Use of Neutrosophic Cognitive Maps for the Analysis of Five Didactic Options for Instruction in the Numerical and Research Skills of Accounting Students

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Abstract. This article explores the innovative use of Neutrosophic Cognitive Maps to evaluate and compare five teaching approaches aimed at improving numerical and research skills among accounting students. This methodology, which integrates elements of neutrosophic theory, allows us to capture the inherent uncertainty and ambiguities in the perception and evaluation of educational options. Through a detailed and systematic analysis, the strengths and limitations of each approach are examined, highlighting how Neutrosophic Cognitive Maps offer a robust conceptual structure for discerning between the subtle complexities that affect effective learning. The results reveal profound elements about how different teaching strategies can influence the acquisition of key competencies in accounting. From the integration of advanced technologies to more traditional methods focused on conceptual development, each approach is evaluated not only for its surface effectiveness, but also for its ability to adapt to the cognitive and emotional diversity of students. This multidimensional approach underscores the importance of considering not only quantitative results, but also the underlying processes and subjective perceptions that shape the educational experience, offering a comprehensive framework for continually improving teaching in de-manding and dynamic academic environments.

Keywords: Didactic Approaches, Neutrosophic Cognitive Map, Neutrosophic Number, Neutrosophic Graph, Hidden Patterns.

1 Introduction

In the contemporary educational field, the design of effective teaching strategies represents a crucial challenge to improve learning and skill development among students, especially in disciplines such as accounting that require a deep mastery of numerical and research skills [1]. The evaluation of different pedagogical alternatives becomes essential not only to optimize the teaching-learning process, but also to adapt to the varied needs and profiles of students in diversified and dynamic academic environments. In this context, the emerging use of Neutrosophic Cognitive Maps represents an innovative and promising approach. These maps not only allow us to visualize and structure complex cognitive and affective interrelationships in the educational process, but also integrate principles of neutrosophic theory, which deals with the uncertainty, indeterminacy and vagueness inherent to human perceptions. This methodology, relatively new in educational research, offers a rich and nuanced conceptual framework to critically evaluate and compare different teaching strategies aimed at strengthening the essential skills required in the field of accounting [2]. The present study focuses specifically on the analysis of five teaching options designed to improve both numerical skills and research capabilities among accounting students. Through a meticulous and systematic approach, the strengths and weaknesses of each approach are explored, seeking to identify not only their superficial effectiveness, but also their ability to foster deep and sustainable learning in a constantly evolving educational context.

The choice of Neutrosophic Cognitive Maps as the main methodological tool is justified by its unique ability to model and represent the ambiguity and indeterminacy inherent in human perception [3]. This methodology not only facilitates the capture of multiple perspectives and divergent points of view on the effectiveness of the proposed educational strategies, but also offers a space for critical reflection on how these strategies can be adapted and optimized according to the specific needs of the students and the demands of the current educational

environment. As we move towards a more comprehensive and holistic approach in teaching complex competencies such as numerical and research skills in accounting, it is crucial to adopt methodologies that not only address the variety of learning styles and individual abilities, but also promote autonomy. intellectual and critical thinking. Neutrosophic Cognitive Maps offer precisely this opportunity by providing a flexible and adaptable framework that can be modulated according to the changing dynamics and demands of the contemporary educational context [4].

In this sense, this study not only seeks to contribute to the growing body of knowledge in the field of education and cognitive psychology, but also to provide practical guidelines and informed guidance for educators, curriculum designers and educational policy makers interested in improving the quality and the effectiveness of teaching in specialized disciplines such as accounting [5]. By embracing the complexity inherent in teaching numerical and inquiry skills, this study is positioned as a crucial starting point for future research and development in the field of innovative and adaptive pedagogy.

2 Related Words.
2. 1 Numerical Skills.

Developing numerical skills is essential in the current educational and professional landscape. These skills are not limited simply to the ability to handle numbers and perform basic arithmetic calculations, but encompass a complex set of competencies that allow one to interpret, analyze and use quantitative data effectively in various contexts. From solving everyday problems to making strategic decisions in companies and organizations, numerical skills are essential to face the challenges of the modern world. In a broader sense, numerical skills involve the ability to understand fundamental mathematical concepts such as algebra, geometry, and statistics [6]. These disciplines not only provide tools to perform accurate calculations, but also foster logical reasoning and the critical ability to evaluate quantitative information objectively. This capacity for critical analysis is crucial in fields as diverse as scientific research, financial planning and data management in the technological field. Furthermore, numerical skills are essential for developing a deep under-standing of complex and abstract phenomena. For example, in science and engineering, these skills allow us to model and simulate physical and natural systems, predicting outcomes and optimizing processes through the use of advanced mathematical tools. Likewise, in areas such as economics and business administration, numerical skills are essential for performing cost analysis, financial projections and risk assessments, providing a solid basis for making informed and strategic decisions [7].

From an educational perspective, the development of numerical skills not only implies the acquisition of technical knowledge, but also the ability to apply that knowledge in practical and real contexts. This requires innovative teaching methods that encourage active learning and discovery, allowing students to explore mathematical concepts through problem solving and experimentation. The integration of educational technologies and digital tools also plays a crucial role in facilitating interactive and adaptive learning, personalizing the learning experience according to individual needs and promoting a deeper and more meaningful understanding of numerical concepts [8]. However, despite the growing importance of numerical skills in the 21st century, significant challenges remain in their teaching and learning. One of these challenges lies in the negative perception that some students may have towards mathematics and related disciplines, which can generate emotional and psychological barriers that hinder the effective development of these skills. Addressing this gap requires inclusive pedagogical approaches that promote a positive and motivating learning culture, highlighting the practical relevance and real applications of numerical skills in daily life and in various professions. Additionally, the gap in numerical proficiency between different demographic and socioeconomic groups also represents a significant challenge to educational equity. It is crucial to implement educational policies and programs that ensure equal access to resources and learning opportunities in mathematics and related disciplines, empowering all students to reach their full academic and professional potential [9].

The development of numerical skills is not only fundamental for individual and professional success, but also plays a crucial role in building an informed, innovative and resilient society. By investing in the continuous improvement of the teaching and learning of these skills, we can strengthen the foundations for scientific, economic and social progress, ensuring that each individual has the necessary tools to effectively meet the challenges and seize the opportunities of the modern world. and ethics.

2.2 Neutrosophic Cognitive Maps.

Neutrosophic Cognitive Maps represent a significant evolution in the field of complex data representation and analysis. This unconventional methodology not only seeks to capture the complexity inherent in human perceptions, but also integrates principles of neutrosophic theory, which deals with truth, falsehood, and indeterminacy simultaneously. This innovative approach is especially relevant in contexts where ambiguity and uncertainty are key factors in decision making and understanding complex phenomena [10].

From a conceptual point of view, Neutrosophic Cognitive Maps allow you to visualize and structure relationships between concepts that may be ambiguous or contradictory according to different perspectives. This not only broadens the spectrum of analysis by including divergent opinions and perceptions, but also promotes a deeper and more holistic understanding of the issues investigated [11]. This ability to manage the vagueness inherent in human reality is crucial in disciplines such as philosophy, psychology and sociology, where subjective interpretations play a central role in the construction of knowledge. In practical terms, Neutrosophic Cognitive Maps find application in a variety of fields, from scientific research to strategic planning and business decision making. Its methodological flexibility allows researchers and practitioners to explore and analyze complex and multidimensional data in a structured and comprehensive manner. This methodology not only provides a visual representation of the complexity inherent in the systems and processes studied, but also facilitates the identification of hidden patterns and subtle connections that might be overlooked with more traditional approaches. However, like any emerging methodology, Neutrosophic Cognitive Maps face challenges and criticism. One of the main questions lies in the difficulty of quantifying and validating the indeterminacy and vagueness represented in these maps. Objectively evaluating the quality and reliability of data entered into maps can be complicated, especially when subjective or qualitative information is involved. Furthermore, interpretation of results can vary significantly depending on the theoretical framework and underlying assumptions of those using this methodology [12].

Despite these challenges, Neutrosophic Cognitive Maps offer considerable potential to advance the understanding and modeling of complex systems in an increasingly interconnected and dynamic world. By integrating principles from neutrosophic theory, these maps not only address reality in all its complexity and ambiguity, but also promote an inclusive and multidimensional approach to research and decision-making. This is especially valuable in contexts where the diversity of opinions and perspectives enriches the analysis process and contributes to more robust and adaptive solutions. In conclusion, Neutrosophic Cognitive Maps represent a powerful and promising tool for researchers and professionals seeking to navigate the complexity of the contemporary world. Its ability to represent and analyze vagueness and indeterminacy offers new opportunities to understand and address complex problems in fields as diverse as business management, public policy, and social science. As research in this area advances, it is crucial to continue exploring and refining this methodology to maximize its usefulness and accuracy in the information and knowledge age [13].

This section contains the basic concepts of neutrosophic cognitive maps and the algorithms associated with them.

Definition 1: ([14]) Let X be a universe of discourse. A *neutrosophic set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \rightarrow]_r^-0, 1^+[$ which satisfy the condition $^-_r 0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ are the truthfulness, indeterminacy, and falsity membership functions of x in A, respectively, and their images are standard or non-standard subsets of $]_r^-0, 1^+[$.

Definition 2: ([14]) Let X be a universe of discourse. A *single-valued neutrosophic set* (SVNS) A on X is a set of the form:

$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\}$ (1)

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfies the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ denotes the truthfulness, indeterminacy, and falsity membership functions of x in A, respectively. For convenience, a *single-valued neutrosophic number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

Other important definitions are related to graphics.

Definition 3: ([15, 17-18]) A *neutrosophic graph* is a graph that contains at least one indeterminate edge, which is represented by dotted lines.

Definition 4: ([15, 17-18]) A *neutrosophic directed graph* is a directed graph that contains at least one indeterminate edge, which is represented by dotted lines.

Definition 5: ([15, 17-18]) A *neutrosophic cognitive map* (NCM) is a neutrosophic directed graph, whose nodes represent concepts and whose edges represent causal relationships between the edges.

If $C_1, C_2, \ldots, C_k$ there are k nodes, each of them C_i $(i = 1, 2, \ldots, k)$ can be represented by a vector $(x_1, x_2, \ldots, x_k)$ where $x_i \in \{0, 1, I\}$. $x_i = 0$ means that the node C_i is in an up state, $x_i = 1$ it means that the node C_i is in a down state, and $x_i = I$ it means that the node C_i is in an undetermined state, at a specific time, or in a specific situation.

If C_m and C_n are two nodes of the NCM, a directed edge from C_m to C_n is called *a connection* and represents causality from C_m to C_n. Each node in the NCM is associated with a weight within the set $\{-1, 0, 1, I\}$. If α_{mn} denotes the edge weight $C_m C_n$, $\alpha_{mn} \in \{-1, 0, 1, I\}$ then we have the following:

$\alpha_{mn} = 0$ Yeah C_m does not affect C_n,

$\alpha_{mn} = 1$If an increase (decrease) in $C_m$produces an increase (decrease) in C_n,

$\alpha_{mn} = -1$If an increase (decrease) of $C_m$produces a decrease (increase) of C_n,

$\alpha_{mn} = I$If the effect ofC_m on $C_n$is indeterminate.

Definition 6: ([19]) An NCM that has edges with weights $\{-1, 0, 1, I\}$is called *a simple neutrosophic cognitive map.*

Definition 7: ([19]) If $C_1, C_2, \dots, C_k$they are the nodes of an NCM. The *neutrosophic matrix* N(E) is defined as $N(E) = (\alpha_{mn})$, whereα_{mn} denotes the weight of the directed edge $C_m C_n$, such that $\alpha_{mn} \in \{-1, 0, 1, I\}$. N(E)It is called *neutrosophic adjacency.* NCM *matrix.*

Definition 8: ([19]) Let be $C_1, C_2, \dots, C_k$the nodes of an NCM. We go $A = (a_1, a_2, \dots, a_k)$where $a_m \in \{-1, 0, 1, I\}$. A is called *instantaneous state. neutrosophic vector* and means a position of the on-off-indeterminate state of the node at a given instant.

$a_m = 0$if $C_m$it is disabled (has no effect),

$a_m = 1$if $C_m$it is activated (has an effect),

$a_m = I$YeahC_m It is indeterminate (its effect cannot be determined).

Definition 9: ([19]) Let $C_1, C_2, \dots, C_k$the nodes of an NCM be. Leave $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4}, \dots, \overrightarrow{C_m C_n}$ be the edges of the NCM, then the edges constitute a *directed cycle.*

The NCM is called *cyclic* if it has a directed cycle. It is said *acyclic* if it does not have a directed cycle.

Definition 10: ([19]) An NCM containing cycles is said to have *feedback.* When there is feedback in the NCM it is said to be a *dynamic system.*

Definition 11: ([19]) Let $\overrightarrow{C_1 C_2}, \overrightarrow{C_2 C_3}, \overrightarrow{C_3 C_4}, \dots, \overrightarrow{C_{k-1} C_k}$ be a cycle. When $C_m$it is activated and its causality flows along the edges of the cycle and is then the cause of $C_m$itself, then the dynamic system circulates. This is true for each node $C_m$with $m = 1, 2, \dots, k$. The equilibrium state of this dynamic system is called the *hidden pattern.*

Definition 12: ([19]) If the equilibrium state of a dynamic system is a single state, then it is called *a fixed point.*

An example of a fixed point is when a dynamic system begins by being activated by C_l. If the NCM is supposed to sit onC_l and C_k, that is, the state remains like this $(1, 0, \dots, 0, 1)$, then this neutrosophic state vector is called *fixed point.*

Definition 13: ([19]) If the NCM is established with a neutrosophic state vector that repeats in the form:

$A_1 \to A_2 \to \cdots \to A_m \to A_1$, then the equilibrium is called the NCM *limit cycle.*

Method to determine hidden patterns

Let be $C_1, C_2, \dots, C_k$the nodes of the NCM with feedback. Let E be the associated adjacency matrix. A hidden pattern is found when activated and C_la vector input $A_1 = (1, 0, 0, \dots, 0)$is provided. The data must pass through the neutrosophic matrix N(E), which is obtained by multiplyingA_1 by the matrix N(E).

Leave$A_1 N(E) = (\alpha_1, \alpha_2, \dots, \alpha_k)$ with the threshold operation of replace $\alpha_m$by 1 if $\alpha_m > p$andα_m for 0 if $\alpha_m < p$(p is a suitable positive integer) andα_m is replaced by I if it is not an integer. The resulting concept is updated; The vector $C_1$is included in the updated vector by transforming the first coordinate of the resulting vector to 1.

Yeah$A_1 N(E) \to A_2$ It is assumed, then $A_2 N(E)$considered and the same procedure is repeated. This procedure is repeated until a limit cycle or set point is reached.

Definition 14: ([20]) A *neutrosophic number* N is defined as a number as follows:

$N = d + I$(2)

where d is called *determined part* and they call me the *indeterminate part.*

Given $N_1 = a_1 + b_1 I$and $N_2 = a_2 + b_2 I$are two neutrosophic numbers, some operations between them are defined as follows:

$N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$(Addition);

$N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$(Difference),

$N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),

$\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)}I$(Division).

3 Results and Discussion.

First, we specify the variables to take into account for the study, these are the following:

Here are five teaching options for instruction in numerical and research skills for accounting students:

1. **Problem-Based Learning (PBL):** This methodology involves presenting students with problematic cases or situations related to accounting. Students work in teams to identify and analyze relevant numerical data, applying research methods to arrive at evidence-based solutions or recommendations.

2. **Financial Simulations:** Use interactive simulations that imitate real financial scenarios. This includes the use of specialized software to perform financial analysis, cash flow projections, and evaluate investment performance. Students develop practical numerical skills as they investigate and make strategic decisions based on the results obtained.

3. **Case Studies in Auditing and Accounting**: Use case studies based on real auditing and accounting situations. Students analyze accounting documents, perform complex financial calculations, and apply investigative techniques to identify irregularities or areas for improvement in accounting practices. This encourages the development of advanced numerical skills and the ability to carry out detailed investigations.

4. **Use of Data Analysis Tools:** Introduce students to the use of data analysis software such as Excel, SPSS or data mining software. Through hands-on exercises, students learn to manipulate large data sets, perform statistical analysis, and present results effectively. This option promotes both numerical skills and research competencies through the exploration and management of complex data.

5. **Independent Research Projects:** Assign research projects that require the collection, analysis and presentation of actual financial data. Students choose topics of interest within the field of accounting, design appropriate research methodologies, and apply advanced numerical techniques to reach informed conclusions. This option encourages academic autonomy and deepening numerical and research skills.

These teaching options not only strengthen accounting students' numerical and research skills, but also prepare them to face real challenges in the professional world, integrating theory and practice effectively.

Let be $E = \{e_1, e_2, \cdots, e_n\}$ the set of n experts. R_{ijk} symbolizes the relationship between the jth and kth criteria ($j, k \in \{1,2,\ldots,5\}$, $j \neq k$) according to the expert e_i ($i = 1,2,\ldots,n$) such that $R_{ijk} \in \{-5, -4, \cdots, -1, 0, 1, \cdots, 4, 5, I\}$.

1. The numerical values of R_{ijk} are calculated, then $\hat{R}_{ijk} = R_{ijk}$, and if $R_{ijk} = I$ then is kept $\hat{R}_{ijk} = I$.

2. For each fixed pair $j, k \in \{1,2,\ldots,5\}$, it is calculated $\bar{R}_{jk}$ as follows:

- If the mode of $\hat{R}_{ijk}$ for $i = 1,2,\ldots,n$ is unimodal, we take $\bar{R}_{jk} = mode_i(\hat{R}_{ijk})$ and $\bar{R}_{kj} = 0$.

- If the mode of $\hat{R}_{ijk}$ for $i = 1,2,\ldots,n$ is not unimodal, it is defined as follows:

  ✧ If $\hat{R}_{ikj}$ for $i = 1,2,\ldots,n$ is unimodal, take $\bar{R}_{kj} = mode_i(\hat{R}_{ikj})$ and $\bar{R}_{jk} = 0$.

  ✧ If $\hat{R}_{ikj}$ for $i = 1,2,\ldots,n$ is not unimodal, it is taken $\bar{R}_{jk} = \bar{R}_{kj} = I$.

3. In this way, the adjacency matrix is formed with the elements $\bar{R}_{jk}$ obtained from this algorithm.

To obtain the weights and form the NCM, 30 specialists in mathematics teaching were surveyed. Among them are scientists and academics with at least 10 years of experience. The Adjacency Matrix obtained is summarized in Table 1.

Table 1. The prediction adjacency matrix of the teaching options according to the 30 experts surveyed.

Variable	V 1	V 2	V 3	V 4	V 5
V 1	0	I	I	0	I
V 2	I	0	-1	0	1
V 3	I	0	0	0	0
V 4	1	0	1	0	1
V 5	I	0	-1	0	0

Figure 1 contains the NCM graph according to the adjacency matrix established in Table 1.
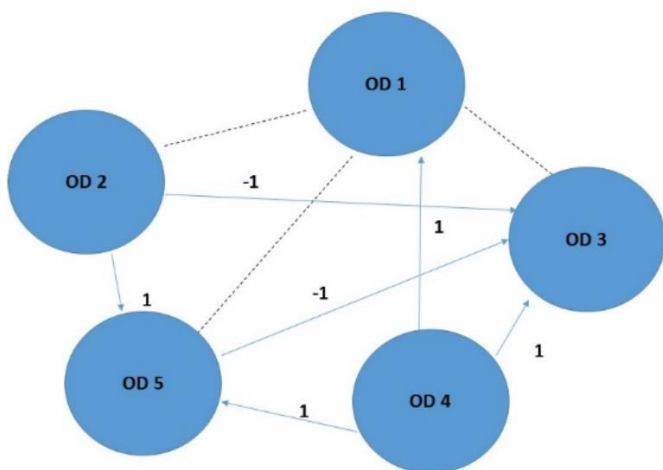

Figure 1: Neutrosophic Cognitive Map obtained from the experts.

All possible cases of convergence were studied when at least one of the variables was activated. This occurs in a total number of cases equal to $2^5 - 1 = 31$. Table 2 summarizes the results in absolute and relative frequencies for each of the three possible states of activated (1), deactivated (0) or indeterminate (I).

Table 2: Absolute frequency of convergence of the system in each of the possible values. Relative frequen-cies in percentage appear in parentheses.

Convergence To Value						
SDG	**0**	**%**	**1**	**%**	**Yo**	**%**
OD1	4	12.90	9	29.03	18	58.06
OD2	5	16.13	4	12.90	22	70.97
OD3	9	29.03	13	41.94	9	29.03
OD4	2	6.45	11	35.48	18	58.06
OD5	26	83.87	5	16.13	0	0.00
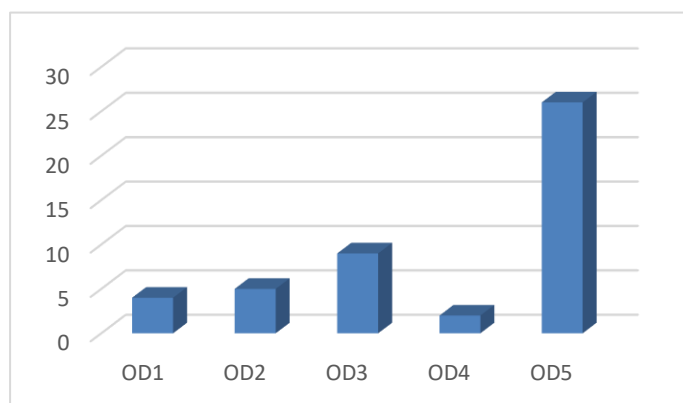
Figure 2: Absolute convergence frequency of the system (0).

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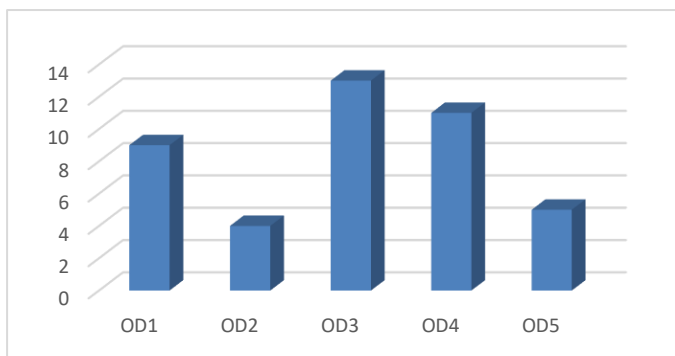
Figure 3: Absolute convergence frequency of system (1).
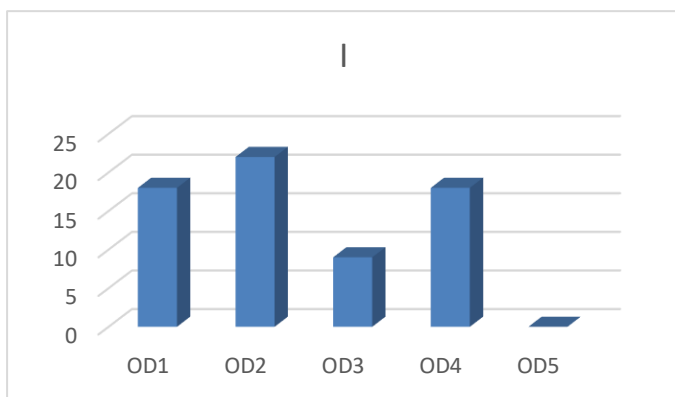

Figure 4: Absolute frequency of system convergence (I).

The results shown in Table 2 confirm the complexity of the work to be done to implement the didactic options for instruction in the numerical and research skills of accounting students.

Table 2 shows that the most robust teaching option is OD $_3$ or "Case **Studies in Auditing and Accounting:**" since it is activated in almost half of the possible initial conditions, while it is indeterminate in 29.3% of them.

The safest teaching option is OD $_5$ or "Independent **Research Projects"**. However, this will be activated in 16.3% of the possible initial conditions, which makes it difficult for it to be activated from the rest of the variables.

The rest of the options OD $_2$ or "Financial **Simulations"**, OD $_4$ or "Use **of Data Analysis Tools"** and OD $_1$ or "Problem**-Based Learning (PBL)"** show similar behaviors to each other, where there is indeterminacy for the majority. of the possible initial conditions of the states. This fact corroborates the complex and experimental nature of the project to be implemented.

A more detailed study shows that the most efficient proposal is to activate (or implement) the teaching options OD $_3$ and OD $_4$ ($x_0 = (0, 0, 1, 1, 0)$) or OD $_3$ and OD $_5$ ($x_0 = (0, 0, 1, 0, 1)$). If the three OD $_3$, OD $_4$ and OD $_5$ are activated ($x_0 = (0, 0, 1, 1, 1)$) The same results are obtained, however, this is not enough to activate the first two didactic options.

In the other cases of initial conditions it can be seen that no other option is activated.

Accounting education requires teaching methods that not only convey theoretical knowledge but also develop practical and research skills crucial for professional success. In this context, Neutrosophic Cognitive Maps have provided an exhaustive and detailed evaluation of various teaching options, revealing complex patterns and offering valuable elements about their effectiveness. This methodology has allowed us to identify that "Case Studies in Auditing and Accounting" (OD 3) stand out as the most robust option, activating in almost half of the possible initial conditions and showing indeterminacy in 29.3% of them. This combination of certainty and indeterminacy reflects the flexibility and applicability of this approach in various educational settings. The robustness of OD 3 suggests that case studies based on real situations are highly effective in fostering advanced numerical skills and detailed research competencies. By facing authentic problems, students can apply their theoretical knowledge to practical situations, developing critical and analytical thinking that is essential in accounting practice. This methodology not only strengthens technical skills, but also promotes a deep understanding of accounting and auditing principles, preparing students for real-world challenges.

On the other hand, "Independent Research Projects" (OD 5) are presented as the safest didactic option, although with an activation rate of 16.3% in the possible initial conditions. This low activation rate indicates that although OD 5 is very effective when implemented, its applicability may be limited by the need for specific conditions and an appropriate learning environment. However, when these conditions are met, independent research projects can foster academic autonomy and a deepening of numerical and research skills, essential for professional development in accounting. The remaining options, "Financial Simulations" (OD 2), "Use of Data Analysis Tools" (OD 4) and "Problem-Based Learning" (OD 1), show similar behaviors with high indeterminacy in most conditions. initials. This underlines the experimental and complex nature of these approaches. The high indeterminacy could suggest that its effectiveness depends largely on specific contextual and implementation factors, which may limit its general applicability but offer great benefits in suitable settings.

A more detailed analysis reveals that the combination of options OD 3 and OD 4 or OD 3 and OD 5 turns out to be the most efficient proposal. Simultaneously activating "Case Studies in Auditing and Accounting" with "Use of Data Analysis Tools" or "Independent Research Projects" maximizes the development of numerical and research skills in accounting students. This combination allows the complementary strengths of each approach to be leveraged, providing a rich and diversified learning experience that addresses both technical competencies and research skills. It is interesting to note that when the three options are activated (OD 3, OD 4 and OD 5) similar results are obtained, but the first two didactic options cannot be activated. This suggests that, although each methodology has its own strengths, their combination may not always be synergistic. This observation highlights the importance of careful planning and strategic implementation of teaching options to maximize their effectiveness.

In summary, Neutrosophic Cognitive Maps have proven to be an invaluable tool to evaluate and optimize didactic methodologies in teaching accounting. The robustness of OD 3, combined with the security of OD 5 and the flexibility of OD 4, offers a comprehensive and adaptable framework for developing numerical and research skills. By strategically integrating these approaches, educators can create dynamic and effective learning environments that prepare students to meet professional challenges with confidence and competence [21, 22].

This detailed evaluation and analysis not only provides guidance for the implementation of teaching methodologies in accounting, but also highlights the importance of considering the complexity and indeterminacy inherent in education. By addressing these factors proactively and strategically, we can significantly improve the quality of teaching and learning in this crucial discipline.

4 Conclusion

Accounting education requires a balanced combination of teaching methods that convey theoretical knowledge and develop practical and research skills essential for professional success. Neutrosophic Cognitive Maps have proven to be a powerful tool to evaluate the effectiveness of various teaching options, offering valuable elements and revealing complex patterns. Through this methodology, we have identified that "Case Studies in Auditing and Accounting" (OD 3) are the most robust option, due to their ability to activate in almost half of the possible initial conditions and show an indeterminacy of 29.3 %. The effectiveness of OD 3 lies in its ability to confront students with real problems, allowing them to apply their theoretical knowledge in practical situations. This not only encourages the development of advanced numerical skills and detailed research competencies, but also promotes critical and analytical thinking essential to accounting practice. The implementation of case studies based on real situations prepares students for the challenges of the professional world, strengthening both their technical skills and their understanding of accounting and auditing principles.

On the other hand, "Independent Research Projects" (OD 5) are presented as the safest didactic option, although with an activation rate of 16.3%. This low activation rate suggests that although OD 5 is highly effective when implemented, its applicability may be limited by the need for specific conditions and an appropriate learning environment. However, when these conditions are met, independent research projects foster academic autonomy and deepening numerical and research skills, essential for professional development in accounting. The remaining options, "Financial Simulations" (OD 2), "Use of Data Analysis Tools" (OD 4) and "Problem-Based Learning" (OD 1), show similar behaviors with high indeterminacy in most conditions. initials. This high indeterminacy suggests that the effectiveness of these approaches is highly dependent on specific contextual and implementation factors, which may limit their general applicability but offer great benefits in appropriate settings. A more detailed analysis reveals that the combination of options OD 3 and OD 4 or OD 3 and OD 5 turns out to be the most efficient proposal. Simultaneously activating "Case Studies in Auditing and Accounting" with "Use of Data Analysis Tools" or "Independent Research Projects" maximizes the development of numerical and research skills in accounting students. This combination allows the complementary strengths of each approach to be leveraged, providing a rich and diversified learning experience that addresses both technical competencies and research skills.

It is notable that when the three options are activated (OD 3, OD 4 and OD 5) similar results are obtained, but the first two didactic options cannot be activated. This suggests that, although each methodology has its own strengths, their combination may not always be synergistic. This observation highlights the importance of careful planning and strategic implementation of teaching options to maximize their effectiveness.

In summary, Neutrosophic Cognitive Maps have proven to be an invaluable tool to evaluate and optimize didactic methodologies in teaching accounting. The robustness of OD 3, combined with the security of OD 5 and the flexibility of OD 4, offers a comprehensive and adaptable framework for developing numerical and research skills. By strategically integrating these approaches, educators can create dynamic and effective learning environments that prepare students to meet professional challenges with confidence and competence. To improve the quality of teaching and learning in accounting, it is crucial to proactively and strategically address the complexity and indeterminacy inherent in education. The detailed assessment and analysis provided by Neutrosophic Cognitive Maps not only offers guidance for the implementation of teaching methodologies, but also highlights the importance of considering these factors in the design and implementation of educational programs. In this way, we can significantly advance the preparation of highly trained and adaptable accounting students, ready to meet the challenges of today's professional world.

5 References

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