Neutrosophic Sets and Systems, Vol. 70, 2024
University of New Mexico

Analyzing Interdisciplinary Education in General Medicine Using Smarandache's Multivalued Logic Hypothesis Theory and Plithogenic Probability

Dolores Hernandez De la Cantera[1] , Rosangela Caicedo Quiroz [2] , Mairim Lago Queija [3], Jeanntte Rodriguez Gonzalez [4] , Maikel Y. Leyva Vazquez [5]

[1] Facultad de Ciencias Médicas Victoria de Girón, La Habana, Cuba.
[2] Universidad Bolivariana del Ecuador (UBE), km 5.5 Vía Durán, Guayas, Ecuador. Email: rcaicedoq@ube.edu.ec
[3] Universidad de Ciencias Médicas de La Habana, Facultad"Victoria de Girón". La Habana, Cuba. Email: mairim.lago@infomed.sld.cu
[4] Universidad de Ciencias Médicas de La Habana, Facultad"Victoria de Girón". La Habana, Cuba..
[5] Universidad de Guayaquil (UG), Ciudadela Universitaria, Guayaquil, Guayas, Ecuador. Email. Email: maikel.leyvav@ug.edu.ec

5

Abstract. Smarandache extended the concept of falsifiability to include hypotheses that involve multiple values. Smarandache's extension of classical logic introduces Partial Falsifiability within multi-valued logic, which allows for the inclusion of partial truth values, uncertainties, and false values, unlike traditional falsifiability which only classifies hypotheses as completely true or false. Using this approach this study investigates specifically the concept of interdisciplinarity in the field of integral general medicine, with a specific emphasis on the integration of nursing procedures. The method employs sentiment analysis of scientific questions using the Consensus tool and plithogenic statistics to assess complex hypotheses. The findings indicate that the combination of nursing procedures and interprofessional approaches greatly improves teamwork, communication, and clinical competence. The results suggest a high probability of truth (0.67), some indeterminacy (0.33), and a low probability of falsity (0.17). Future research will focus on utilizing alternative sentiment analysis tools and incorporating the concept of fallibility into hypotheses using Smarandache's multivalued logic in different contexts.

Keywords: interdisciplinarity, general integral medicine, nursing procedures falsifiability of a hypothesis, multi-valued logics, plithogenic statistics

.

1 Introduction

The assessment of sentiment in scientific literature has received considerable attention in recent years, primarily because of the increasing accessibility of scientific publications. Sentiment analysis in this context specifically aims to interpret the emotions and attitudes of the authors as conveyed through the citations/themes found in scholarly databases [1].

In a recent publication, Smarandache [2] expanded the notion of falsifiability to encompass hypotheses that involve multiple values in logic. In classical logic, falsifiability traditionally deals with hypotheses that can be definitively classified as either completely true or completely false. Florentin's extension incorporates the concept of Partial Falsifiability into the realm of multi-valued logic, allowing hypotheses to possess partial truth values, uncertainties, and false values [3]. In the context of neutrosophic logic, a hypothesis $NLH(T, I, F)$ is considered falsifiable if certain conditions exist that allow the hypothesis to be negated, resulting in $\neg NLH(F, 1 - I, T)$, where t, i, and f are degrees of truth, indeterminacy, and falsity, respectively, and they all fall within the range of [0,1]. In the probabilistic interpretation, a neutrosophic probabilistic hypothesis [4], $NPH(T, I, T)$ is defined with t, i, and f values ranging from 0 to 1, representing the probability, indeterminacy, and falsity, respectively. This approach offers a more comprehensive and intricate assessment of the falsifiability and probability of hypotheses in intricate scientific like medical education and social science contexts.

The Consensus Meter [5] is a novel tool in Consensus AI that functions as a gauge to quantify agreement and disagreement among a group of papers(Figure 1). The system functions by posing straightforward binary inquir ies, enabling a swift evaluation of the degree of agreement or disagreement among participants. The responses are categorized as "Yes," "No," or "Possibly," which offers a distinct perspective on the group's position regarding a particular subject [6]. The Consensus Meter is a tool that utilizes neutrosophic logic/probability to assess the falsifiability and probability of a hypothesis. It offers a nuanced evaluation of the hypothesis's validity in various conditions.

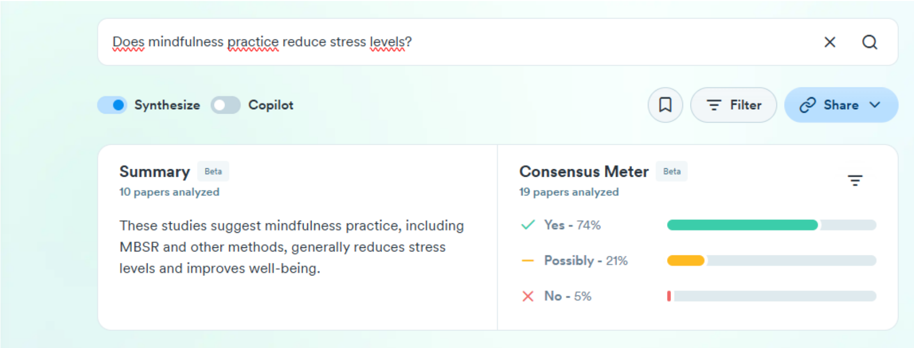

Figure 1: Consensus Meter Interface for Assessing the Impact of Mindfulness on Stress Reduction

A scientific question as "Does X result in Y?", explores the cause-and-effect connection between two variables. This question type seeks to ascertain whether alterations in variable X have a direct impact on variable Y. An illustration of this is the inquiry, "Does smoking induce lung cancer?", which investigates the correlation between smoking and the development of lung cancer. These inquiries are pivotal for establishing causal relationships [7]. Plithogenic probability, as defined in [8], assigns multiple probabilities to each event E in a probability space U, in contrast to classical probability, imprecise probability, and neutrosophic probability, which assign only one probability. The plithogenic probability distribution function, P(x), for a random variable x, is defined by multiple plithogenic probability distribution sub-functions. Each sub-function quantifies the probability (relative to a specific attribute value) of the occurrence of the value x. The probabilities of occurrence can be represented using classical, imprecise, or neutrosophic probabilities, depending on the level of chance involved. This approach enables the separation of the probabilities of occurrence for each question that constitutes the hypothesis being analyzed.

The incorporation of nursing procedures and interprofessional approaches into medical education significantly improves teamwork, communication, clinical proficiency, and patient care outcomes [9]. These educational methodologies not only enhance the professional competencies of students but also foster a more cooperative and patient-centered healthcare milieu [10]. However, effectively executing these strategies requires overcoming practical obstacles and ensuring their continuous integration into educational curricula [11]. One of the difficulties in implementing this approach is the need to coordinate curricula across various professional programs and ensure their long-term integration into existing educational frameworks [12]. This paper studies this approach to medical education using Smarandache's partial falsifiability hypothesis theory, sentiment analysis with the Consensus tool, and plithogenic statistics, extending the research tool based on set theory [13].

2 Prelininaries

2.1 Plithogenic Probability

Neutrosophic (or Indeterminate) Data is characterized by its inherent vagueness, lack of clarity, incompleteness, partial unknowns, and conflicting information [14, 15]. The data can be classified as either quantitative (metrical), qualitative (categorical), or a combination of both. Plithogenic Variate Data[16] describes the connections or correlations between Neutrosophic variables. A Neutrosophic Variable [17, 18], which can be a function or operator, deals with neutrosophic data in either its arguments, its values, or both. Complex problems often require multiple measurements and observations due to their multidimensional nature like measures needed on scientific inquiries. Neutrosophic variables can exhibit dependence, independence, partial dependence, partial independence, or partial indeterminacy como in science [19].

A Plithogenic Set [20, 21] is a non-empty set P whose elements within the domain of discourse U ($P \subseteq U$) are characterized by one or more attributes $A_1, A_2, \cdots, A_m$, where m is at least 1. where each attribute can have a set of possible values within the spectrum S of values (states), such that S can be a finite, infinite, discrete, continuous, open, or closed set.

Each element $x \in P$ is characterized by all the possible values of the attributes that are inside the set $V = \{v_1, v_2, \cdots, v_n\}$. The value of an attribute has a degree of appurtenance $d(x, v)$ of an element x in the set P, based on a specific criterion. The degree of appurtenance can be either fuzzy, intuitionistic fuzzy, or neutrosophic, among others [22].

That means,

$$\forall x \in P, d: P \times V \to \mathcal{P}([0,1]^z) \quad (1)$$

Where $d(x, v) \subseteq [0,1]^z$ and $\mathcal{P}([0,1]^z)$ is the power set of $[0,1]^z$. $z = 1$ (the fuzzy degree of appurtenance), $z = 2$ (the intuitionistic fuzzy degree of appurtenance), or $z = 3$ (the neutrosophic degree of appurtenance).

Plithogenic Probability [23], derived from Plithogenic Variate Analysis, represents a multi-dimensional probability ("plitho" meaning "many" and synonymous with "multi"). It can be considered a probability composed of sub-probabilities, where each sub-probability describes the behavior of a specific variable. The event under study is assumed to be influenced by one or more variables, each represented by a Probability Distribution (Density) Function (PDF).

Consider an event E in a given probability space, whether classical or neutrosophic, determined by $n \geq 2$ variables. $v_1, v_2, \ldots, v_n$, denoted as $E(v_1, v_2, \ldots, v_n)$. The multi-variate probability of event E occurring denoted as MVP(E), relies on multiple probabilities. Specifically, it depends on the probability of event E occurring with respect to each variable: $P1(E(v_1))$ for variable v_1, $P2(E(v_2))$ for variable v_2, and so forth. Therefore, $MVP(E(v_1, v_2, \ldots, v_n))$ is represented as $\left(P1(E(v_1)), P2(E(v_2)), \ldots, Pn(E(v_n))\right)$. The variables $v_1, v_2, \ldots, v_n$, and the probabilities $P_1, P_2, \ldots, P_n$, may be classical or have some degree of indeterminacy [24].

To transition from Plithogenic Neutrosophic Probability (PNP) to Univariate Neutrosophic Probability UNP, we employ the conjunction operator [25]:

$$UNP(v_1, v_2, \ldots, v_n) = v_1 \wedge_{i=1}^{n} v_n \quad (2)$$

$\wedge$ In this context, it is a neutrosophic conjunction (t-norm). If we take $\wedge_p$ as the plithogenic conjunction between probabilities of the PNP type, where $(T_A, I_A, F_A) \wedge_p (T_B, I_B, F_B) = (T_A \wedge T_B, I_A \vee I_B, F_A \vee F_B)$, such that $\wedge$ is the t-norm minimum of fuzzy logic and $\vee$ the t-conorm maximum[26, 27].

2 Material and Methods

Figure 2 contains a diagram of the steps to follow in this method based on ."Partial Falsifiability of Fuzzy and Fuzzy-Extension Hypotheses" as proposed by Smarandache [2]. The research process entails a sequence of systematic processes aimed at examining a hypothesis, assessing its soundness, and drawing conclusions based on detailed data analysis. Below is a detailed description of each phase of the procedure

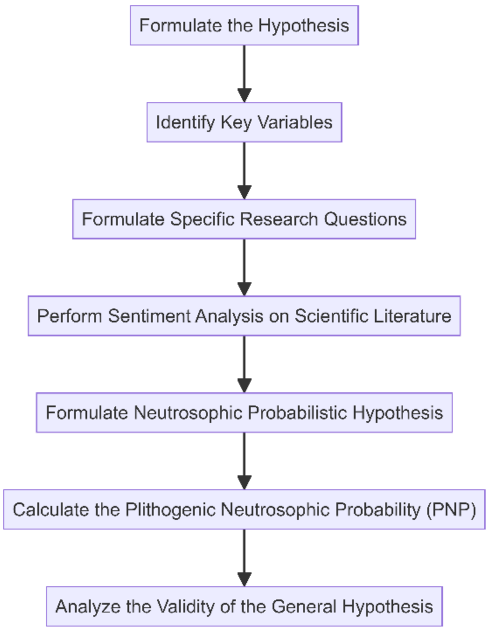

Figure 2: Scheme of the proposed method

a. Formulate the Hypothesis

Begin by explicitly stating the hypothesis that you intend to examine. Make sure that indicates a cause-and-effect relationship between the variables. For example, "Increased study time leads to higher exam scores."

b. Identify Key Variables

Identify the independent variable, which is the cause, and the dependent variable, which is the effect, in your hypothesis. This aids in directing your research inquiries towards the exact relationship to investigate.

c. Formulate Specific Research Questions

Split the hypothesis into precise research questions formulated as "Does X cause Y?" This enables a comprehensive and focused examination of the postulated correlation.

d. Perform sentiment analysis on scientific literature.

To conduct sentiment analysis on a research paper and quantify the occurrences of "Yes," "Possibility/Indeterminacy," and "No," a sentiment analysis tool for scientific statements is needed . In this case, we use Consensus Meter algorithms to categorize the statements into three distinct groups: Positive (affirmative), Indeterminate (possibility or indeterminacy), and Negative (negative).

e. Formulate Neutrosophic Probabilistic Hypothesis

Determine the ratios of each category to construct the neutrosophic probability hypothesis (T, I, F), where T denotes the truth value, I represents the indeterminacy, and F indicates the falsity.

f. Calculate the Plithogenic Neutrosophic Probability (PNP)

By utilizing the neutrosophic probabilities assigned to each question the Univariate Neutrosophic Probability (UNP) is calculated to assess the soundness of the overall hypothesis. This process entails combining the separate probabilities to offer a thorough assessment of the overall hypothesis.

$$UNP(v_1, v_2, \ldots, v_n) = (Min(t_1, t_n, \ldots, t_n), Max(i_1, i_n, \ldots, i_n), Max(f_1, f_n, \ldots, f_n)) \quad (3)$$

Where:

$T_1, T_2, \ldots, T_n$: are the truth probabilities values of each question.

$I_1, I_2, \ldots, I_n$: are the indeterminacy probabilities values of each question.

$F_1, F_2, \ldots, F_n$: are the falsity probabilities values of each question

g. Analyze the validity of the general hypothesis

In this case, the negation of NPH is represented as [28]:

$$(T, I, F) = (F, I, T) \quad (4)$$

This step entails analyzing the negated neutrosophic probabilities to evaluate the overall soundness and dependability of the general hypothesis. By evaluating the levels of falsehood, uncertainty, and truthfulness, one can ascertain the degree to which the hypothesis is valid, ambiguous, or incorrect depending on the scientific literature.

3 Case Study

Incorporating nursing procedures and interprofessional approaches into medical education greatly improves collaboration, communication, clinical proficiency, and patient outcomes in actual clinical environments. Incorporating these components into medical curricula fosters a cooperative atmosphere in which healthcare practitioners acquire the skills to collaborate efficiently, thereby enhancing the quality of patient care. Through prioritizing interprofessional education, medical students acquire a more profound comprehension of the responsibilities and contributions of diverse healthcare providers, resulting in enhanced coordination and increased efficiency in healthcare delivery.

Furthermore, incorporating nursing procedures into medical education aids in refining the clinical aptitude of students. This approach guarantees that upcoming healthcare professionals possess practical knowledge and essential competencies necessary for patient care. Additionally, it promotes a setting that values ongoing education and adjustment, which is crucial in the constantly changing healthcare industry. The outcome is an enhanced and self-assured healthcare workforce capable of providing exceptional care and adjusting to the ever-changing demands of patients.

Although there are potential advantages, there are also various constraints and difficulties that could lead to uncertainty and potentially undermine the hypothesis. Differences in the way educational institutions implement programs, including variations in resources, expertise, and commitment, can result in inconsistent outcomes and substantial disparities in program effectiveness. Variations in educational environments, encompassing cultural, social, and organizational elements, can impact the assimilation and achievement of nursing protocols and interprofessional methodologies, leading to diverse levels of effectiveness in different settings. Practical barriers, such

as the coordination of curricula across multiple professional programs, conflicts in scheduling, and divergent academic priorities, can hinder the smooth integration. Ensuring sustainability and long-term integration necessitates ongoing backing, resources, and dedication from stakeholders. Without sustained endeavor, the initial advantages may dwindle. Another challenge arises from the resistance to change exhibited by faculty, students, and institutions, which can be attributed to deeply ingrained practices, limited awareness, or perceived risks to professional autonomy. Furthermore, the process of determining and analyzing the effects of interprofessional education on clinical outcomes is intricate and necessitates reliable tools and methodologies. Insufficient evaluation mechanisms can result in inconclusive or deceptive findings, thereby exacerbating the uncertainty surrounding the matter.
In this case study the hypothesis is stated as follows.
The inclusion of nursing procedures and interprofessional approaches in medical education improves teamwork, communication, clinical competence, and patient care outcomes in real clinical settings.
To investigate this hypothesis, we followed a systematic research process based on the notion of "Partial Falsability of Fuzzy and Fuzzy-Extension Hypotheses" proposed by Smarandache [2].

Below is a description of each question along with the variable intended to be measured:

Teamwork and Communication

Q1: Does the inclusion of nursing procedures in medical education lead to better teamwork and communication in clinical settings?

Variable: Quality of teamwork and communication in clinical settings.

Patient Care Outcomes

Q2: Does integrating nursing education into medical training improve patient care outcomes?

Variable: Patient care outcomes (e.g., recovery rates, patient satisfaction).

Practical Challenges in Clinical Settings

Q3: Can the interdisciplinary approach in medical education realistically address the challenges faced in practical, real-world medical settings?

Variable: Ability to address practical challenges in clinical settings through an interdisciplinary approach.

Clinical Competence

Q4: Does integrating interdisciplinary procedures into medical education improve clinical competence in graduates?

Variable: Level of clinical competence of graduates.

These questions allow for the measurement of different aspects and outcomes of the interdisciplinary approach in medical education and how it affects the training and performance of healthcare professionals.

Sentiment about each question is investigated using the Consensus Tool (Table 1) that classifies paper with Positive, Indeterminate, and Negative stances about a specific question

Questions\Example of Stances in Papers	Positive	Indeterminacy	Negative	Neutrosophic Probability
Q1	[29-34]	[35]		(0.86, 0.14, 0)
Q2	[36-39]	[40]	[41]	(0.67, 0.17, 0.17)
Q3	[41-44]	[45]		(0.67, 0.33, 0)
Q4	[46-51]	[52, 53]		(0.75, 0.25, 0)

Table 1: Sentiment Evaluation on Research Questions in Interdisciplinary Medical Education using the Consensus Tool

Figure 3 shows the probabilities of positive, indeterminate, and negative sentiments for questions Q1, Q2, Q3, and

Q4.

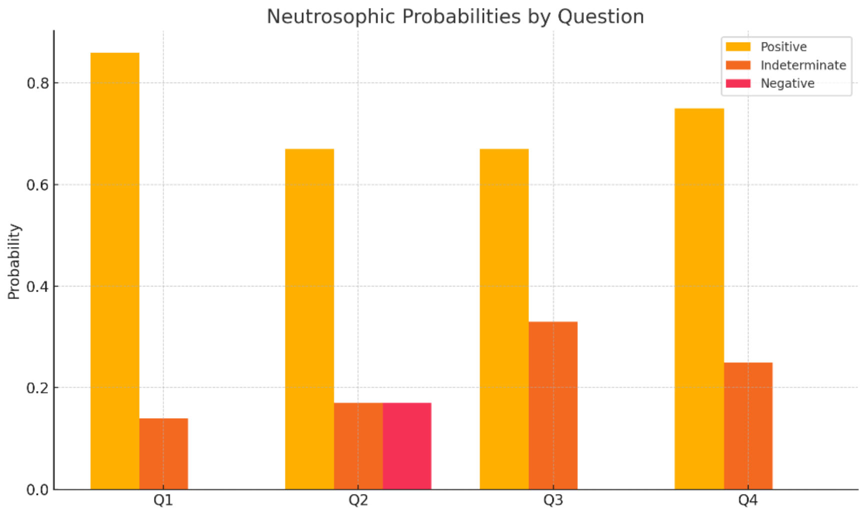

Figure 2: Neutrosophic Probabilities for Sentiment Analysis of Research Questions

Then, the univariate neutrosophic probability is calculated as follows:

$$UNP(H) = \wedge_{p}{}_{i=1}^{4} \text{ PNP}(Q_i) \quad (5)$$

$$UNP\ (0.86, 0.14, 0), (0.67, 0.17, 0.17), (0.67, 0.33, 0)\ (0.75, 0.25, 0)$$

$$= (min(0.86, 0.67, 0.67, 0.65), max(0.14, 0.17, 0.33, 0.25), max(0, 0.17, 0, 0))$$

$$= (0.67, 0.33, 0.17)$$

The value (0.67, 0.33, 0.17) for a neutrosophic probabilistic hypothesis indicates the following:

- **0.67:** There is a 67% probability that the hypothesis is true. This means there is a high likelihood that the inclusion of nursing procedures and interprofessional approaches in medical education improves teamwork, communication, clinical competence, and patient care outcomes in real clinical settings.
- **0.33:** There is a 33% indeterminacy, meaning there is some uncertainty about the validity of the hypothesis.
- **0.17:** There is a 17% probability that the hypothesis is false.

Negation of the Hypothesis

The negation of the hypothesis yields the values (0.17, 0.33, 0.67), which can be interpreted as follows:

- **0.17:** There is a 17% probability that the negation of the hypothesis is true. This means there is a relatively low likelihood that excluding nursing procedures and interprofessional approaches from medical education would improve teamwork, communication, clinical competence, and patient care outcomes.
- **0.33:** There is a 33% indeterminacy, indicating some uncertainty about the validity of the negated hypothesis. This mirrors the uncertainty present in the original hypothesis.
- **0.67:** There is a 67% probability that the negation of the hypothesis is false. This means there is a high likelihood that excluding nursing procedures and interprofessional approaches from medical education would not improve, or might even harm, teamwork, communication, clinical competence, and patient care outcomes.

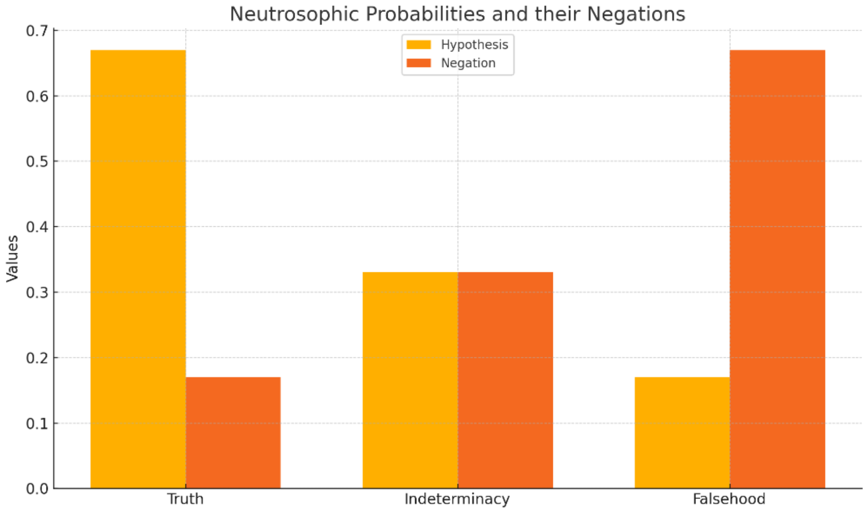

Figure 3: Neutrosophic Probabilities and Their Negations [28].

The results of the neutrosophic probabilistic hypothesis analysis suggest a strong likelihood that incorporating nursing procedures and interprofessional approaches into medical education has positive effects on important clinical and educational outcomes[54]. However, the presence of indeterminacy highlights the need for further research and consideration of contextual factors to fully validate these findings. The high falsity value for the negated hypothesis reinforces the positive impact of these educational approaches.

The Consensus Meter can be considered a sentiment analysis tool for scientific statements. This type of tool uses language models to classify and summarize responses to specific questions, providing an aggregated view of scientific opinion on a given topic. However, it has limitations, including the potential for incorrect classifications about 10% of the time and missing specific nuances of the original question. Additionally, it does not assess research quality and only includes a snapshot of available studies, not all existing research. Future research will explore the utilization of alternative sentiment analysis methods [55].

4. Conclusion

The assessment of the interdisciplinary influence in the field of general medicine, through the utilization of sentiment analysis and plithogenic statistics, uncovers noteworthy observations. An analysis of the sentiments expressed by authors towards cited works can be achieved through sentiment analysis of scientific citations. On the other hand, plithogenic probability takes into account multiple variables that have different levels of truth, indeterminacy, and falsity. The findings of this study suggest that incorporating nursing procedures and interprofessional approaches into medical education is likely to enhance teamwork, communication, clinical competence, and patient care outcomes. These conclusions are supported by a neutrosophic probabilistic hypothesis, which indicates a high probability of truth (0.67), some uncertainty (0.33), and a low probability of falsehood (0.17).

Future research will prioritize the utilization of alternative sentiment analysis tools for scientific inquiries or hypotheses. Furthermore, it would entail utilizing the concept of fallibility in hypotheses with multivalued logics of Smarandache in various situations.

References

[1] Yousif, A., Niu, Z., Tarus, J. K., & Ahmad, A. (2019). A survey on sentiment analysis of scientific citations. Artificial Intelligence Review, 52, 1805-1838.
[2] Smarandache, F. (2024). Note on Partial Falsifiability of Fuzzy and Fuzzy-Extension Hypotheses. Plithogenic Logic and Computation, 1, 93-95.
[3] Nabeeh, N. (2023) “Assessment and Contrast the Sustainable Growth of Various Road Transport Systems using Intelligent Neutrosophic Multi-Criteria Decision-Making Model”, Sustainable Machine Intelligence Journal, 2, pp. (2):1–12. doi:10.61185/SMIJ.2023.22102.
[4] Lathamaheswari, M., Sudha, S., Broumi, S., Smarandache, F., & Othman, C. (2022). Neutrosophic perspective of Neutrosophic probability distributions and its application. Collected Papers. Volume X: On Neutrosophics, Plithogenics, Hypersoft Set, Hypergraphs, and other topics, 267.

[5] Otio. (n.d.). Consensus AI: An innovative tool for measuring group agreement. Otio AI. Retrieved July 28, 2024, from https://otio.ai/blog/consensus-aisi
[6] Consensus. (2023, January 31). Consensus Meter: Guardrails and Limitations. Consensus. https://consensus.app/home/blog/consensus-meter/
[7] Potter, T. S., Zalewski, Z., Miao, M., Allsup, C., Thompson, K. M., Hayden, D., ... & Lankau, E. W. (2024). Applying causal reasoning to investigate multicausality in microbial systems. Ecosphere, 15(5), e4782.
[8] Smarandache, F. (2022). Plithogeny, plithogenic set, logic, probability and statistics: a short review. Journal of Computational and Cognitive Engineering, 1(2), 47-50.
[9] Mahmood, L., Mohammed, C., & Gilbert, J. (2021). Interprofessional simulation education to enhance teamwork and communication skills among medical and nursing undergraduates using the TeamSTEPPS® framework.. Medical journal, Armed Forces India, 77 Suppl 1, S42-S48 . https://doi.org/10.1016/j.mjafi.2020.10.026.
[10] Scherer, Y., Myers, J., O'Connor, T., & Haskins, M. (2013). Interprofessional Simulation to Foster Collaboration between Nursing and Medical Students. Clinical Simulation in Nursing, 9. https://doi.org/10.1016/J.ECNS.2013.03.001.
[11] Homeyer, S., Hoffmann, W., Hingst, P., Oppermann, R., & Dreier-Wolfgramm, A. (2018). Effects of interprofessional education for medical and nursing students: enablers, barriers and expectations for optimizing future interprofessional collaboration – a qualitative study. BMC Nursing, 17. https://doi.org/10.1186/s12912-018-0279-x.
[12] Kent, F., & Keating, J. (2015). Interprofessional education in primary health care for entry level students--A systematic literature review.. Nurse education today, 35 12, 1221-31 . https://doi.org/10.1016/j.nedt.2015.05.005.
[13] Veri, F. (2023). Transforming family resemblance concepts into fuzzy sets. Sociological Methods & Research, 52(1), 356-388.
[14] Rashno, E., Minaei-Bidgoli, B., & Guo, Y. (2020). An effective clustering method based on data indeterminacy in neutrosophic set domain. Engineering Applications of Artificial Intelligence, 89, 103411.
[15] M.Ali, A. and Muthuswamy, M. (2023) "Neutrosophic Multi-Criteria Decision-Making Framework for Sustainable Evaluation of Power Production Systems in Renewable Energy Sources", Sustainable Machine Intelligence Journal, 4, pp.(3):1–10. doi:10.61185/SMIJ.2023.44103.
[16] Smarandache, F. (2021). Plithogenic Probability & Statistics are generalizations of MultiVariate Probability & Statistics. Neutrosophic Sets & Systems, 43.
[17] Gafar, M. G., Elhoseny, M., & Gunasekaran, M. (2020). Modeling neutrosophic variables based on particle swarm optimization and information theory measures for forest fires. The Journal of Supercomputing, 76(4), 2339-2356.
[18] Reyes Espinoza, L. K., Mafla Herrería, C., & Sánchez Sandoval, P. A. (2024). Proceso Analítico Jerárquico Neutrosófico para la evaluación de los pacientes con Trombosis Venosa Profunda atendidos en el hospital IESS Ibarra. Neutrosophic Computing and Machine Learning, 31, 198-209.
[19] Nabeeh, N. (2023) "Assessment and Contrast the Sustainable Growth of Various Road Transport Systems using Intelligent Neutrosophic Multi-Criteria Decision-Making Model", Sustainable Machine Intelligence Journal, 2, pp. (2):1–12.
[20] Smarandache, F. (2018). Plithogenic Set, an Extension of Crisp, Fuzzy, Intuitionistic Fuzzy, and Neutrosophic Sets--Revisited. Neutrosophic Sets and Systems, 21, 153-167.
[21] Smarandache, F. (2021). Introducción a la Lógica Plitogénica. Neutrosophic Computing and Machine Learning, 18, 1-6.
[22] Rezaei, A. Oner, T. Katican, T. Smarandache, F. Gandotra, N. (2022). A short history of fuzzy, intuitionistic fuzzy, neutrosophic and plithogenic sets. Journal of International Journal of Neutrosophic Science, 18(1), 99-116.
[23] Troya-Sarzosa, J. F., & Oña, C. (2024). Using Plithogenic Statistics to Determine Optimal Guinea Pig Manure Dosing in Prickly Pear Cultivation. Neutrosophic Sets and Systems, 69, 58-66.
[24] Smarandache, F. (2021). Introduction to Plithogenic Logic as generalization of MultiVariate Logic. Neutrosophic Sets and Systems, 1.
[25] Smarandache, F., Abdel-Basset, M., Vazquez, M. L., & Broumi, S. (2023). Neutrosophic Sets and Systems {Special Issue: Neutrosophic Advancements And Their Impact on Research in Latin America}, Vol. 62, 2023. Neutrosophic Sets and Systems, 62(1), 40.
[26] Mohamed, Z., M. Ismail, M. and Abd El-Gawad, A. (2023) "Sustainable Supplier Selection using Neutrosophic Multi-Criteria Decision Making Methodology", Sustainable Machine Intelligence Journal, 3, pp. (2)
[27] Martin, N., Karuppiah, S. J., Smarandache, F., Rojas, R., & Vazquez, M. Y. L. (2023). Post-pandemic impact on the occupational shift of rural populace—a case study using neutrosophic comparison t-test. In Cognitive Intelligence with Neutrosophic Statistics in Bioinformatics (pp. 259-265). Academic Press.
[28] C. Ashbacher, Introduction to Neutrosophic Logic, American Research Press, Rehoboth, NM, 2002
[29] Petty, G., Dolansky, M., & Luebbers, E. (2016). Practicing Inter-Professional Teamwork among Nursing and Medical Students. The journal of nursing care, 5, 1-3. https://doi.org/10.4172/2167-1168.1000330.
[30] Maclean, S., Kelly, M., Geddes, F., & Della, P. (2017). Use of simulated patients to develop communication skills in nursing education: An integrative review.. Nurse education today, 48, 90-98 . https://doi.org/10.1016/j.nedt.2016.09.018.
[31] Horsley, T., Reed, T., Muccino, K., Quinones, D., Siddall, V., & McCarthy, J. (2016). Developing a Foundation for Interprofessional Education Within Nursing and Medical Curricula. Nurse Educator, 41, 234–238. https://doi.org/10.1097/NNE.0000000000000255.
[32] O'Leary, K., Wayne, D., Haviley, C., Slade, M., Lee, J., & Williams, M. (2010). Improving Teamwork: Impact of Structured Interdisciplinary Rounds on a Medical Teaching Unit. Journal of General Internal Medicine, 25, 826-832. https://doi.org/10.1007/s11606-010-1345-6.
[33] Henderson, A., & Alexander, H. (2011). Maximising the Integration of Medical and Nursing Students in Clinical Learning Environments: An Australian Perspective. , 131-148. https://doi.org/10.1007/978-90-481-3937-8_8.

[34] Berduzco-Torres, N., Choquenaira-Callañaupa, B., Medina, P., Chihuantito-Abal, L., Caballero, S., Gallegos, E., San-Martín, M., Bolton, R., & Vivanco, L. (2020). Factors Related to the Differential Development of Inter-Professional Collaboration Abilities in Medicine and Nursing Students. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.00432.
[35] Stychno, E., & Kulczycka, K. (2023). Communication in Medical Teams: a Literature Review. Teka Komisji Prawniczej PAN Oddział w Lublinie. https://doi.org/10.32084/tkp.6863.
[36] Azad, A., Min, J., Syed, S., & Anderson, S. (2020). Continued nursing education in low-income and middle-income countries: a narrative synthesis. BMJ Global Health, 5. https://doi.org/10.1136/bmjgh-2019-001981.
[37] Coster, S., Watkins, M., & Norman, I. (2017). What is the impact of professional nursing on patients' outcomes globally? An overview of research evidence.. International journal of nursing studies, 78, 76-83 . https://doi.org/10.1016/j.ijnurstu.2017.10.009.
[38] Bluestone, J., Johnson, P., Fullerton, J., Carr, C., Alderman, J., & BonTempo, J. (2013). Effective in-service training design and delivery: evidence from an integrative literature review. Human Resources for Health, 11, 51 - 51. https://doi.org/10.1186/1478-4491-11-51.
[39] Collins, C., Doran, G., Patton, P., Fitzgerald, R., & Rochfort, A. (2021). Does education of primary care professionals promote patient self-management and improve outcomes in chronic disease? An updated systematic review. BJGP Open, 5. https://doi.org/10.3399/BJGPO.2020.0186.
[40] Ton, E., Butteri, M., Alba, I., Duong, D., Wang, M., Suekawa, V., & Amin, A. (2017). Closing the Clinical Knowledge Gap: Achieving Collaborative Nursing Education Between Hospitalists and Nurses. Current Emergency and Hospital Medicine Reports, 5, 114-118. https://doi.org/10.1007/s40138-017-0138-1.
[41] Rachwal, C., Langer, T., Trainor, B., Bell, M., Browning, D., & Meyer, E. (2018). Navigating Communication Challenges in Clinical Practice: A New Approach to Team Education. Critical Care Nurse, 38, 15–22. https://doi.org/10.4037/ccn2018748.
[42] Hayat, K. (2023). Transforming Medical Education and Training. Pakistan BioMedical Journal. https://doi.org/10.54393/pbmj.v6i05.877.
[43] Goldman, M. (2016). Education in Medicine: Moving the Boundaries to Foster Interdisciplinarity. Frontiers in Medicine, 3. https://doi.org/10.3389/fmed.2016.00015.
[44] Grift, T., & Kroeze, R. (2016). Design Thinking as a Tool for Interdisciplinary Education in Health Care. Academic Medicine, 91, 1234–1238. https://doi.org/10.1097/ACM.0000000000001195.
[45] Caverzagie, K., Nousiainen, M., Ferguson, P., Cate, O., Ross, S., Harris, K., Busari, J., Bould, M., Bouchard, J., Iobst, W., Carraccio, C., & Frank, J. (2017). Overarching challenges to the implementation of competency-based medical education. Medical Teacher, 39, 588 - 593. https://doi.org/10.1080/0142159X.2017.1315075.
[46] Walrath, J., Muganlinskaya, N., Shepherd, M., Awad, M., Reuland, C., Makary, M., & Kravet, S. (2006). Interdisciplinary medical, nursing, and administrator education in practice: the Johns Hopkins experience.. Academic medicine : journal of the Association of American Medical Colleges, 81 8, 744-8 . https://doi.org/10.1097/00001888-200608000-00013.
[47] Shepitko, V., Sherstyuk, O., Boruta, N., Tykhonova, O., Tarasenko, Y., Skotarenko, T., & Levchenko, O. (2023). Interdisciplinary Integration as a Main Factor in the Development of Clinical and Professional Thinking of Students of Medical Higher Education Institutions of Ukraine. Ukraïns′kij žurnal medicini, bìologìï ta sportu. https://doi.org/10.26693/jmbs08.01.268.
[48] Bondarenko, S., Pylypyshyn, O., & Sopiha, M. (2022). METHODS AND TECHNOLOGIES OF TEACHING MEDICAL STUDENTS ON THE BASIS OF INTERDISCIPLINARY INTEGRATION. Медична освіта. https://doi.org/10.11603/m.2414-5998.2021.4.12694.
[49] Ef, B., Rf, A., Me, B., & On, S. (2011). Interdisciplinary integration as an instrument for development a standard of medical education. Morfologiia̐(Saint Petersburg, Russia), 139, 85.
[50] Scicluna, H., Grimm, M., O'Sullivan, A., Harris, P., Pilotto, L., Jones, P., & McNeil, H. (2012). Clinical capabilities of graduates of an outcomes-based integrated medical program. BMC Medical Education, 12, 23 - 23. https://doi.org/10.1186/1472-6920-12-23.
[51] Scicluna, H., Grimm, M., O'Sullivan, A., Harris, P., Pilotto, L., Jones, P., & McNeil, H. (2012). Clinical capabilities of graduates of an outcomes-based integrated medical program. BMC Medical Education, 12, 23 - 23. https://doi.org/10.1186/1472-6920-12-23.
[52] Sobral, D. (1990). [Interdisciplinarity in medical education: 3 aspects of analysis].. Educacion medica y salud, 24 4, 379-88 .
[53] Bandiera, G., Boucher, A., Neville, A., Kuper, A., & Hodges, B. (2013). Integration and timing of basic and clinical sciences education. Medical Teacher, 35, 381 - 387. https://doi.org/10.3109/0142159X.2013.769674.
[54] Abouhawwash, M. and Jameel, M. (2023) "Evaluation Factors of Solar Power Plants to Reduce Cost Under Neutrosophic Multi-Criteria Decision Making Model", Sustainable Machine Intelligence Journal, 2, pp. (1):1–11. doi:10.61185/SMIJ.2023.22101.
[55] Abdelhafeez, A., Aziz, A., & Khalil, N. (2022). Building a sustainable social feedback loop: a machine intelligence approach for Twitter opinion mining. Sustainable Machine Intelligence Journal, 1, 6-1.

Received: March 1, 2024. Accepted: July 29, 2024