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Design Thinking Model Based on Plithogenic Logic for the Management of Entrepreneurship and Innovation in Higher University Education in Peru

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Abstract. Design Thinking is a methodology that has been gaining popularity in the business world and also in higher education management. This methodology proposes a set of steps to follow, with the client and the human being at the center of attention. It encourages the search for creative and collaborative solutions to problems. The role of Design Thinking in entrepreneurship and entrepreneurship management for higher education lies in its contribution to innovation in business management within this field. The development of skills in Design Thinking fosters creativity, innovation, and critical thinking in students, improving their problem-solving and project development skills. The incorporation of Design Thinking is recommended in educational programs to strengthen entrepreneurial skills and prepare students for market challenges. In this paper, we propose a plithogenic model for the implementation and evaluation of Design Thinking in the management of entrepreneurship and innovation within Peruvian higher education. Design Thinking is consistent with a more humane and inclusive education. Plithogeny is a theory dedicated to modeling cases of multidimensionality, when there is a dynamic between concepts of different origins, as well as their opposites and neutrals. Plithogenic Logic is a pluri-logic, composed of various truth values for the various variables that make up the phenomenon being studied. Due to the complexity of the Design Thinking model, which is composed of various dimensions, we rely on the plithogenic logic, where the degrees of truthfulness, indeterminacy, and falsity of compliance of each variable are taken into account.

Keywords: Management, Higher Education, Higher Education Management, Design Thinking, Plithogeny, Neutrosophy, Plithogenic Logic.

1. Introduction

Design Thinking is an interdisciplinary and collaborative human-centered methodology used to solve complex problems in creative and innovative ways. It is based on a deep understanding of end-user needs, as the core design element, to develop practical and effective solutions. It refers to how designers observe and think. It is an iterative process that presents concepts about problem-solving and relationships between ideas that allow for solutions. It contemplates a way of thinking that leads to transformation, evolution, and innovation, implying new business management methods.

Design Thinking is an innovative methodology established to solve problems worldwide, using integral, emotional, and experimental intelligence, reducing risks and aiming to achieve great successes based on human needs related to other disciplines that generate desired solutions that are operationally and technologically feasible and economically viable. It allows for the convergence of the user's desired characteristics with the designer's technical knowledge and the project's financial viability.

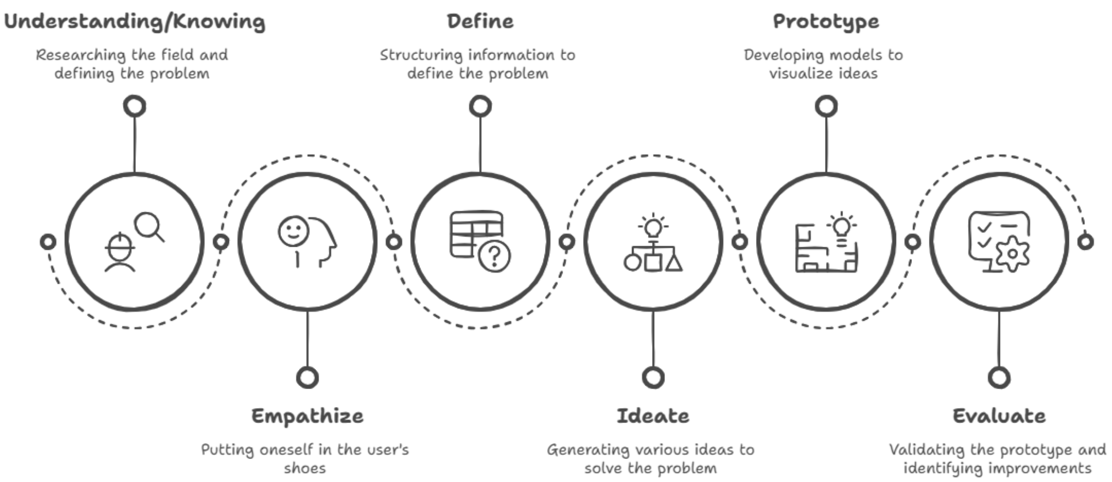

Figure 1. Designg thinking process

This methodology consists of the following steps:

a. Understanding/Knowing: This stage involves researching the field, understanding the problem, and understanding its objective, to clarify and define its boundaries. It also allows for identifying the needs of the future user.
b. Empathize: This is the basic stage because it can be used to determine specific design characteristics that benefit users. It involves putting oneself in other people's shoes and constantly applying empathy to generate effective solutions.
c. Define: This stage determines and describes the problem. All the information gathered from the user and their context is structured to obtain the point of view.
d. Ideate: Its purpose is to compile various ideas based on the approach to build them and arrive at various solutions to satisfy the user by covering their initially stated needs.
e. Prototype: At this stage, models and plans are developed to represent the proposed ideas to visualize them more clearly and be able to interact with them. This way, it is easier to observe their operation and determine their viability and defects.
f. Evaluate: Seeks to validate the prototype and identify the main opportunities for design improvement.

Design Thinking is used in companies to:

- Identify user needs through empathy and observation,
- Define problems with a customer-centric approach,
- Generate innovative ideas through creativity sessions,
- Prototype solutions and test them before implementation,
- Validate and improve products or services with real feedback.

It has become a key methodology in higher education and educational management, as it fosters creativity, critical thinking, and innovative problem-solving. It links to teaching in higher education in the following ways:

1. Student-centered learning: Focuses on empathy, allowing students to be the protagonists of their learning,
2. Fostering Creativity: Helps students develop innovative solutions to real-life problems,

3. Iterative methodology: Students can test ideas, receive feedback, and continually improve their proposals.

Regarding management within Higher Education centers:

1. Improved decision-making: Educational leaders can apply Design Thinking to design more effective strategies,
2. Innovation in educational models: Facilitates the creation of more dynamic academic programs adapted to current needs,
3. Optimization of administrative processes: Used to improve resource management and the student experience.

In short, Design Thinking is transforming higher education by fostering creativity and innovation in both the classroom and educational administration.

This article aims to design a plithogenic Design Thinking model, for Peruvian higher education, for the development of entrepreneurship and innovation management within national centers for this level of education.

To achieve this goal we rely on Plithogenic Logic, which emerged from Plithogenic sets and the theory of Plithogeny in general [1-3]. Plithogeny is dedicated to studying the complex dynamics that exist between phenomena with variables of different types, where concepts, their opposites, and neutrals can be included, in this way generalizing classical dialectics that only studies the interaction between two opposites [4-9]. The advantage of Plithogeny is that it allows for more accurate modeling of real-life phenomena, since the world we live in presents more nuances than those that can be modeled with classical tools [10-17].

The Plithogenic logic is a logic that combines several degrees of truthfulness, which can be Boolean, fuzzy, intuitionistic fuzzy, neutrosophic, among others, and even a hybridization between them [1, 2]. Due to the complexity of implementing the Design Thinking, and the uncertainty and indeterminacy in the evaluation of phenomena where there is a high degree of subjectivity, we decided to use the plithogenic neutrosophic logic for processing model data.

The paper is divided into a Preliminaries section, where the main concepts of Plithogenic Logic and Design Thinking in Higher Education are recalled. Further, it is the section called The Model containing the design of the proposed model and one illustrative example. The last section is the Conclusion.

2 Preliminaries

2.1 On the Plithogenic Logic

Let us denote by P the Plithogenic Logical proposition that is categorized by many degrees of truth values for many corresponding attribute values (or random variables) that characterize this proposition [1, 2]. It is a pluri-logic.

So, let us denote it by $P(V_1, V_2, \dots, V_n)$, $n \geq 1$, such that $V_1, V_2, \dots, V_n$ are the attribute-values or random variables that define, individually to some degree, the truth-value of P.

These random variables could be either pair-wise independent or there exists some degree of dependence among each other. The degree of independence or dependence between two random variables is used to define the operator of the conjunction that is used to compute the cumulative truth of the proposition P.

The random variables can be, namely, classical, fuzzy, intuitionistic fuzzy, indeterminate, neutrosophic, and so on.

$P(V_1) = t_1$ denotes the truth-value of P for the random variable V_1,

$P(V_2) = t_2$ denotes the truth-value of P for the random variable V_2,

…

$P(V_n) = t_n$ denotes the truth value of P for the random variable V_n.

$V_1, V_2, \dots, V_n$ are associated with any types of probability distributions, $P(V_1)$, $P(V_2)$, …, $P(V_n)$. P is characterized by n probability distributions or n sub-truth-values. A *cumulative truth value* of the logical proposition P is obtained by combining $P(V_1)$, $P(V_2)$, …, and $P(V_n)$.

According to the values taken by $t_1, t_2, \dots, t_n$ we have the type of Plithogenic Logic:

1. For $t_1, t_2, \dots, t_n \in \{0, 1\}$, such that 0 represents falseness and 1 represents truefulness, then it is called a *Plithogenic Boolean (Classical) Logic*.
2. For $t_1, t_2, \dots, t_n \subset [0, 1]$, such that $\exists i\ t_i \subset (0, 1)$, then it is called a *Plithogenic Fuzzy Logic*, which is divided by the following classification:
   a. *Single-Valued Plithogenic Fuzzy Logic*, if $t_1, t_2, \dots, t_n$ are single-valued (crisp) numbers in $[0, 1]$.
   b. *Subset-Valued* (like Interval-Valued, Hesitant-Valued, and so on) *Plithogenic Fuzzy Logic*, when $t_1, t_2, \dots, t_n$ are subsets (intervals, hesitant subsets, and so on) in $[0, 1]$.
3. It is a *Plithogenic Intuitionistic Fuzzy Logic* when $\forall j = 1,2, \dots, n$; $P(V_j) = (t_j, f_j)$, $t_j, f_j \subset [0, 1]$, and $t_j + f_j \leq 1$, where t_j are the degrees of truth and f_j are the degrees of falsehood. P is classified by:
   a. *Single-Valued Plithogenic Intuitionistic Fuzzy Logic*, if all $t_1, t_2, \dots, t_n$ and $f_1, f_2, \dots, f_n$ are single-valued numbers in $[0, 1]$.
   b. *Subset-Valued Plithogenic Intuitionistic Fuzzy Logic*, when all $t_1, t_2, \dots, t_n$ and $f_1, f_2, \dots, f_n$ are subsets in $[0, 1]$.
4. If $V_1, V_2, \dots, V_n$ are indeterminate (neutrosophic) functions, with vague or unclear arguments and/or values, then it is a *Plithogenic Indeterminate Logic*.
5. It is a *Plithogenic Neutrosophic Logic* when $\forall j = 1,2, \dots, n$; $P(V_j) = (t_j, i_j, f_j)$, $t_j, i_j, f_j \subset [0, 1]$, such that, t_j are the degrees of truth, i_j are the degrees of indeterminacy, and f_j are the degrees of falsehood. P is classified by:
   a. *Single-Valued Plithogenic Neutrosophic Logic*, if all $t_1, t_2, \dots, t_n$, $i_1, i_2, \dots, i_n$, and $f_1, f_2, \dots, f_n$ are single-valued numbers in $[0, 1]$.
   b. *Subset-Valued Plithogenic Neutrosophic Logic*, when all $t_1, t_2, \dots, t_n$, $i_1, i_2, \dots, i_n$, and $f_1, f_2, \dots, f_n$ are subsets in $[0, 1]$.
6. It is called *Plithogenic (other fuzzy extensions) Logic*, when it is another extension of fuzzy logic, e.g., Pythagorean Fuzzy, Picture Fuzzy, Fermatean Fuzzy, Spherical Fuzzy, q-Rung Orthopair Fuzzy, Refined Neutrosophic Logic, and refined logic.
7. It is a *Plithogenic Hybrid Logic* when $P(V_1)$, $P(V_2)$, …, $P(V_n)$ are mixed types of the probability distributions defined above.

Example 1 ([2]): Let us suppose P is the proposition "John loves his city". We have the following random variables:

V_1: low/high percentage of COVID-19 virus infected inhabitants,
V_2: nonviolent/violent,
V_3: crowded/uncrowded,
V_4: clean/dirty,
V_5: quiet/noisy.

So, we can use the notation $P(V_1, V_2, V_3, V_4, V_5)$. Then, using a Plithogenic Neutrosophic Logic, we have:

$P(V_1, V_2, V_3, V_4, V_5) =$
$((0.86, 0.12, 0.54), (0.18, 0.44, 0.72), (0.90, 0.05, 0.05), (0.09, 0.14, 0.82), (0.82, 0.09, 0.14))$,

Therefore, according to the percentage of COVID-19 virus-infected inhabitants, John loves his city with 86% of certainty, 12% of indeterminacy, and 54% of dislike. The equivalent reasoning can be assumed for the other variables.

Using the neutrosophic conjunctive operator min/max/max, we obtain:

$(0.86, 0.12, 0.54) \wedge_N (0.18, 0.44, 0.72) \wedge_N (0.90, 0.05, 0.05) \wedge_N (0.09, 0.14, 0.82) \wedge_N (0.82, 0.09, 0.14) =$
$(min\{0.86, 0.18, 0.90, 0.09, 0.82\}, max\{0.12, 0.44, 0.05, 0.14, 0.09\}, max\{0.54, 0.72, 0.05, 0.82, 0.14\}) =$
$(0.09, 0.44, 0.82)$.

Let us note that we assumed the five variables are independent each other, otherwise we have to use dependence values in the conjuntion.

2.2 Design Thinking in Higher Education

The dimensions to evaluate the Design Thinking methodology in the training of Higher Education students are summarized in the following aspects:

1. Development of Academic and Professional Empathy: Evaluates the student's ability to understand the social, academic, and professional context of the problems addressed, promoting comprehensive training focused on the real needs of the environment.
2. Critical-Analytical Thinking Training: Measures the development of higher cognitive skills that allow for the identification, formulation, and analysis of complex problems from multiple perspectives, applying logical and ethical reasoning.
3. Fostering Creativity and Innovation: Reflects the student's ability to generate original and practical solutions, stimulating initiative and imagination applied to real-life learning and entrepreneurship contexts.
4. Consolidation of cognitive recursions for problem-solving. It focuses on the student's ability to materialize ideas through prototypes, projects, or simulations, facilitating experiential learning and continuous improvement through trial and error based on cognitive recursion.
5. Promoting entrepreneurship and management skills. Evaluates how the Design Thinking-led training process strengthens entrepreneurial skills, leadership, collaborative work, and adaptability to the challenges of the professional market, as well as developing resilience capabilities.

Note that these dimensions focus on Design Thinking with the idea of improving students' creative and entrepreneurial skills.

3 The Model

Let us begin the model design by indicating the measurement scales used. These consist of both a linguistic component and a numerical component. See Table 1.

Table 1: Linguistic scale and associated numerical value.

Linguistic value	**Associated numerical value**
Extremely low	0
Very low	0.2
Low	0.4
Medium	0.5
High	0.6
Very high	0.8
Extremely High	1

This scale is only a starting point because raters are asked to use it as the basis for other, more complex scales. For example, to rate an object on a specific aspect, a rater is asked to give his or her opinion of how much the object responds concerning satisfaction (T), dissatisfaction (F), and indeterminacy (I). Suppose the triple T, I, F is answered as, T = "Very high", I = "Very low", F = "Very low", the numerical equivalent is the triple $(0.8, 0.2, 0.2)$. If asked about the weight or importance of an aspect, then the response T = "Very high", I = "Very low", and F = "Very low", is evaluated as the weight $(0.8, 0.2, 0.2)$.

The second step is to determine the aspects to be measured, these are the stages within Design Thinking:

S1. Understand/Know,
S2. Empathize,
S3. Define,
S4. Devise,
S5. Prototype,
S6. Evaluate.

Each of these stages is evaluated for the following dimensions, which we had indicated previously:

D1. Development of academic and professional empathy,
D2. Training in critical-analytical thinking,
D3. Promotion of creativity and innovation,
D4. Consolidation of cognitive recurrences for problem-solving,
D5. Promoting entrepreneurship and management skills.

In this way, if there is more than one evaluator $E = \{e_1, e_2, \dots, e_n\}$, the process evaluation is carried out for each stage $S = \{S_1, S_2, \dots, S_6\}$ in terms of each of the dimensions $D = \{D_1, D_2, \dots, D_5\}$. Thus, we have the value $v_{ijk} = \left(T_{ijk}, I_{ijk}, F_{ijk}\right)$ (i = 1,2,…,n; j = 1,2,…,6; k = 1,2,…,5), which is the evaluation given by the ith expert on the jth stage in terms of the kth dimension. Therefore, the procedure to follow is:

1. An analysis of the tactics for implementing stage S1 is performed and implemented.
2. Once the decision is made to move from S1 to S2, each expert is asked to evaluate the results of stage S1. This evaluation is equal to $v_{i1k} = (T_{i1k},\ I_{i1k},\ F_{i1k})$. There is also a set of values $w_{i1k} = (wT_{i1k}, wI_{i1k}, wF_{i1k})$ that represent the weights assigned by each expert to each of the dimensions within stage S1. This stage change is achieved according to the results proposed in the following:
    a. A small threshold of acceptable values is set to indicate error. We set this value to $\epsilon = 0.2$ although it can be lower to ensure greater accuracy.

b. $v_{i1k} = (T_{i1k}, I_{i1k}, F_{i1k})$ are converted into crisp values with the help of the score function using the following equation [18]:

$$\mathcal{S}((T, I, F)) = \frac{2+T-I-F}{3} \qquad (1)$$

They are converted to $\tilde{v}_{i1k} = \mathcal{S}\big((T_{i1k}, I_{i1k}, F_{i1k})\big)$, $\widetilde{w}_{i1k} = \mathcal{S}\big((wT_{i1k}, wI_{i1k}, wF_{i1k})\big)$. The standard deviation of the values $\sigma(\{\tilde{v}_{i1k}\})$ and $\sigma(\{\widetilde{w}_{i1k}\})$ are calculated for each k.

If $\sigma(\{\tilde{v}_{i1k}\}) > \epsilon$ or $\sigma(\{\widetilde{w}_{i1k}\}) > \epsilon$, then the experts are asked to re-evaluate and then repeat this step. If not, go to the next step. This ensures consistency in the evaluations.

3. Plithogenic evaluation is associated with this stage as:

$$\mathrm{P_{v1}}(\mathrm{v_{111}}, \mathrm{v_{112}}, \mathrm{v_{113}}, \mathrm{v_{114}}, \mathrm{v_{115}}) = \big((\mathrm{T_{111}}, \mathrm{I_{111}}, \mathrm{F_{111}}), (\mathrm{T_{112}}, \mathrm{I_{112}}, \mathrm{F_{112}}), (\mathrm{T_{113}}, \mathrm{I_{113}}, \mathrm{F_{113}}), (\mathrm{T_{114}}, \mathrm{I_{114}}, \mathrm{F_{114}}), (\mathrm{T_{115}}, \mathrm{I_{115}}, \mathrm{F_{115}})\big),$$

$$\mathrm{P_{v2}}(\mathrm{v_{211}}, \mathrm{v_{212}}, \mathrm{v_{213}}, \mathrm{v_{214}}, \mathrm{v_{215}}) = \big((\mathrm{T_{211}}, \mathrm{I_{211}}, \mathrm{F_{211}}), (\mathrm{T_{212}}, \mathrm{I_{212}}, \mathrm{F_{212}}), (\mathrm{T_{213}}, \mathrm{I_{213}}, \mathrm{F_{213}}), (\mathrm{T_{214}}, \mathrm{I_{214}}, \mathrm{F_{214}}), (\mathrm{T_{215}}, \mathrm{I_{215}}, \mathrm{F_{215}})\big),$$

…

$$\mathrm{P_{vn}}(\mathrm{v_{n11}}, \mathrm{v_{n12}}, \mathrm{v_{n13}}, \mathrm{v_{n14}}, \mathrm{v_{n15}}) = \big((\mathrm{T_{n11}}, \mathrm{I_{n11}}, \mathrm{F_{n11}}), (\mathrm{T_{n12}}, \mathrm{I_{n12}}, \mathrm{F_{n12}}), (\mathrm{T_{n13}}, \mathrm{I_{n13}}, \mathrm{F_{n13}}), (\mathrm{T_{n14}}, \mathrm{I_{n14}}, \mathrm{F_{n14}}), (\mathrm{T_{n15}}, \mathrm{I_{n15}}, \mathrm{F_{n15}})\big).$$

In addition, the weights are as follows:

$$\mathrm{P_{w1}}(\mathrm{w_{111}}, \mathrm{w_{112}}, \mathrm{w_{113}}, \mathrm{w_{114}}, \mathrm{w_{115}}) = \begin{pmatrix} (w\mathrm{T_{111}}, \mathrm{wI_{111}}, \mathrm{wF_{111}}), (w\mathrm{T_{112}}, \mathrm{wI_{112}}, \mathrm{wF_{112}}), (\mathrm{wT_{113}}, \mathrm{wI_{113}}, \mathrm{wF_{113}}), (\mathrm{wT_{114}}, \mathrm{wI_{114}}, \mathrm{wF_{114}}), \\ (w\mathrm{T_{115}}, \mathrm{wI_{115}}, \mathrm{wF_{115}}) \end{pmatrix},$$

$$\mathrm{P_{w2}}(\mathrm{w_{211}}, \mathrm{w_{212}}, \mathrm{w_{213}}, \mathrm{w_{214}}, \mathrm{w_{215}}) = \begin{pmatrix} (\mathrm{wT_{211}}, \mathrm{wI_{211}}, \mathrm{wF_{211}}), (w\mathrm{T_{212}}, \mathrm{wI_{212}}, \mathrm{wF_{212}}), (\mathrm{wT_{213}}, \mathrm{wI_{213}}, \mathrm{wF_{213}}), (\mathrm{wT_{214}}, \mathrm{wI_{214}}, \mathrm{wF_{214}}), \\ (w\mathrm{T_{215}}, \mathrm{wI_{215}}, \mathrm{wF_{215}}) \end{pmatrix},$$

…

$$\mathrm{P_{wn}}(\mathrm{w_{n11}}, \mathrm{w_{n12}}, \mathrm{w_{n13}}, \mathrm{w_{n14}}, \mathrm{w_{n15}}) = \begin{pmatrix} (w\mathrm{T_{n11}}, \mathrm{wI_{n11}}, \mathrm{wF_{n11}}), (w\mathrm{T_{n12}}, \mathrm{wI_{n12}}, \mathrm{wF_{n12}}), (w\mathrm{T_{n13}}, \mathrm{wI_{n13}}, \mathrm{wF_{n13}}), (\mathrm{wT_{n14}}, \mathrm{wI_{n14}}, \mathrm{wF_{n14}}), \\ (w\mathrm{T_{n15}}, \mathrm{wI_{n15}}, \mathrm{wF_{n15}}) \end{pmatrix}.$$

These values are aggregated using the following equation:

$$\mathrm{P}_{S_1}\big(\mathrm{D1}_{S_1}, \mathrm{D2}_{S_1}, \mathrm{D3}_{S_1}, \mathrm{D4}_{S_1}, \mathrm{D5}_{S_1}\big) = \big((T_{11}, I_{11}, F_{11}), (T_{21}, I_{21}, F_{21}), (T_{31}, I_{31}, F_{31}), (T_{41}, I_{41}, F_{41}), (T_{51}, I_{51}, F_{51})\big) \ldots\ldots\ldots\ldots (2)$$

Such that:

$$(T_{\mathrm{k1}}, I_{\mathrm{k1}}, F_{\mathrm{k1}}) = \Big(\wedge_{N}{}_{i=1}^{n}(\mathrm{wT_{i1k}} \wedge \mathrm{T_{i1k}}), \wedge_{N}{}_{i=1}^{n}(\mathrm{wI_{i1k}} \wedge \mathrm{I_{i1k}}), \wedge_{N}{}_{i=1}^{n}(\mathrm{wF_{i1k}} \wedge \mathrm{F_{i1k}})\Big)$$

In this way, a final evaluation is obtained for this stage for all experts, for each dimension k.

4. It is determined whether the stage was completed by establishing a threshold value θ, we recommend taking $\theta = 0.6$ or higher.

If $\forall k\ \mathcal{S}\big((T_{\mathrm{k1}}, I_{\mathrm{k1}}, F_{\mathrm{k1}})\big) \geq \theta$, it is determined that the objectives of the stage have been satisfactorily met,

Otherwise, it is determined which dimensions were not satisfied and improvements are recommended to go to the next stage.

5. The same steps carried out until now are repeated, which consist of analyzing the tactics to implement stage S_j $j \geq 2$.
6. Once the decision is made to move from Sj to Sj+1, each of the experts is asked to evaluate the results of stage Sj. This evaluation is equal to $v_{ijk} = (T_{ijk}, I_{ijk}, F_{ijk})$. There is also a set of values $w_{ijk} = (wT_{ijk}, wI_{ijk}, wF_{ijk})$ that represent the weights assigned by each expert to each of the dimensions within stage Sj. In this stage change, the following occurs:

   $v_{i1k} = (T_{ijk}, I_{ijk}, F_{ijk})$ are converted into crisp values with the help of the score function using Equation 1:

   They are converted into $\tilde{v}_{ijk} = \mathcal{S}\left((T_{ijk}, I_{ijk}, F_{ijk})\right)$, $\tilde{w}_{ijk} = \mathcal{S}\left((wT_{ijk}, wI_{ijk}, wF_{ijk})\right)$. $\sigma(\{\tilde{w}_{ijk}\})$ and $\sigma(\{\tilde{v}_{ijk}\})$ are calculated for each k.

   If $\sigma(\{\tilde{v}_{ijk}\}) > \epsilon$ or $\sigma(\{\tilde{w}_{ijk}\}) > \epsilon$, the experts are asked to reevaluate and then repeat this step. If not, go on to the next step.
7. This stage is associated with a plithogenic evaluation such as:

$$P_{v1}(v_{1j1}, v_{1j2}, v_{1j3}, v_{1j4}, v_{1j5}) = \left((T_{1j1}, I_{1j1}, F_{1j1}), (T_{1j2}, I_{1j2}, F_{1j2}), (T_{1j3}, I_{1j3}, F_{1j3}), (T_{1j4}, I_{1j4}, F_{1j4}), (T_{1j5}, I_{1j5}, F_{1j5})\right),$$

$$P_{v2}(v_{2j1}, v_{2j2}, v_{2j3}, v_{2j4}, v_{2j5}) = \left((T_{2j1}, I_{2j1}, F_{2j1}), (T_{2j2}, I_{2j2}, F_{2j2}), (T_{2j3}, I_{2j3}, F_{2j3}), (T_{2j4}, I_{2j4}, F_{2j4}), (T_{2j5}, I_{2j5}, F_{2j5})\right),$$

…

$$P_{vn}(v_{nj1}, v_{nj2}, v_{nj3}, v_{nj4}, v_{nj5}) = \left((T_{nj1}, I_{nj1}, F_{nj1}), (T_{nj2}, I_{nj2}, F_{nj2}), (T_{nj3}, I_{nj3}, F_{nj3}), (T_{nj4}, I_{nj4}, F_{nj4}), (T_{nj5}, I_{nj5}, F_{nj5})\right).$$

In addition, the weights are as follows:

$$P_{w1}(w_{1j1}, w_{1j2}, w_{1j3}, w_{1j4}, w_{1j5}) = \begin{pmatrix} (wT_{1j1}, wI_{1j1}, wF_{1j1}), (wT_{1j2}, wI_{1j2}, wF_{1j2}), (wT_{1j3}, wI_{1j3}, wF_{1j3}), (wT_{1j4}, wI_{1j4}, wF_{1j4}), \\ (wT_{1j5}, wI_{1j5}, wF_{1j5}) \end{pmatrix},$$

$$P_{w2}(w_{2j1}, w_{2j2}, w_{2j3}, w_{2j4}, w_{2j5}) = \begin{pmatrix} (wT_{2j1}, wI_{2j1}, wF_{2j1}), (wT_{2j2}, wI_{2j2}, wF_{2j2}), (wT_{2j3}, wI_{2j3}, wF_{2j3}), (wT_{2j4}, wI_{2j4}, wF_{2j4}), \\ (wT_{2j5}, wI_{2j5}, wF_{2j5}) \end{pmatrix},$$

…

$$P_{wn}(w_{nj1}, w_{nj2}, w_{nj3}, w_{nj4}, w_{nj5}) = \begin{pmatrix} (wT_{nj1}, wI_{nj1}, wF_{nj1}), (wT_{nj2}, wI_{nj2}, wF_{nj2}), (wT_{nj3}, wI_{nj3}, wF_{nj3}), (wT_{nj4}, wI_{nj4}, wF_{nj4}), \\ (wT_{nj5}, wI_{nj5}, wF_{nj5}) \end{pmatrix}.$$

These values are aggregated using the following equation:

$$P_{S_j}\left(D1_{S_j}, D2_{S_j}, D3_{S_j}, D4_{S_j}, D5_{S_j}\right) = \left((T_{j1}, I_{j1}, F_{j1}), (T_{j2}, I_{j2}, F_{2j}), (T_{j3}, I_{j3}, F_{j3}), (T_{j4}, I_{j4}, F_{j4}), (T_{j5}, I_{j5}, F_{j5})\right) \quad (3)$$

Such that:

$$(T_{jk}, I_{jk}, F_{jk}) = \left(\wedge_{N\,i=1}^{\,n}(wT_{ijk} \wedge T_{ijk}), \wedge_{N\,i=1}^{\,n}(wI_{ijk} \wedge I_{ijk}), \wedge_{N\,i=1}^{\,n}(wF_{ijk} \wedge F_{ijk})\right)$$

In this way, a final evaluation is obtained for this stage for all experts for each dimension.

6. If $\forall k\, \mathcal{S}\left(\left(T_{jk}, I_{jk}, F_{jk}\right)\right) \geq \theta$ then the objectives of the stage were satisfactorily met,

   Otherwise, the dimensions that were not met are determined, and improvements are recommended to move on to the next stage. When j = 6, the overall evaluation of the entire process is made, and then the final stage is determined whether it was satisfactory.

   Let us illustrate this procedure with a hypothetical example.

Example 2. Let us suppose there are three evaluators of the jth stage on the implementation of Design Thinking in a Peruvian higher education center. Let us assume that the evaluation results are summarized in Table 2 for evaluation and in Table 3 for importance.

Table 2: Results of the experts' assessment for the example of satisfactory achievement of objectives for the jth stage.

Dimension/Expert	**e1**	**e2**	**e3**
D1	(0.6, 0.2,0.4)	(0.8, 0.2,0.2)	(0.8, 0.2,0.2)
D2	(0.8,0.2,0.2)	(1,0.2,0.2)	(0.8,0,0.2)
D3	(0.6,0.2,0.2)	(0.8,0,0.2)	(0.6,0.2,0)
D4	(1,0,0)	(0.8,0,0.2)	(1,0.2,0.2)
D5	(0.8,0.2,0.2)	(0.6,0.2,0.2)	(0.8,0.2,0)

Table 3: Results of the weights assigned by the experts in the example on the importance of each dimension for the jth stage.

Dimension/Expert	**e1**	**e2**	**e3**
D1	(1,0,0)	(0.8,0.2,0.2)	(0.6,0.2,0.4)
D2	(0.8,0,0)	(1,0,0)	(0.8,0.2,0.2)
D3	(0.8,0,0.2)	(0.8,0.2,0.2)	(1,0,0)
D4	(0.6,0.4,0.2)	(0.8,0.2,0)	(0.6,0,0.4)
D5	(0.5,0.4,0.5)	(0.6,0.2,0.4)	(0.4,0.2,0.6)

Let us also set $\theta = 0.6$ and $\epsilon = 0.2$.

Table 4 shows the results of applying the score function to the values in Table 2 and Table 3, as well as their standard deviations for each dimension.

Table 4: Results of applying the score function to the assessments in Table 2 and their standard deviations for each dimension.

Dimension/Expert	**e1**	**e2**	**e3**	**Standard Deviation**
D1	0.66666667	0.8	0.8	0.06285394
D2	0.8	0.86666667	0.86666667	0.03142697
D3	0.73333333	0.86666667	0.8	0.05443311
D4	1	0.86666667	0.86666667	0.06285394
D5	0.8	0.73333333	0.86666667	0.05443311

Table 5 shows the results of applying the score function to the values in Table 3 and the standard deviation.

Table 5: Results of applying the score function to the assessments in Table 3 and their standard deviations for each dimension.

Dimension/Expert	e_1	e_2	e_3	Standard Deviation
D_1	1	0.8	0.66666667	0.13698698
D_2	0.93333333	1	0.8	0.08314794
D_3	0.86666667	0.8	1	0.08314794
D_4	0.66666667	0.86666667	0.73333333	0.08314794
D_5	0.53333333	0.66666667	0.53333333	0.06285394

From the results shown in Tables 4 and 5, the standard deviations of each of the dimensions are less than $\epsilon = 0.2$, therefore it is considered that there is coherence in the experts' evaluations.

Table 6 summarizes the results of applying Equation 3 as an aggregation of the results for each of the dimensions and the score function for each of them.

Table 6: Aggregation results using Equation 3 and applying the score function for each dimension.

Dimension	Neutrosophic conjunctive aggregation	Score function
D_1	(0.6, 0.2, 0.4)	0.66666667
D_2	(0.8, 0.2, 0.2)	0.8
D_3	(0.6, 0.2, 0.2)	0.73333333
D_4	(0.6, 0.4, 0.4)	0.6
D_5	(0.4, 0.4, 0.6)	0.46666667

From Table 6 it can be seen that all the results of the score function are higher than the threshold $\theta = 0.6$, except for Dimension 5, therefore it is recommended to analyze what to do, whether to continue to the next stage or work to improve the implementation of the jth stage.

4. Conclusion

Design Thinking is a methodology that has gained popularity in the business world today. It has also been successfully used in organizations within education and higher education, particularly in Peru. This methodology consists of six stages. In this paper, we propose five dimensions to measure in each stage and a method for evaluating and implementing Design Thinking in a Peruvian higher education center. The dimensions aim to measure the development of entrepreneurship and innovation competencies in students. To do this, we rely on Plithogenic Logic, especially the Plithogenic Neutrosophic Logic. This new logic allows uncertainty and indeterminacy to be taken into account within logic whose evaluations are subjective. It also allows for the evaluation of each dimension separately, thus better identifying which ones do or do not meet the minimum requirements. The proposed model enhances the flexibility of Classical Design Thinking, since it allows for peer evaluation among specialists, with agreement only reached if the evaluations between experts do not exceed a threshold. We also illustrate the usefulness of the method with an example. In future works, we will propose a final aggregate value for all dimensions. To do this, we will conduct a study on the dependence between the dimensions, obtaining values that will be part of the conjunction.

References

[1] Smarandache, F. (2021). Introducción a la Lógica Plitogénica. Neutrosophic Computing and Machine Learning, 18, 1-6.

[2] Smarandache, F. (2021). Introduction to Plithogenic Logic as Generalization of MultiVariate Logic. Neutrosophic Sets and Systems, 45, 1-7.

[3] Villacrés, G. E. F., Naranjo, F. A. V., and López, R. R. L. (2021). Plithogenic Logic for Determination of Strategic Solutions for Ergonomic Occupational Health Risks. Infinite Study.

[4] Smarandache, F. (2017). Plithogeny, plithogenic set, logic, probability, and statistics. Infinite Study.
[5] Smarandache, F. (2022). Plithogeny, plithogenic set, logic, probability and statistics: a short review. Journal of Computational and Cognitive Engineering, 1, 47-50.
[6] Smarandache, F. (2017). Plithogeny. Plithogenic Set, Logic, Probability, and Statistics, Pons, Brussels.
[7] Smarandache, F. (2019). Plithogenic Set. nidus idearum, 27, 59-59.
[8] Singh[1], P. K. Plithogenic set for multi-variable data analysis. International Journal of Neutrosophic Science (IJNS) Volume 1, 2020, 81.
[9] Smarandache, F. (2018). Plithogenic Set, an Extension of Crisp, Fuzzy, Intuitionistic Fuzzy, and Neutrosophic Sets-Revisited. Neutrosophic Sets and Systems, 21, 153-166.
[10] De la Cantera, D. H., Quiroz, R. C., Queija, M. L., Gonzalez, J. R., & Vazquez, M. Y. L. (2024). Analyzing Interdisciplinary Education in General Medicine Using Smarandache's Multivalued Logic Hypothesis Theory and Plithogenic Probability. Neutrosophic Sets and Systems, 70, 369-377.
[11] Criollo Delgado, R. M., Vidal Rischmoller, J. C., & Mendoza Zenozain, E. A. (2024). Plithogenic Hypothesis on the Influence of Electronic Com-merce on Retail Sales Dynamics in Shopping Centers. Neutrosophic Sets and Systems, 74(1), 36.
[12] Martin, N., Smarandache, F., and Sudha, S. (2023). A novel method of decision making based on plithogenic contradictions. Neutrosophic systems with applications, 10, 12-24.
[13] Al-Hamido, R. K. (2024). Neutrosophic Generalized Topological Space, Plithogenic Logic and Computation, 2, 1-9.
[14] Sudha, S., Martin, N., and Smarandache, F. (2023). State of Art of Plithogeny Multi Criteria Decision Making Methods. Neutrosophic Sets and Systems, 56, 390-409.
[15] Sudha, S., Martin, N., & Smarandache, F. (2023). Applications of Extended Plithogenic Sets in Plithogenic Sociogram. International Journal of Neutrosophic Science (IJNS).
[16] Batista-Hernández, N., Leyva-Vázquez, M. Y., González-Caballero, E., Valencia-Cruzaty, L. E., Ortega-Chávez, W., and Smarandache, F. (2021). A new method to assess entrepreneurship competence in university students using based on plithogenic numbers and SWOT analysis. International Journal of Fuzzy Logic and Intelligent Systems, 21, 280-292.
[17] Gómez-Rodríguez, V. G., Batista-Hernández, N., Avilés-Quiñonez, W. P., Escobar-Jara, J. I., Vargas-Zambrano, R. E., Sánchez-Rovalino, R. M., Reigosa-Lara, A. and Alfonso-Caveda, D. (2024). Feasibility Study of the Application of Proposals for the Implementation of Compliance in the Low-Quantity Process in Public Procurement in Ecuador Using Plithogenic SWOT Analysis. Neutrosophic Sets and Systems, 71, 114-121.
[18] Smarandache, F. (2020). The Score, Accuracy, and Certainty Functions determine a Total Order on the Set of Neutrosophic Triplets (T, I, F). Neutrosophic Sets and Systems, 38, 1-14.

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