earned by students in 2o period, after applying the DMA, are higher than those of the 1o period, although obvious realization must be emphasized. It is believed that no other factor, in addition to the use of DMA, had influence on better productivity of students.

Hypothesis testing, a statistical inference method used for the analysis of results, consisted of assessing the population before and after the use of the DMA, in order to verify the validity of hypothesis. In accordance with the technique, the null hypothesis (H_0), was defined as: students who have some sort of disabilities have the same ability to learn as students without disabilities.

According to the technique, was defined a proposition known as a 'null hypothesis (H_0)' that students who have some sort of disabilities have the same ability to learn that an apprentice considered normal. As hypothesis of equality (H_1), defined it that usage of DMA plays a role of effectiveness in the quality of relationship of teaching and student learning with disability.

Based on differences (di) (values before and after the use of DMA), it has been calculated the average ($\overline{D}$) and the standard deviation (SD). The method also considered the calculation of the test statistic (t) and the use of a supporting table called Student t. According to the method, with a 10% level of significance (α), there is verified evidence from the increase in the value of the notes from the 1o to the 2o period, the rejection of the null hypothesis. Thus, the null hypothesis (H_0) was denied and thus the hypothesis of equality was considered true.

By means of the results obtained, one can infer that DMA, sustained in a similarity psico metabolica momentary of the apprentice, plays a role of effectiveness in the quality of relationship of teaching and learning.

Also, the cognitive faculty is intrinsically related to a need, and that the setting of learning depends on the shape and conduct by which presents itself enough for your understanding.

6. **Conclusions.** This paper presented theoretical foundations and practical experiments used to justify the modelling used in this research.

This research investigated, conceived and implemented a conceptual model of a Digitized Mental Architecture – DMA to support the teaching and learning process of people with disabilities, sustained in their culture and life experience, opening the prospect of teaching for this universe of people.

To achieve this goal, in a case study on "Cognitive Development for the teaching and learning of People with Disabilities", a prototype applied to the domain of knowledge of history was built and implemented in experiments.

The results of experiments showed that the prototype satisfactorily answered the expectations.

The fuzzy logic was extremely useful to deal with linguistic information and qualitative reasoning. The multipolar-valued fuzzy set is a new tool that, addition of fuzzy logic, presents characteristics of neural networks, which provided the linguistic and qualitative reasoning and the parallel and integrated processing and integration of the information. For these characteristics this tool has adapted well to psychological reality which wished up to model.

The perception about the behavior of people with disabilities, usually circumspect in their worlds limited by their own barriers imposed by society, it was possible to concatenate, decide and opt for the construction of a DMA, able to represent the main Machine Interface according to the possibilities of the transience of the relevance of the information perceived by the five senses, and decide on a level of sufficiency to submit to a syllabus of study. Thus, it has become possible to transfer to the system the maximum of what a person with a disability appropriates according to the minimum their sensors are able to understand and interpret.

Based on the results obtained, it can be stated which the modeling presented synthesizes a new vision about cognition, being able to simulate the psychological processes, allowing inferences on several issues related to teaching. Thus, taking into account the innovative character in dealing with this multidisciplinary subject, it can conclude this work provides a new and powerful computational tool to research in psychology and cognitive science.

The authors of this study believe that the social inclusion of people with disabilities, by means of a prototype as the structure DMA, amplified in their proper approaches, not only can it provide as must, through the use of appropriate technologies, the reduction of inequalities and promote greater socio-economic and cultural well-being among people.

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