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Neutrosophic criteria in the evaluation of educational applications for children with disabilities

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Abstract. Software Engineering is a technological profession, which promotes the development of various sectors. Education and teaching in children with disabilities have benefited from the emergence of educational applications. New computer technologies to support the learning of children with special needs address the development of quality software and compete with other tools to achieve greater motivation for children with disabilities. Research processes in special education require evaluations and criteria to be optimized based on the results obtained in the schools. The dimensions that are displayed in each element and sub-element to achieve the capture of the child are not clear enough for the programmers, mainly because of the level of maturity reached in this discipline. These elements hinder the ability of programmers to design their research strategies and experts to recognize excellent research. That is why the study is focused on analyzing the consensus and acceptance of experts on the evaluation of educational applications for children with disabilities based on the analysis carried out with the elements and sub-elements that make up the set of acquisition and motivation for learning, through the Iadov neutrosophic method.

Keywords: Assessment, applications, special education, neutrosophic Iadov

1 Introduction

Educational applications for children with special needs emerged at the end of 2008 as an initiative to provide foundations that serve populations with special educational needs, the opportunity to take advantage of the motivational and attention possibilities that are involved in computer environments. Subsequently, an integration of these games was carried out in a computational platform to optimize their application in learning situations.[1]. In addition, new academic activities were implemented in the software, as a result of the information collected in the pilot and field tests of each of the games tested.

The computational environment and the programmers have used different freely distributed tools oriented to the design of the Web environment, such as Java, HTML, PHP, JavaScript, and Ajax. Several of this software is supported by MySQL database [2]. Among the components to be taken into account by developers of educational applications for children with disabilities are:

- Playful activities that allow the child to exercise in different areas of knowledge, in addition to promoting their interest and concentration and
- Administrator component that allows configuring activities and generating monitoring reports, which is useful for tutors or therapists in charge of children with disabilities. The article sets out a framework and the formulation of the project. Subsequently, the software and the results obtained in the pilot tests are described to enumerate the conclusions of the experience.

The projections of new applications depend on the experience of the results obtained in children with disabilities, although there are undetermined variables that influence the final results [3]. In terms of software design, it would be interesting to include visual and hearing aids to achieve higher levels of student engagement and motivation.

The computational environment aims to facilitate the learning of children with disabilities, in addition to allowing monitoring by tutors or therapists [4]. Its implementation in several countries has achieved successful results. It is noteworthy that a good evaluation of an educational application for children with disabilities depends on the presence of variables that achieve a close relationship between learning-software-child with disabilities (see tables 1 and 2) [5,6].

Selective acquisition: the material is shown to be effective and reliable for teaching due to its	Distributed acquisition: The digital teaching material diversifies its potential, depending on the user	Sustained acquisition: The material is diversified according to the learning rhythms of each user.

• Consistency in use: When the child uses the material, he quickly identifies how he should interact with it. • Stylistic coherence: It refers to the style and forms of presentation of the content with a clear design and the use of appropriate colors. • Reliability: This would imply calling the user's attention to the possible consequences that may occur because of their actions (leaving the resource, opening a link on a new page, etc.). Reliability: Probability that a device or system fulfills a certain function under certain conditions during a certain time.	• Multitasking: This allows to perform several tasks at the same time, such as listening to an audio track while reading a text • Interactive personalization: The material has the flexibility to anticipate the needs of the student according to usage profiles so that their learning experience improves.	• Response speed: It refers to the fact that the program responds to the navigation speed that the user needs, which will depend on their learning pace. • Flexibility: This concept means that the program offers the user several ways and possibilities to access the content that is presented. • Adaptation to expectations: It refers to the adaptation to the cognitive and linguistic level of the user. • Stimulation: Set of images, sounds, videos, and other multimedia elements that make the program attractive to the child.

Table 1. Capturing: The material stimulates and motivates the student to exercise their learning ability appropriately.[6].

- Loyalty: This concept refers to the fact that the material manages to be used correctly as a resource for learning.[7]
- Friendliness: It refers to the set of characteristics that make the use of the material easy and pleasant for the user.
- Pictograms (buttons): The equivalence of the icons with their corresponding content is taken into account.
- Accessibility: That it be accessible to the special characteristics that the user could present.
- Navigability: It refers to the fact that the material has clear and consistent navigation options.
- Organization: The material should have a hierarchical structure.

Procedural memory	Declarative memory
• Contextuality: It refers to the fact that the material integrates elements of interest from the student's environment so that it allows easy access to the contents that are presented. • Didactic effectiveness: This concept is related to the possibility of visualizing the path or route that the learner has followed through the site so that he cannot be disoriented. • Auxiliarity: It means that the material has standards, instructions, or educational objectives.	• Granularity: It means that while a user is viewing the resource, it offers information of different types and levels such as images, text, videos, etc. • Efficacy: Refers to the fact that the material is capable of fulfilling its desired objective. • Efficiency: It is appreciated in the determination of cognitive effort and efficient communication. • Dynamicity: It refers to the updating of the contents of the material

Table 2. Procedural memory

This paper promotes the evaluation of applications from the study of indeterminate elements and sub-elements in the results of a population with learning disabilities that deserve to be investigated, to propose possible solutions, and to improve the quality of life of children with special education needs [8] [9].

Once the different previous approaches have been analyzed, the aforementioned techniques are applied, as follows:

The objective of this study is to evaluate the consensus and acceptance of experts on the evaluation of educational applications to capture the attention of children with disabilities based on the results obtained. Iadov's

method stands out for the simplicity with which it can be applied to obtain the collective evaluation of experts in educational applications for children with disabilities. Neutrosophy combined with the Iadov method allows including the indeterminacy, contradiction, and lack of knowledge of the evaluators, therefore, the results of the evaluation are more attached to the real knowledge of the specialists.

All experts were surveyed to assess their level of satisfaction with the methodology used. The groups were made up of a total of 60 experts.

2 Materials and methods

To apply the neutrosophic Iadov technique, the experts must use a linguistic evaluation system that shows their opinion accurately [10] [11]. This system and its neutrosophic and numerical equivalents are shown in Table 3 [10] [12].

Linguistic term	SVNN	Scale
Clearly satisfied	(1;0;0)	3
More satisfied than dissatisfied	(1,0.35,0.35)	23
Undefined	I	1.5
More dissatisfied than satisfied	(0.35, 0.35, 1)	1
Clearly dissatisfied	(0;0;1)	0
Contradictory	(1;0;1)	2

Table 3. Evaluation system for experts. Linguistic terms are associated with their neutrosophic evaluation and a score value

The term I in Neutrosophy is interpreted as a unit of indeterminacy.

Another component of the method is the Iadov Logic Table, which assigns numerical values to three closed questions that are applied to the experts. If necessary, open questions can be applied in the surveys[13].

1st QUESTION	Yes			I don't know			No		
2nd QUESTION	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
3rd QUESTION									
It is a consolidated research process	1	2	6	2	2	6	6	6	6
It is a partially consolidated research process	2	3	3	2	3	3	6	3	6
It does not matter to me	3	3	3	3	3	3	3	3	3
It is a less consolidated research process than it really claims to be	6	3	6	3	4	4	3	4	4
It is an unconsolidated research process	6	6	6	6	4	4	6	4	5
I do not know what to say	2	3	6	3	3	3	6	3	4

Table 4. Derivation of Iadov's Logic table.

To survey the level of satisfaction of the experts, the Iadov neutrosophic technique was used. This technique is based on the use of single value neutrosophic sets (SVNS) associated with linguistic variables or their ability to increase interpretability in recommendation models and the use of indeterminacy [14] [15].

The definition of SVNS is as follows

Let X be a universe of discourse. An SVNS A over X is an object of the form.

$$A = \{[x, u_a(x), r_a(x), v_a(x)] : \in X\}\, dA = \{[x, u_a(x), r_a(x), v_a(x)] : \in X\} d \quad (1)$$

Where:

$u_a(x): X \to [0\ ,1], r_a(x): X \to [0\ ,1]\ y\ v_a(x): X \to [0\ ,1]$

With

$0 \leq\ u_a(X), r_a(X), v_a(X)\ \leq 3, \forall x\ \in X$

For convenience, a Single Value Neutrosophic Number (SVNN) will be expressed as $A = (a, b, c), where\ a, b, c \in\ [0,1]\ and\ satisfies\ 0 \leq a + b + c\ \leq 3.$

To find a single SVNS that describes multiple sets at once, use the aggregation operators. One of these operators is the neutrosophic weighted average (WA), which is defined as follows [13].

Let $\{A_1, A_2, \dots, A_n\} \in SVNS\ (x)$, where $A_j = (a_j, b_j, c_j)(j = 1, 2, \dots, n)$, be the Neutrosophic Weighted Average (WA) Operator, it is calculated as follows:

$$WA\ (A_1, A_2, \dots, A_n) = \sum_{i=1}^{n} [w_j, A_i] \quad (2)$$

Where:

$WA\ (w_1, w_2, \dots, w_n) = \sum_{i=1}^{n} [w_j, A_i]$ is the vector of $A_j\ (j = 1,2, \dots, n)$ such that $w_n \in [0,1]$ y $\sum_{i=1}^{n} w_i = 1$

To deneutrosophicate this set so that a single value is obtained, a scoring function is usually used [16].

Let A = (a, b, c), the score function S of an SVNS, based on the degree of indeterminate membership and the degree of false membership, is defined by the following equation:

$$S(A) = 2+abc \quad (3)$$

For the use of an SVNS to measure individual satisfaction, this value must be associated with a linguistic variable [10]. Therefore, the scales shown in Table 2 were specified and the corresponding score was calculated using (3)

For cases in which the evaluation corresponds to indeterminacy (undefined) (I), a process was developed.

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (4)$$

To calculate the Global Satisfaction Index of the respondents (GSI), the WA aggregation operator (2) was used, taking into account the score values and the fact that all the respondents have the same weight, hence $w_i = \frac{1}{n}$

The instrument designed for the application of the survey was a questionnaire of five questions, three of which are closed (1, 3, and 5), and two are open (2 and 4). The three closed questions were related through the "Iadov Logic Table", which is presented in Table 3 [14] [11].

The algorithm used for the application of the neutrosophic Iadov technique is the following:

1. Once the questionnaire has been applied, the corresponding value (from 1 to 6) for the satisfaction rating of the surveyed experts is found in Iadov's logical table of three inputs. [11].
2. The linguistic variable, the SVNS, and the score according to table 2 are made to correspond to this value.
3. The score value of each respondent is used to calculate the group satisfaction index (GSI) from the aggregation of all the scores using the WA (2) aggregation operator formula.
4. The GSI is interpreted from the location of the value in the graph of figure 1.

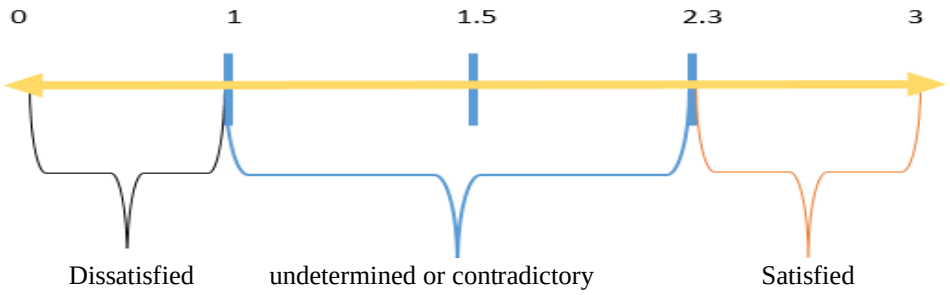

Figure 1. Scale to determine the level of satisfaction according to the scores used

The two open questions allowed completing the assessment of the level of satisfaction with the applied methodology. The five questions were the following:

- Do you think that the integration of educational applications for children with disabilities will improve academics? (question 1)
- Do you consider that the scope should be developed to specify which elements should be present in the design and evaluation of the software? (question 4)
- What is your opinion about educational applications for children with disabilities? (question 5)
- Do you think that some elements of educational applications could be developed for children with disabilities? (question 2)
- What do you think of the new educational applications for children with disabilities and their benefits? (question 3)

3 Results

Using the information obtained from the survey, it is possible to refer to the variables that define the elements that must be taken into account when evaluating an educational application for children with disabilities (see table 5).

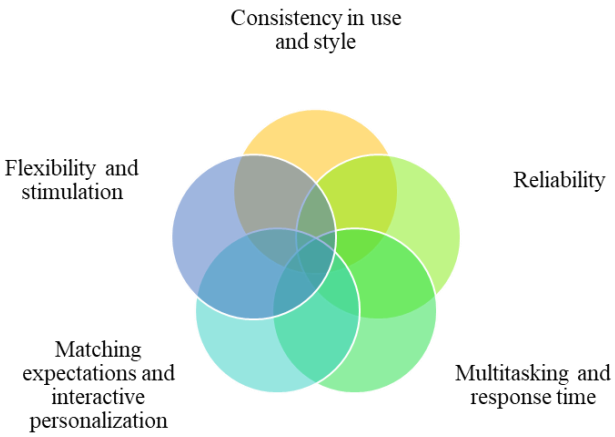

Figure 2. Sub-elements of the neutrosophic collection set.

To capture the attention of children with disabilities around the educational application, the evaluation of each element and sub-element must be analyzed to decide on a possible diagnosis within the neutrosophic set called selective capture (see table 5).

Code	Elements	Sub-elements
E1	Usage and stylistic consistency	✓ When the child uses the material, he quickly identifies how he should interact with it. ✓ It refers to the style and forms of presentation of the content with a clear design and the use of appropriate colors.
E2	Reliability	✓ It would involve calling the user's attention to the possible consequences that may occur as a result of their actions
E3	Multitasking and response time	✓ It allows performing several tasks at the same time, such as listening to an audio track while reading a text. ✓ It refers to the fact that the program responds to the browsing speed that the user needs, which will depend on their learning pace.
E4	Matching expectations and interactive personalization	✓ It refers to the adaptation to the cognitive and linguistic level of the user ✓ The material has the flexibility to anticipate the needs of the student according to usage profiles so that their learning experience improves.
E5	Flexibility and stimulation	✓ This concept means that the program offers the user several ways and possibilities to access the content that is presented. ✓ Set of images, sounds, videos, and other multimedia elements that make the program attractive to the child.

Table 5. Elements of the neutrosophic collection set

From the application of the survey by the group of experts, the results were obtained regarding the individual satisfaction levels shown in Figure 3 and the information regarding the neutrosophic group studied.

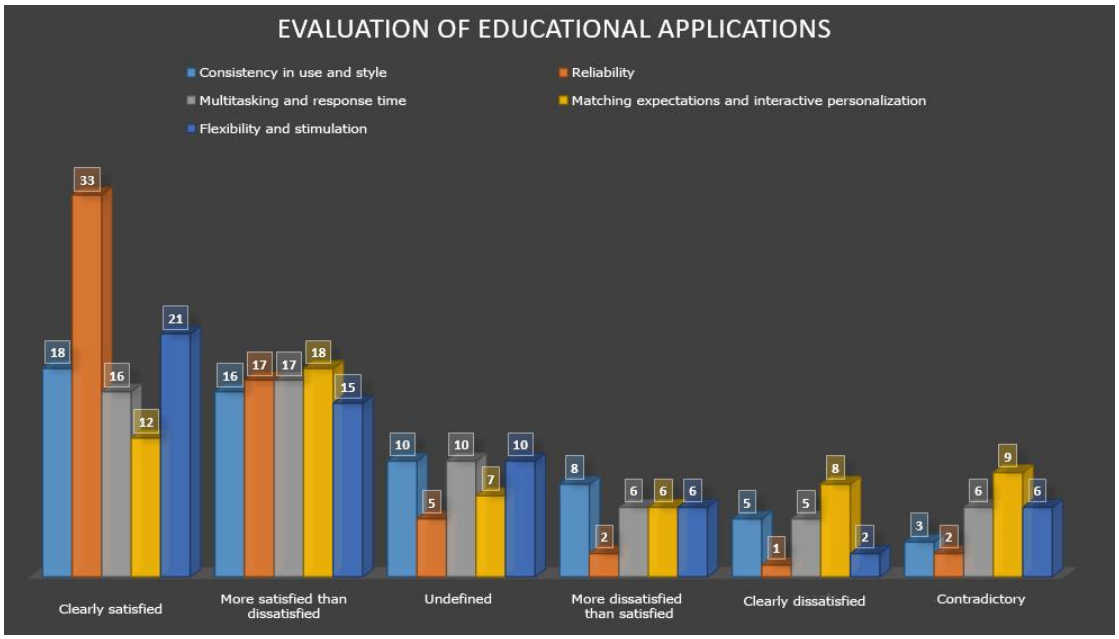

Figure 3: Levels of satisfaction of the group of experts for each element.

Positive levels of satisfaction can be seen in educational applications for children with disabilities, with a predominance of reliability; flexibility, and stimulation; as in the *consistency in usage and style*. However, experts with dissatisfaction are observed, especially in the adaptation to expectations and interactive personalization. Indeterminate and contradictory positions were also found, between the level of belonging of each element.

The calculations of the ISG according to the frequency of observation and the individual satisfaction indices of the designed categories and their corresponding scores are shown in tables 6 to 10, for each group, respectively.

Linguistic term	SVNU	Punctuation (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	3	18	54	0.90
More satisfied than dissatisfied	(1,0.35,0.35)	23	16	36.8	0.61
Undefined	I	1.5	10	15	0.25
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	8	8	0.13
Clearly dissatisfied	(0;0;1)	0	5	0	0.00
Contradictory	(1;0;1)	2	3	6	0.10
Group Satisfaction Index					**2.00**

Table 6: Calculation of the Group Satisfaction Index (GSI) of the element. Usage and stylistic consistency

Linguistic term	SVNU	Punctuation (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	3	33	99	1.65
More satisfied than dissatisfied	(1,0.35,0.35)	2.5	17	42.5	0.71
Undefined	I	1.5	5	7.5	0.13
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	2	2	0.03
Clearly dissatisfied	(0;0;1)	0	1	0	0.00
Contradictory	(1;0;1)	2	2	4	0.07
Group Satisfaction Index					**2.58**

Table 7: Calculation of the Group Satisfaction Index (GSI) of the Reliability element

Linguistic term	SVNU	Punctuation (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	3	16	48	0.80
More satisfied than dissatisfied	(1,0.35,0.35)	2.5	17	42.5	0.71
Undefined	I	1.5	10	15	0.25
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	6	6	0.10
Clearly dissatisfied	(0;0;1)	0	5	0	0.00
Contradictory	(1;0;1)	2	6	12	0.20
Group Satisfaction Index					**2.06**

Table 8: Calculation of the Group Satisfaction Index (GSI) of the multitasking element and response speed

Linguistic term	SVNU	Punctuation (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	3	12	36	0.60
More satisfied than dissatisfied	(1,0.35,0.35)	2.5	18	45	0.75
Undefined	I	1.5	7	10.5	0.18
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	6	6	0.10
Clearly dissatisfied	(0;0;1)	0	8	0	0.00
Contradictory	(1;0;1)	2	9	18	0.30
Group Satisfaction Index					**1.93**

Table 9: Calculation of the Group Satisfaction Index (GSI) of the element. Adaptation to expectations and interactive personalization

Linguistic term	SVNN	Punctuation (S)	Frequency (F)	F*S	(F*S)/n
Clearly satisfied	(1,0,0)	3	21	63	1.05
More satisfied than dissatisfied	(1,0.35,0.35)	2.5	15	37.5	0.63
Undefined	I	1.5	10	15	0.25
More dissatisfied than satisfied	(0.35, 0.35, 1)	1	6	6	0.10
Clearly dissatisfied	(0;0;1)	0	2	0	0.00
Contradictory	(1;0;1)	2	6	12	0.20
Group Satisfaction Index					**2.23**

Table 10: Calculation of the Group Satisfaction Index (ISG) of the element Flexibility and stimulation

Out of the elements evaluated, only the *reliability* is higher than 2.30, so it is established that the experts agree on the integration of educational applications for children with disabilities as part of the teaching process. As one of the primary requirements, it would mean drawing the attention of the disabled child to the application about the possible derivations that may occur as a result of their actions.

As for the element *consistency in use and style; Multitasking and response time; Flexibility and stimulation;* there is a level of indeterminacy or contradiction between the sub-elements of each element of the neutrosophic set. Indeterminacy studies must be carried out for each sub-element and analyze the degree of membership that affects the development of the learning process.

These results obtained from the experts' satisfaction with the elements found in the collection set with the Iadov technique, were reaffirmed by the experts' answers to the open questions. Among the most frequent opinions, the child's uptake of the application stands out as an incidence variable. Among the contradictions, the experts refer that it is a consolidated teaching process, although each sub-element must be defined and evaluated in conditions of subset and set in learning. They can help the reflection of current designers and serve as a guide for the improvement of educational applications based on the contribution of elements of comparison with the teaching strategies of each country.

It is noteworthy that there is a great gap between designers, programmers, educational psychologists, education, and children with disabilities to define an application on the basics of child learning. This requires that an evaluation be carried out on the results of different educational applications in groups of children with disabilities.

4 Conclusions

From the results obtained, it is concluded that:

- Mobile and computer applications have made improvements in the field of education; however, those that are designed for children with disabilities are scarce or difficult to access, and others do not meet the needs of each child with their specific disability. Creating a technological tool for educational purposes that is aimed at a group of children with disabilities is one of the challenges for each programmer in visualizing the teaching and learning environment.
- Application of the neutrosophic IADOV technique allows experts to represent indeterminacy as part of their knowledge and the complimentary evaluations based on linguistic terms presented in the questionnaire. It constitutes an instrument of great value for the study of satisfaction - dissatisfaction of experts when evaluating educational applications. However, a deeper neutrosophic study of the sub-elements would allow integration from the level of indeterminacy.
- From the results presented by the evaluation of the experts, it can be concluded that the use of educational applications has significantly improved the attention and uptake of children with learning disabilities. It should be noted that there are certain elements such as reliability that allow the recruitment and motivation of children with disabilities. The application shows that it is a computational tool that favors learning in this type of special disability.

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