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Assessing Higher Education's Role in Personality Formation Using NeutroAlgebra

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Abstract. This study examines the role of higher education in personality formation, highlighting its influence on the development of critical thinking, autonomy in decision-making, social skills, and creativity. While there is a favorable influence in these areas, the data also highlight limitations in developing problem-solving skills and cementing ethical and moral ideals. Emotional management has a neutral influence, whereas social awareness and citizenship reveal modest improvement, suggesting a need for increased attention on building civic involvement. The study proposes the use of neutroalgebra and neutrosophic theory to more accurately assess these abstract dimensions. Future work could explore the use of other uninorms to generate neutroalgebras, potentially leading to more robust models and precise evaluation tools in higher education.

Keywords: Higher education, personality formation, critical thinking, Neutroalgebra, Prospector.

1 Introduction

The function of higher education in the creation of personality is a subject of rising interest in the academic and social sectors, because education not only strives to convey technical information, but also to shape people with firm values and ideals. The power of educational institutions to impact the personality of students, molding their attitudes, beliefs and actions, is a vital factor in the entire creation of the individual. Over the previous decades, several studies have underlined the necessity of an education that fosters not only academic brilliance, but also the personal and social development of students [1]. However, analyzing this influence remains a difficulty, particularly when it comes to measuring aspects as abstract and complex as personality. Historically, higher education has progressed from an elitist approach, meant for a tiny social elite, towards a more inclusive and democratic model, accessible to a greater section of the public [2]. This transition has brought with it new obligations for educational institutions, which must now ensure not just the transfer of information, but also the training of persons capable of tackling the ethical and social difficulties of modern society. In this context, higher education has been recognized as a critical tool for the holistic development of the human person, but the method in which this effect is exerted and quantified has been a source of continual discussion.

The key challenge that this research tackles consists in the difficulties of precisely and objectively measuring how higher education contributes to the construction of students' personalities. Although there are numerous techniques to evaluate educational effect in academic and professional terms, the assessment of its influence on personality remains an underexplored subject and full of methodological obstacles [3]. The complexity and multidimensional character of human personality implies that any effort at measuring needs sophisticated instruments and methodologies that can manage the ambiguity and indeterminacy inherent in this process. Despite developments in educational psychology and personality theory, there is a considerable vacuum in the research regarding approaches that effectively capture the interplay between higher education and personality formation [4]. Traditional evaluation techniques, which mainly concentrate on cognitive and behavioral components, fail to capture the complete educational process or the subtle impacts that the educational environment imposes on pupils. Furthermore, most research concentrate on practical outcomes, leaving aside the influence on more abstract and subjective characteristics, such as values, attitudes and beliefs [5]. This research presents a solution to this difficulty by employing neutroalgebra, a method that permits a more comprehensive and accurate examination of the effect of higher education on personality development [6]. Neutroalgebra, with its capacity to manage uncertainty and indeterminacy [7,8, 9], is proposed as a unique technique to address the difficulty inherent in the assessment of these abstract

elements of human development [10]. Using this method, we strive to not only measure the effect of higher education, but also to better understand how students' personalities grow and change in an educational setting.

The formation of personality is a dynamic and ongoing process shaped by a complex interplay of genetic, environmental, and social factors. From the earliest stages of life, personality develops via distinct and sometimes surprising routes, impacted by experiences, relationships, and social environments such as family, education, and media. This process is distinguished by a conflict between society conformity and individual authenticity, needing a balance that is vital for personal progress. As individuals navigate life's stages, their personalities continue to evolve, demonstrating the capacity for adaptation and self-determination in the face of life's challenges. Ultimately, personality formation is a lifetime process of self-discovery and growth, reflecting both the individual's inner world and their interactions with the larger environment[11].

The application of this method has the potential to offer new perspectives on how educational institutions can improve their training programs to encourage more balanced and robust personal development. By better understanding the relationship between higher education and personality formation, educators and administrators will be able to design more effective strategies to support the holistic growth of their students. This study will therefore not only contribute to the existing theory on education and personality, but will also offer practical tools to improve the quality of higher education as a whole [12].

2 Preliminaries

2.1 NeutroAlgebra and PROSPECTOR function

The idea of NeutroAlgebra proposes a new algebraic structure that generalizes Partial Algebra by including the notion of indeterminacy. In NeutroAlgebra, a given set X is divided into three regions: <A> (true), <antiA> (false), and <neutA> (indeterminate), which may overlap depending on the context. This framework allows for the definition of NeutroFunctions, which are partially well-defined, indeterminate, or outer-defined within their domain, as well as NeutroAxioms, which are true, false, or indeterminate for different elements. These notions expand standard algebraic structures to cover a greater range of possibilities, accommodating uncertainty and partial truth, and are further classed alongside Classical and AntiAlgebras. Additionally, the PROSPECTOR function, applied in the MYCIN expert system [13] , is specified as an uninorm that conforms to particular mathematical criteria, including commutativity, associativity, and monotonicity.

Definition 1 ([14]): Let X be a given nonempty space (or simply set) integrated into a universe of discourse U. Let <A> be an item (concept, attribute, idea, statement, theory, etc.) specified on the set X. Through the process of neutrosophication, we split the set X into three regions [two opposite ones <A> and <antiA>, and one neutral (indeterminate) <neutA> between them], regions which may or may not be disjoint – depending on the application, but they are exhaustive (their union equals the whole space).

A NeutroAlgebra is an algebraic structure characterized by the existence of at least one NeutroOperation or NeutroAxiom. A NeutroAxiom is a unique sort of axiom that is true for certain items, is ambiguous for others, and is untrue for the remaining elements. This allows NeutroAlgebra to incorporate a degree of flexibility and uncertainty, distinguishing it from traditional algebraic systems where axioms are either universally true or false.The NeutroAlgebra is a generalization of Partial Algebra, which is an algebra that has at least one Partial Operation, while all its Axioms are totally true (classical axioms).

Definition 2 ([14]): A function f: X→Y is termed a Partial Function if it is well-defined for certain items in X, and undefined for all the other elements in X. Therefore, there exist certain elements a ∈ X such that f(a) ∈ Y (well-defined), whereas for every other element b ∈ X we obtain f(b) is undefined.

Definition 3 ([14]): A function f: X→ Y is called a NeutroFunction if it has elements in X for which the function is well-defined (degree of truth (T)), elements in X for which the function is indeterminate {degree of indeterminacy (I)}, and elements in X for which the function is outer-defined {degree of falsehood (F)}, where T, I, F ∈ [0, 1], with (T, I, F) ≠ (1, 0, 0) that represents the (Total) Function, and (T, I, F) ≠ (0, 0, 1) that represents the Anti-Function.

Classification of Functions

i. (Classical) Function, which is a function well-defined for all the elements in its domain of definition.
ii. NeutroFunction, which is a function partially well-defined, partially indeterminate, and partially outer-defined on its domain of definition.
iii. AntiFunction, which is a function outer-defined for all the elements in its domain of definition.

Definition 4 ([14]): A (classical) *Algebraic Structure* (or Algebra) is a nonempty set *A* endowed with some (totally well-defined) operations (functions) on *A*, and satisfying some (classical) axioms (totally true) - according to the Universal Algebra.

Definition 5 ([14]): A (classical) *Partial Algebra* is an algebra defined on a nonempty set *PA* that is endowed with some partial operations (or partial functions: partially well-defined, and partially undefined). While the axioms (laws) defined on a Partial Algebra are all totally (100%) true.

Definition 6 ([14]): A *NeutroAxiom* (or *Neutrosophic Axiom*) defined on a nonempty set is an axiom that is true for some set of elements {degree of truth (T)}, indeterminate for other set of elements {degree of indeterminacy (I)}, or false for the other set of elements {degree of falsehood (F)}, where T, I, F ∈ [0, 1], with (T, I, F) ≠ (1, 0, 0) that represents the (classical) Axiom, and (T, I, F) ≠ (0, 0, 1) that represents the AntiAxiom.

Classification of Algebras

i) A (classical) *Algebra* is a nonempty set *CA* that is endowed with total operations (or total functions, i.e. true for all set elements) and (classical) Axioms (also true for all set elements).
ii) A *NeutroAlgebra* (or *NeutroAlgebraic Structure*) is a nonempty set *NA* that is endowed with: at least one *NeutroOperation* (or *NeutroFunction*), or one *NeutroAxiom* that is referred to the set (partial-, neutro-, or total-) operations.
iii) An *AntiAlgebra* (or *AntiAlgebraic Structure*) is a nonempty set *AA* that is endowed with at least one *AntiOperation* (or *AntiFunction*) or at least one *AntiAxiom*.

Additionally, the PROSPECTOR function is defined in the MYCIN expert system in the following way; it is a mapping from $[-1,1]^2$ into $[-1,1]$ with formula, [15, 16]:

$$P(x,y) = \frac{x+y}{1+xy} \qquad (1)$$

This function is a uninorm, [17, 18, 19], with neutral element 0, thus it fulfils commutativity, associativity, and monotonicity. Here we respect the condition that $P(-1,1)$ and $P(1,-1)$ are undefined.

3 Material and Methods

This section contains the results of this investigation, for this we explain some characteristics of the method . The set NeutroGroup consists of all integers between $-n$and n plus the symbolic element I to represent indeterminacy [20]. This is $NG_7 = \{-10,-9,-8,-7,-6,-5,-4,-3,-2,-1,0,1,2,3,4,5,6,7,9,10,I\}$and $\odot_{10}$is used

First of all, for convenience $P(x,y)$ is extended to $\bar{P}(x,y)$ such that:

$\bar{P}(x,y) = P(x,y)$ for all $(x,y) \in [-10,10]^2 \setminus \{(-10,10),(10,-10)\}$,

$\bar{P}(-10,10) = \bar{P}(10,-10) = I$,

$\bar{P}(I,I) = I$.

$$\bar{P}(I,x) = \bar{P}(x,I) = \begin{cases} \text{I, if x} > 0 \\ \text{x, if x} \le 0 \end{cases}. \qquad (2)$$

Definition 7 : Let S be a finite set defined as $S = \left\{(x,y): x,y \in \left\{\frac{k}{7}, I\right\},\ k \in \mathbb{Z} \cap [-7,7]\right\}$.

The operator $\odot_{10}$ is defined for every $(x,y) \in S$, such that:

If $\bar{P}(x,y)$ is not undefined, then $\odot_{10}\ y = \frac{round(\bar{P}(x,y)*10)}{10}$, where *round* is the function that output the integer nearest to the argument.

If $\bar{P}(x,y)$ is undefined then $x \odot_{10} y = I$.

Then $\odot_{10}$ is a finite NeutroAlgebra. This is because $\odot_{10}$ is commutative and associative for the subset of elements of S without any undefined component, but it is not associative otherwise.

E.g., if $a = -6, b = 5, c = I$, then $a \odot_{10} (b \odot_{10} c) = a$ and $(a \odot_{10} b) \odot_{10} c = -1 \neq a$, therefore associativity is a NeutroAxiom.

Function *round* is used for guarantying $\odot_{10}$ is an inner operator.

For the sake of clarity, we use the elements of Tables 1 and Table 2 of Cayley tables.

Table 1: Cayley table of $\odot_{10}$.

$\odot_{10}$	**-10**	**-9**	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
-9	-10	-10	-10	-10	-10	-10	-10	-9	-9	-9	-9
-8	-10	-10	-10	-10	-9	-9	-9	-9	-9	-8	-8
-7	-10	-10	-10	-9	-9	-9	-9	-8	-8	-7	-7
-6	-10	-10	-9	-9	-9	-8	-8	-8	-7	-7	-6
-5	-10	-10	-9	-9	-8	-8	-8	-7	-6	-6	-5
-4	-10	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4
-3	-10	-9	-9	-8	-8	-7	-6	-6	-5	-4	-3
-2	-10	-9	-9	-8	-7	-6	-6	-5	-4	-3	-2
-1	-10	-9	-8	-7	-7	-6	-5	-4	-3	-2	-1
I	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
0	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0
1	-10	-9	-8	-6	-5	-4	-3	-2	-1	0	1
2	-10	-9	-7	-6	-5	-3	-2	-1	0	1	2
3	-10	-8	-7	-5	-4	-2	-1	0	1	2	3
4	-10	-8	-6	-4	-3	-1	0	1	2	3	4
5	-10	-7	-5	-3	-1	0	1	2	3	4	5
6	-10	-7	-4	-2	0	1	3	4	5	5	6
7	-10	-5	-2	0	2	3	4	5	6	6	7
8	-10	-4	0	2	4	5	6	7	7	8	8
9	-10	0	4	5	7	7	8	8	9	9	9
10	I	10	10	10	10	10	10	10	10	10	10

Table 2: Cayley table of $\odot_{10}$ (Continuation).

$\odot_{10}$	**I**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	I.
-9	-9	-9	-9	-8	-8	-7	-7	-5	-4	0	10
-8	-8	-8	-7	-7	-6	-5	-4	-2	0	4	10
-7	-7	-6	-6	-5	-4	-3	-2	0	2	5	10
-6	-6	-5	-5	-4	-3	-1	0	2	4	7	10
-5	-5	-4	-3	-2	-1	0	1	3	5	7	10
-4	-4	-3	-2	-1	0	1	3	4	6	8	10
-3	-3	-2	-1	0	1	2	4	5	7	8	10
-2	-2	-1	0	1	2	3	5	6	7	9	10
-1	-1	0	1	2	3	4	5	6	8	9	10
I	I	I.	I	I	I.	I	I	I.	I	I	I.
0	0	1	2	3	4	5	6	7	8	9	10
1	I	2	3	4	5	6	7	7	8	9	10
2	I	3	4	5	6	6	7	8	9	9	10
3	I	4	5	6	6	7	8	8	9	9	10
4	I	5	6	6	7	8	8	9	9	10	10

$\odot_{10}$	**I**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
5	I	6	6	7	8	8	8	9	9	10	10
6	I	7	7	8	8	8	9	9	9	10	10
7	I	7	8	8	9	9	9	9	10	10	10
8	I	8	9	9	9	9	9	10	10	10	10
9	I	9	9	9	10	10	10	10	10	10	10
10	I	10	10	10	10	10	10	10	10	10	10

$\odot_{10}$ It satisfies the properties of commutativity and associativity and has 0 as a null element. Furthermore , it satisfies each one of the following properties [20]:

- If x, y < 0 then $x \odot_{10} y \leq min(x, y)$,
- If x, y > 0then $x \odot_{10} y \geq max(x, y)$,
- If x $< 0$and y > 0 or if x $> 0$and y < 0, then we have $\min(x, y) \leq x \odot_7 y \leq \max(x, y)$.
- $\forall x \in G, x \odot_{10} 0 = x$.
- $(-10) \odot_{10} 10 = 10 \odot_{10} (-10) = I$.

The methodology employed in this study to evaluate the effectiveness of higher education in personality formation involves the following steps:

Step 1: Definition of Variables to Evaluate

The first step involves defining the key variables that will be used to evaluate the effectiveness of higher education as a critical instrument in personality formation. These variables, denoted as $V = \{v_1, v_2, \dots, v_n\}$, , represent the specific aspects of personality development that will be assessed throughout the study. Each variable corresponds to a distinct dimension of personality, reflecting how higher education influences the overall formation and growth of an individual's character and abilities.

Step 1 Data Collection: Gather opinions from a group of experts $P = \{p_1, p_2, \dots, p_l\}$, in short, informal texts about aspects/variables to evaluate $V = \{v_1, v_2, \dots, v_n\}$ on a discrete scale from -10 to 10. "I" is assigned to indicate indeterminacy.

To evaluate using scale, where the values range from -10 to 10, where -10 is strongly disagree or extreme disapproval

In this scale, negative values represent levels of disagreement or disapproval, 0 represents a neutral position, and positive values indicate levels of agreement or approval.

Step 3 Aggregation: For each variable each person opinión is aggragated to obtain the final results, we have a group of people whose opinion is studied. Let's call this set of people by $P = \{p_1, p_2, \cdots, p_l\}$, so that the values are taken into account, $x_{total,i}$ it is the total value of the ith variable,

$$x_{total,i} = x_{i,1} \odot_{10} x_{i,2} \odot_{10} x_{i,3} , \dots, \odot_{10} x_{i,n} \quad (1)$$

This aggregated value, $x_{total,i}$ represents the collective assessment for the iii-th variable, taking into account the diverse perspectives of all individuals in the group $P = \{p_1, p_2, \dots, p_l\}$, The operation $\odot_{10}$ used in the aggregation allows for a nuanced combination of opinions, accommodating both consensus and the presence of indeterminacy in the responses[21, 22]. The final result for each variable reflects the overall effectiveness of higher education in influencing that particular aspect of personality formation, providing a comprehensive view of how different educational experiences impact student development [23, 24].

4 Case Study

To evaluate the effectiveness of higher education as a key instrument in personality formation, an innovative approach is adopted based on neutrosophic theory. This approach allows us to more accurately capture and analyze the complex and often contradictory perceptions that students have about their role in personality formation. The applied technique encompasses numerous essential factors, concentrating on how students view and value their effect on the personal development of students. In the next sections, the processes and computations done in this investigation are explained in detail. Neutrosophic techniques were utilized to analyze the positivity, negativity

and indeterminacy of the views obtained, which enabled us to acquire a more nuanced and realistic perspective of the usefulness of higher education in the creation of personality.

Step 1: Definition of Variables to Evaluate

The factors to assess The efficiency of higher education as a crucial tool in the creation of personality are the following:

Development of Critical Thinking: To what degree does higher education enhance your capacity to examine, question, and reflect critically on numerous topics?

Problem Solving Ability: How effectively do you believe higher education has enhanced your ability to address and solve complex problems, both in the academic field and in real-life situations?

Autonomy and Decision Making: To what degree does higher education encourage independence in thinking and the capacity to make informed and ethical decisions?

Development of Social abilities: How effectively does higher education help to the growth of your interpersonal abilities, such as effective communication, empathy, and collaboration?

Strengthening Ethical and Moral beliefs: How much has higher education affected the consolidation of your ethical and moral beliefs, and their application in everyday life?

Capacity for Adaptation and Flexibility: How equipped do you believe higher education has enabled you to adjust to changes and tackle problems in diverse personal and professional contexts?

Personal Identity and Self-Concept: To what degree has higher education helped you create a clear sense of personal identity and a positive, realistic self-concept?

Social Awareness and Citizenship: How efficiently has higher education contributed to your creation of social awareness, including your commitment to the community and civic responsibility?

Emotional Management: How well do you feel higher education has qualified you to handle your emotions successfully, especially stress management and resilience in the face of difficulties?

Development of Creativity and invention: How much has higher education spurred your creativity and potential for invention, both in the academic area and in your professional and personal life?

Step 2: Data Collection

A survey was carried out among 10 studnets from different universities in Ecuador, who evaluated each aspect of personality formation on a scale from -10 to 10

Table 3: Results of Data Collection and Aggregation.

Variable	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Student 7	Student 8	Student 9	Student 10	$\odot_{10}$
v1	6	5	7	4	6	8	3	6	5	6	5
v2	-3	-2	-3	-1	-2	-4	-3	-2	-1	-3	-2
v3	3	4	5	3	3	5	4	5	3	4	4
v4	4	4	5	5	4	5	3	4	5	4	4
v5	-2	-3	-2	-3	-3	-2	-2	-3	-2	-2	-2
v6	0	0	4	0	5	0	0	3	0	2	2
v7	0	0	0	3	0	0	-2	0	0	0	0
v8	1	0	3	4	0	0	4	4	3	9	4
v9	0	0	I	3	0	0	2	0	3	3	3
v10	-3	-2	-3	-1	-2	-3	-4	-3	-2	-3	-3

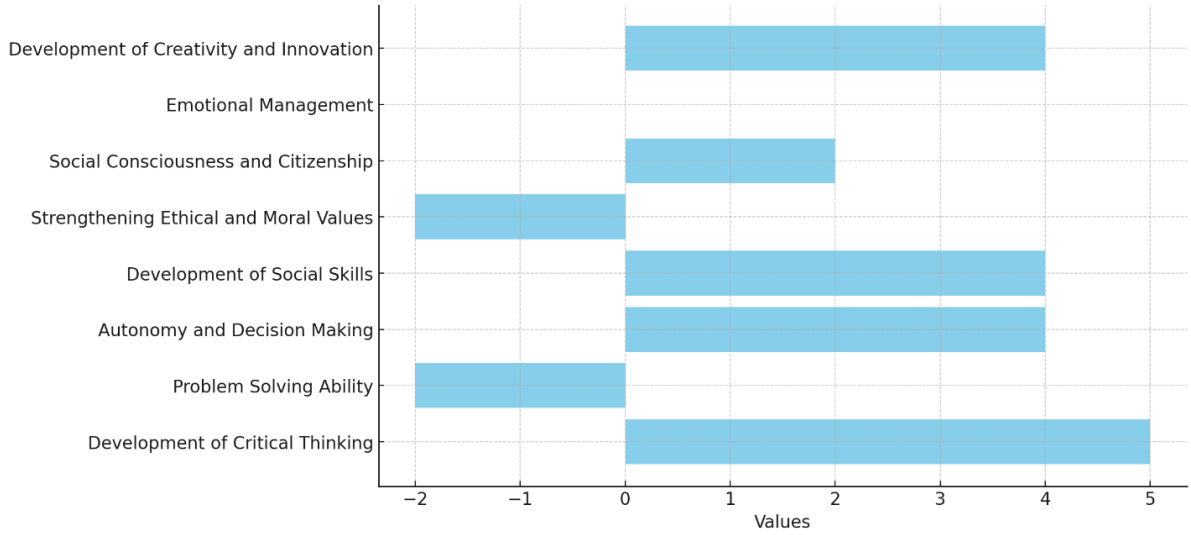

Figure 1: Aggragated alues usisng $\odot_{10}$

The findings reveal a generally beneficial influence of higher education on students' critical thinking (5), autonomy in decision-making (4), social skills (4), and creativity (4). However, there are obstacles in areas such as problem-solving (-2) and the consolidation of ethical and moral ideals (-2). Emotional management is neutral (0), showing that although students gain in numerous important areas, there are major gaps in problem-solving and ethical growth that may require more attention. Social awareness and citizenship obtained a fairly good score (2), showing space for growth in boosting civic involvement.

Conclusion

This research underlines the crucial impact of higher education in forming numerous parts of students' personalities, including critical thinking, autonomy in decision-making, social skills, and creativity. The results show that higher education institutions significantly affect these qualities, contributing to the holistic development of students. However, the research also emphasizes areas where higher education may fall short, notably in strengthening problem-solving ability and the consolidation of ethical and moral beliefs. The neutral impact on emotional regulation offers a possible area for development, while the modest positive effect on social awareness and citizenship refers to the need for greater efforts to encourage civic involvement among students. Future study might examine the use of various uninorms within the framework of neutroalgebra to better represent the complexity and subtleties of personality development in higher education. By experimenting with diverse mathematical frameworks, such as variable uninorms, researchers may construct more robust models that give deeper insights into how educational contexts impact student growth. Additionally, these techniques might assist enhance the assessment instruments utilized in this research, leading to more accurate assessments of the wider implications of higher education on personality development.

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