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An Application of Neutrosophic Logic in the Confirmatory Data Analysis of the Satisfaction with Life Scale

Volkan Duran[1], Selçuk Topal[2,*], Florentin Smarandache[3]

[1] Iğdır University, Faculty of Science and Arts, Iğdır, Turkey; volkan.duran@igdir.edu.tr.

[2] Bitlis Eren University, Faculty of Science and Arts, Bitlis, Turkey; s.topal@beu.edu.tr.

[3] Department of Mathematics, University of New Mexico, 705 Gurley Avenue, Gallup, NM 87301, USA; smarand@unm.edu.

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Abstract

The main concept of neutrosophy is that any idea has not only a certain degree of truth but also a degree of falsity and indeterminacy in its own right. Although there are many applications of neutrosophy in different disciplines, the incorporation of its logic in education and psychology is rather scarce compared to other fields. In this study, the Satisfaction with Life Scale was converted into the neutrosophic form and the results were compared in terms of confirmatory analysis by convolutional neural networks. To sum up, two different formulas are proposed at the end of the study to determine the validity of any scale in terms of neutrosophy. While the Lawshe methodology concentrates on the dominating opinions of experts limited by a one-dimensional data space analysis, it should be advocated that the options can be placed in three-dimensional data space in the neutrosophic analysis. The effect may be negligible for a small number of items and participants, but it may create enormous changes for a large number of items and participants. Secondly, the degree of freedom of Lawshe technique is only 1 in 3D space, whereas the degree of freedom of neutrosophical scale is 3, so researchers have to employ three separate parameters of 3D space in neutrosophical scale while a resarcher is restricted in a 1D space in Lawshe technique in 3D space. The third distinction relates to the analysis of statistics. The Lawhe technical approach focuses on the experts' ratio of choices, whereas the importance and correlation level of each item for the analysis in neutrosophical logic are analysed. The fourth relates to the opinion of experts. The Lawshe technique is focused on expert opinions, yet in many ways the word expert is not defined. In a neutrosophical scale, however, researchers primarily address actual participants in order to understand whether the item is comprehended or opposed to or is imprecise. In this research, an alternative technique is presented to construct a valid scale in which the scale first is transformed into a neutrosophical one before being compared using neural networks. It may be concluded that each measuring scale is used for the desired aim to evaluate how suitable and representative the measurements obtained are so that it's content validity can be evaluated.

Keywords: Convolutional neural network, Neutrosophic logic, Scale development, Neutrosophic social science, Validity.

1 | Introduction

Scale development is an important part of computational social science research, especially for quantitative research. Therefore, this research mostly relies on psychometric research. Usually, psychometricians assess human differences by administering test batteries that have been found to have accurate measuring properties. Effects from these tests are then evaluated by factor analysis and multidimensional scaling to classify latent variables or factors responsible for similar trends of correlations. Specific differences for aimed cognitive skills are generally represented in terms of factors in those studies [1]. The main objective of those who support the psychometric strategy is to allow for the assessment to be made objective. From this standpoint, assessment should be based on objective determinations. For this reason, the psychometric approach emphasizes scales based on

Corresponding Author: s.topal@beu.edu.tr

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statistical methods such as factor analysis, item analysis, and test analysis, and tests its validity and reliability with scientific methods [2].

Neutrosophical set is a potent field of study that has shown its efficiency and strength in various applications. In the meantime, most contributions were theoretical and only validated using mathematical examples or limited data sets and did not use other applications in general [37]. When the literature is reviewed, although it has many applications in natural sciences, recent works focus on the applications of the neutrosophic logic in social sciences [38]. Neutrosophic sets are even more suitable than fuzzy sets to represent the possible responses to questionnaires. The former enables the individual polled to communicate their genuine ideas and emotions even more precisely, thanks to the indeterminacy function of their membership. The benefit of the neutrosophical method is that responders may describe their ideas and emotions more correctly, since both indeterminacy and an independent membership function of falsehood are taken into account [39], [40]. In this respect, this research aims to use the application of the neutrosophic philosophy in social sciences especially in education and assessment and evaluation methods of scale development.

2| Preliminaries

The numerical properties obtained depending on the group to which a test is applied are generally called test statistics. Some of the test statistics can be calculated based on item statistics. In general, the test statistics like the average of the test, the average difficulty of the test, the variance of the test, and other test statistics are highly useful [3]. Researchers want to show whether there is harmony in an instrument's responses. Factor analysis is one of the multivariate approaches that social scientists use to validate psychological aspects. When several independent variables are grouped in a single study, statistical analysis can become rather challenging. It is often advantageous to group together those variables that are correlated with one another. Factor analysis is a technique that allows researchers to see whether many variables can be portrayed as a few factors [4]. Factor analysis seeks to identify some new specific factors by putting together a small number of factors that aren't connected (a p-dimensional space) [5]. It is recommended that the scale of the explanatory factor analysis process should be tested through confirmatory factor analysis [6]. Confirmatory factor analysis could be considered as a way to verify the validity of factor structures. Using this method, it is attempted to prove that the observed variables are connected with the hidden variables and hidden variables are connected. To investigate these relationships, measurement models were built [7].

There are three types of factors for developing a more grounded scale: (i) reliability; (ii) validity; and (iii) sensitivity. Reliability refers to the extent to which a measurement of a phenomenon produces consistent results as given in *Fig. 1* [8]. Therefore, reliability means consistency or stability. Consistency of any measurement scale is important for objective scientific research and this concept is related to 'agreement', 'reproducibility', and 'repeatability' of any measurement. The agreement is the closeness of two measurements made on the same subject as opposed to one another. Reliability includes repeatability. Repeatability means measuring accurately the same variable again and again for the same circumstances [9]. A test or measure is said to be reliable if there are always identical results using the same testing procedure [10]. This means that regardless of how many times the measurement has been taken or by whom it has been performed, you will always obtain the same value. This means two things: first of all, you should get the same result each time you use the measure, and secondly, you should use the measure as many times as possible. This can be an issue in data collection when several people are involved [11]. Reproducibility referred to variations in test results while tests were performed on subjects on different occasions. The changed circumstances may be due to the use of various methods of measurement or instruments, measurement by several observers or raters, or measurements during a period in which the variable's error-free level may undergo a non-negligible change [9].

Reliability is, therefore, the level of error-free. As the amount of error decreases as a result of measurement, reliability increases, and as the number of errors increases, reliability decreases. Reliability levels of

measurement tools are determined by reliability analysis. Reliability is best expressed with the reliability coefficient (r) ranging from 0.00 to +1.00. The closer the reliability coefficient of the measurement tool is to 1, the higher the reliability, the closer to 0, the lower the reliability [12].

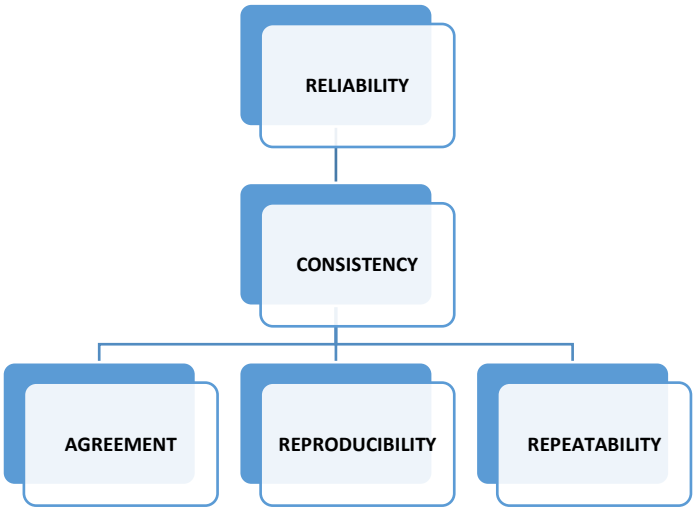

Fig. 1. Reliability and its components.

Validity simply means "measure what is intended to be measured" [13]. There are different types of validity in social sciences (*Fig. 2*). Face validity is a subjective judgment on the operationalization of a construct whether it is appropriate, unambiguous, simple, and proper [14]. Content validity refers to how appropriate and representative the measurements collected are for the desired assessment purpose. The representativeness criterion may have two definitions. Quantifying the extent of sampling is one of them. The second is the extent to which items reflect the structures of the whole scale [15]. Construct is a pattern formed by certain elements that are thought to be related to each other or by the relationships between them. The construct validity measurement tool shows to what extent it can accurately measure the structure and concept that it claims to measure [12]. Construct validity refers to how well you translated or transformed a concept, idea, or behavior that is a construct into a functioning and operating reality, the operationalization [14]. Construct validity is used when trying to quantify a hypothetical construct, like fear. Convergent and discriminant validity should be used to determine the validity of a construct by suggesting that the new measurements are correlated with other measurements of that construct and that the dimensions proposed are inappropriate to the construct unrelated, respectively [16]. Discriminant validity is the extent to which latent variable a discriminates from other latent variables. The Convergent Validity is the degree to which two measurements of a construct are connected theoretically [14]. The validity of the criterion is also divided into concurrent and predictive validity, where the validity of the criterion deals with the correlation between the current measurement and the criterion measurement (such as the gold standard) [16]. Content and construct validity in social sciences are defined as credibility/internal validity. Internal validity is related to the question of whether the research findings fit with reality in the external world. Internal validity is determined by experimenting with specific characteristics and no specific biases. For example, the question of "can we recognize people by looking at their faces?" can be examined. This question is answered by asking two more questions. First, is the independent variable the cause of the dependent variable? Second, can other possible explanations for the relationship between independent variable and dependent be logically eliminated? If the answer to these questions is yes, the researchers can claim that the experiment has internal validity [17]. Criterion validity is the degree to which it is empirically relevant to the outcome. This is something that calculates how well one measure predicts another measure. There are three types of criterion validity namely; concurrent validity, predictive and postdictive validity [14].

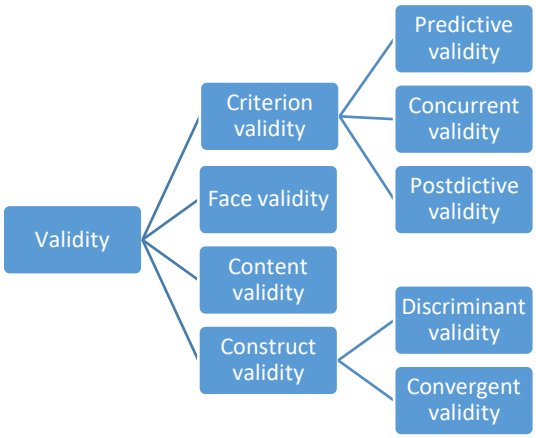

Fig. 2. Subtypes of various forms of validity tests.

Fig. 3. illustrates how reliability and validity are related. In the first target, the shots reached the same spot, but none were effective in reaching the same point. The second target can be regarded as valid but not reliable since the points are expanding over the entire place. The third target did not present reliability or validity, since they hit spread points. The fourth target stands as an indicator of reliability and validity; the shots landed right in the target center and were consistent, right in the target center [18].

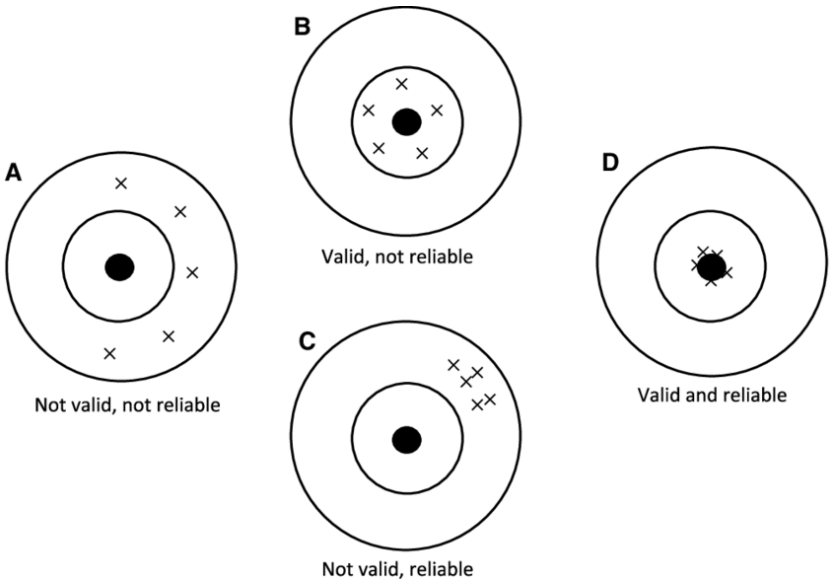

Fig. 3. Possible combinations of validity and reliability of measurement instruments [18].

Sensitivity is defined as the consensus closeness between randomly selected individual measurements or results. It is therefore concerned with the variance of repeated measurements. A measurement tool with low variance is more sensitive than those with a higher variance. For example, as a researcher, one wants to know what is the smallest sample you can use that will take into consideration the variability in the dependent measure and yet be sensitive enough to notice a statistically meaningful difference, whether there is one. Our capacity to distinguish significant differences between groups is defined in part by the variability of individuals in our sample and how much variability occurs among them. Therefore, less variability may contribute to greater sensitivity, and more variability results in less sensitivity [19].

As mentioned above, the key aim of developing questionnaires or scales is to collect correct and appropriate data. The reliability and validity of scale or questionnaire formats is an important feature of testing methodology [14]. The reliable and accurate measurement may, in the simplest intuitive terms, indicate that the current measurement is equal with, or follows, the truth. However, it is often impractical to require the new measurement to be identical to the truth, either because 1) we accept the measurement of a tolerable (or acceptable) error or 2) the truth is simply impossible for us (either because it is not

measurable or because it is only measurable with some degree of error) [16]. In this regard, data space and data range are the important dimensions of developing scales because it also changes the data type, the logical space of the analysis, methodology, and validity and reliability of the results (*Fig. 4*).

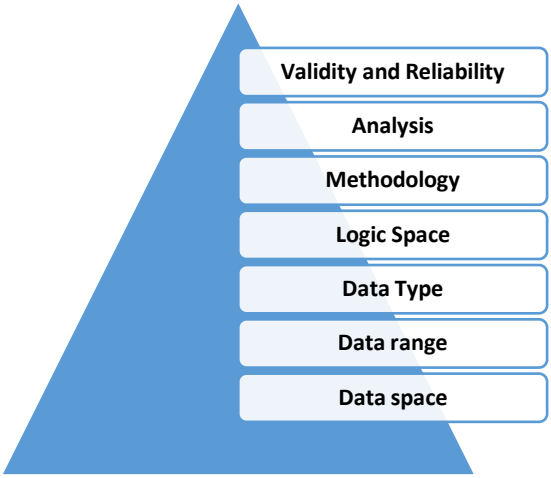

Fig. 4. Data space and data range determines the validity and reliability of any scale.

Data space in measurement tools like scale refers to the set of independent options regarding the particular item of the scale. For example, on any Likert-type scale, the participant can express only one option, so the data space is 1d, whereas on the neutrosophic scale, there are three independent dimensions regarding any item as undecided, agree, and disagree.As it can be seen, data space is 1d in any Likert-type scale and 3d in neutrosophic space and if our measurement tools become more qualitative, like having items requiring free opinions in a paragraph like choices, it has more dimensions, even in ideal cases it has infinite dimensions. However, although n-dimensional space is more appropriate for better valid and reliable results, less dimensional spaces have less vagueness in terms of the interpretation of the data and they can be more easily statistically handled. Additionally, as the dimension of space increases, the objectivity of the measurement tool in terms of measuring common characteristics decreases. The advantage of the 3-dimensional neutrosophic scale is that it both seeks the agreement, disagreement, and confusion levels of the participants. In daily life, many items are encountered to give an opinion about them and we are not restricted within a 1-dimensional space where we can only choose one answer regarding whether we agree, disagree or express uncertainly about a particular case. However, in the three-dimensional neutrosophic space, participants express both their agreement and disagreement level as well as the uncertainty in the items or dimensions of the scale. People sometimes think that they understand a statement, but one word in the statement makes us uncertain whether it is the "right meaning" intended by the source. Similarly, people sometimes agree on some propositions, but just because of the source of the message itself, they also disagree with the item. Therefore, the neutrosophic scale is different from the classical Likert-type scales in terms of data space (*Fig. 5*).

The second important point that distinguishes any measurement tool from each other is the data range. The range of a set of data is the difference between the highest and lowest values in the set. Likert-type scales are commonly arranged in terms of data, ranging from 3 point Likert-type scales to 10 point Likert-type scales. However, the range of the neutrosophic scale is broader than the Likert-type scales. It includes any rational number in a range between 0 and 100. As a result, neutrosophic scales have continuous variable types, whereas Likert-type scales have discrete value types in terms of rational numbers, so data analysis may differ as a result. This can contribute to increasing the sensitivity of the measurement tool in this respect. This is actually what is called as neutrosophic data in some recent researches is the piece of information that contains some indeterminacy. Similar to the classical statistics, it can be classified as [39]:

– *Discrete neutrosophic data, if the values are isolated points.*
– *Continuous neutrosophic data, if the values form one or more intervals.*
– *Quantitative (numerical) neutrosophic data; for example: a number in the interval [2, 5] (we do not know exactly), 47, 52, 67 or 69 (we do not know exactly).*
– *Qualitative (categorical) neutrosophic data; for example: blue or red (we do not know exactly), white, black or green or yellow (not knowing exactly).*
– *The univariate neutrosophic data is a neutrosophic data that consists of observations on a neutrosophic single attribute.*

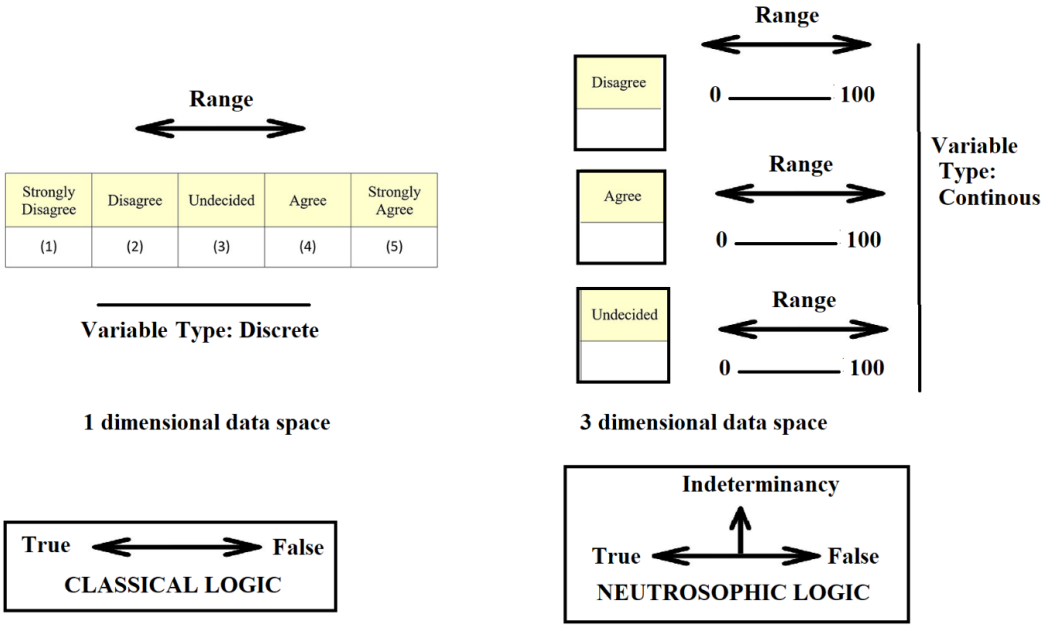

Fig. 5. Data space of classical Likert-type scale, neutrosophic scale.

The third important point of any measurement tool is its logic space. Logic space is important because "in any field of knowledge, each structure is composed from two parts: a space, and a set of axioms (or laws) acting (governing) on it. If the space, or at least one of its axioms (laws), has some indeterminacy of the form (t, i, f) ≠ (1, 0, 0), that structure is a (t, i, f)-Neutrosophic Structure" [41]. Therefore the logic which is in our focus, Neutrosophic Logic, is an emerging field where each proposition is reckoned to have the proportion (percentage) of truth in a subset T, the proportion of indeterminacy in a subset I, and the proportion of falsity in a subset F. A subset of truth (or falsity or indeterminacy) here is considered, rather than just a number, since in many situations can not be precisely determined the proportions of truth and falsity but we can only approach them. For example, suppose that a statement (or proposition) is between 32% and 48% true and 59% to 73% false; worse: 32% to 39% or 41 to 52% true (according to various observers) and 57% or 62% to 71% false. Subsets are not basic intervals but are any set (open or closed or semi-open/semi-closed intervals, discrete, continuous, intersections or unions of previous sets, etc.) following the given proposition. The adventure of gaining meaning and mathematical results from situations of uncertainty was initiated by Zadeh [20]. Fuzzy sets added a new wrinkle to the concept of classical set theory. Elements of the sets have degrees of belongingness (in other words, membership) according to the underlying sets. Atanassov defined intuitionistic fuzzy sets including belongingness and non-belongingness degrees [21], [32]-[34]. Smarandache suggested neutrosophy as a computational solution to the idea of neutrality [22]. Neutrosophic sets consider belongingness, non-belongingness, and indeterminacy degrees. Intuitionistic fuzzy sets are defined by the degree of belongingness and non-belongingness and uncertainty degrees by the 1-(membership degree plus non-membership degree), while the degree of uncertainty is assessed independently of the degree of belongingness and non-belongingness in neutrosophic sets. Here, belongingness, non-belongingness, and degree of uncertainty (uncertainty), like degrees of truth and falsity, can be assessed according to the interpretation of the places to be utilized. This indicates a difference between the neutrosophic set and the intuitionistic fuzzy set. The definition of neutrosophy is, in this sense, a potential solution and representation of problems in different fields. Two

detailed and mathematical fundamental differences between relative truth (IFL) and absolute truth (NL) are as follows:

I. NL can distinguish absolute truth (truth in all possible worlds, according to Leibniz) from the relative truth (truth in at least one world) because NL (absolute truth) = 1^+ while IFL (relative truth) = 1. This has been practiced in philosophy and linguistics (see the Neutrosophy). The standard interval [0, 1] used in IFL has been extended to the unitary non-standard interval $]^- 0, 1^+ [$ in NL. Parallel distinctiveness for absolute or relative falsehood and absolute or relative indeterminacy are allowed to consider in NL.
II. There do not exist any limits on T, I, F apart from they are subsets of $]^- 0, 1^+ [$, thus: $^-0 \leq inf\ T + inf\ I + inf\ F \leq sup\ T + sup\ I + sup\ F \leq 3^+$ in NL. This permission allows dialetheist, paraconsistent, and incomplete information to be identified in NL, while these situations impossible to be identified in IFL since F (falsehood), T (truth), I (indeterminacy) are restricted either to $t + i + f = 1$ or to $t2 + f2 \leq 1$, if T, I, F are all reduced to the points t, i, f respectively, or to sup $T + sup\ I + sup\ F = 1$ if T, I, F are subsets of [0, 1] in IFL.

Although there are usually three options in Likert-type scales: agreement, disagreement, and vagueness, its logic is based on one valued option located on the opposite sides of true and false values. However, the neutrosophic set has three independent components, giving more freedom for analysis so that it brings different logical operations as well. Therefore, the methodology of the analysis of the data should be changed based on the logical structure of the scale. For instance, while factor analysis is used for classical Likert-type scales, neural networks are more appropriate for the analysis of the data of the neutrosophic scales. Nevertheless, it should be noted that classical analysis and methods can indeed be used for neutrosophic scales based on different analysis procedures. To sum up, "a space with an item, it means an opinion, another element induces another opinion, another element in turn induces another opinion, and so on. The opinion of each element of the structure must be respected. In this way it builds a neutrosophic social structure. The result is a very large socio-neutrosophic structure that is intended to be filtered, evaluated, analyzed by scientific algorithms" [42]. Hence, we can conclude that the validity and reliability of the measurement tools can change based on the logical structure of the scale. As a result, in this study, we take The Satisfaction with Life Scale developed by Diener et al. [23] and adapted in Turkish by Dağlı and ve Baysal [24] and convert it into neutrosophic form, compare the results, and use this analysis to propose new type confirmatory analysis procedures and develop neutrosophic scales. There are many ways to evaluate and interpret data. Some recent studies reveal important developments based on the interpretation and effective use of data [42]-[44].

2.1| The Difference between Lawshe Technique and Neutrosophic Scale

Some argue that the well-known Lawshe technique is very similar to neutrosophic analysis and propose what is the reason behind the logic of neutrosophic forms. Initially suggested in a seminal 1975 paper in Lawshe [25], the method of Lawshe was common in various areas including health care, education, organizational development, personnel psychology, and market research for determining and quantifying content validity [26], [27].

Lawshe [25] has proposed a quantitative measure to evaluate validity of the content termed as the Content Validity Ratio (CVR). The validity ratio of content provides information about validity of items. The approach includes the use of an expert panel to evaluate items based on their relevance to the scale domain. Each item on a scale is classified as a three-point rating system (1) point is irrelevant, 2) item is important, but not essential, and 3) item is essential). The percent of experts considering items significant or essential for the substantive content of the scale is calculated for every element of a CVR. Also a overall measurement of the validity of the content of the scale may be created. The index is calculated as a mean of the CVR scores for items [36].

A quantitative criteria is necessary in the Lawshe approach for determining the validity of content. The Content Validity Index and CVR are the criterion for validity used by experts. In order for each item to

be included in the Scale, the content validity ratio is an internationally accepted standard. For all finished items, the Content Validity Index is the average CVR. The CVR should assess whether or not each item is essential, and the Content Validity Index should identify the relationships between the scale items and scale . The Content Validity Index is calculated by using the degree of agreement of the experts on the relevance and clarity of the items. According to CVR values,

– *If all the experts in the panel answered "not necessary" for any item, that item is completely unnecessary.*
– *If all of the experts on the panel gave the answer "useful but not necessary" for any item, that item is significantly necessary.*
– *If the number of experts who give the answer "required" for any item is more than half, it can be commented that the item has a certain validity value, and the validity value of the item will increase as the number of experts who give the answer "required" increases [35].*

First of all, the main difference between those two techniques is in their data space. Although there are three choices in the Lawshe technique for each item as an a-Essential? b-Useful but not essential? Why? c-Not necessary? Why, while membership in neutrosophic logic is very similar to Truth T, indeterminacy I, and falsity F, their dimensions are different from each other because there is only one option regarding each item, which corresponds to one-dimensional data space, but there are three independent data spaces in the neutrosophic form where each data represents a different. According to this, whether all participants agree that the information or ability that has been tested is necessary, or whether none says it is relevant, we are sure that the component has been added or omitted. If there is no majority, the dilemma emerges. There are two hypotheses, both compatible with existing psychophysical principles [28].

– *Every item for which more than half of the experts consider any item to be "essential" has content validity.*
– *The wider the extent or degree of its validity is the more experts (above 50 percent) who view an item as "essential."*

Therefore, the Lawshe technique focuses on the dominant opinions of the experts which are restricted by one-dimensional data space so that it might hide their indeterminacy or disagreement because they are weak compared to the other options. It should be pointed out that altough Lawshe technique is not strictly restricted by the one dimensional options for experts because it also take their suggestions, in the statistical analysis process it focuses on only one options. For a small number of items, the effect of this can be negligible, but for a huge number of items, it can make huge differences.

There is one parameter in the Lawshe technique. Researcher can only choose one option among agreement, disagreement, and indeterminacy based on his/her dominant view. Hence it is actually a 1d dimensional function in a 3-dimensional space. There are three parameters in the Neutrosophic scale. A researcher must choose three options among agreement, disagreement, and indeterminacy. Hence it is actually a 3d dimensional function in a 3-dimensional space. Therefore, the degree of freedom of the Lawshe technique is 1 in 3-d space whereas the degree of freedom of the neutrosophic scale is 3, that is, a researcher is restricted in 1-d space in 3d space of possibilities in Lawshe technique whereas researchers must use three independent parameters of 3d space in neutrosophic scale (*Fig. 6*).

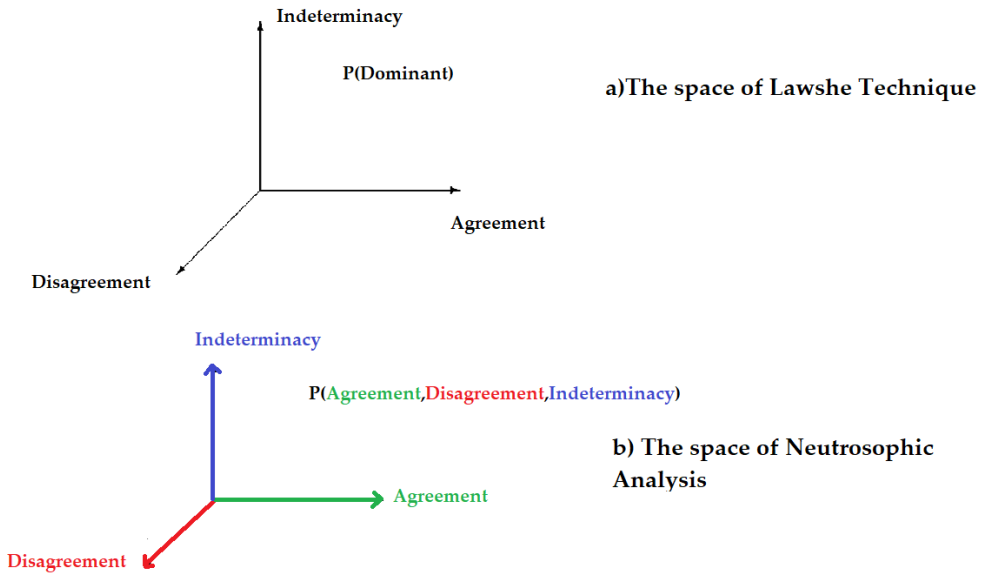

Fig. 6. The difference between the space and parameters of the Lawshe technique with neutrosophic scale.

a) There is one parameter in the Lawshe technique. The analysis focus on one option among agreement, disagreement and indeterminacy based on the dominant view. Hence it is actually a 1d function in 3d space b) there are three parameters in the Neutrosophic scale. The analysis focuses on three options among agreement, disagreement and indeterminacy. Therefore, it is a 3D function in the 3D space.

Therefore, for the participation of a huge number of researchers, the dominant view of the researcher restricted within 1d space in the Lawshe technique may dismiss the other two parameters that cannot be ignored in the actual case. These hidden variables can lead to huge differences especially in the case of the analysis of the options of a huge number of participants and even this cannot be realized. However, in neutrosophic logic, it is impossible to dismiss three parameters since the researchers must give their opinions on them (*Fig. 7*).

The second difference is related to the data range. The Lawshe technique is limited by discrete data that can be manipulated with qualitative comments. Although qualitative comments make the item better, in terms of generalizability we may not be confident that the item is suitable for its content. Opinions of the experts may indicate different content, but the understanding of common participants may indicate different content in this respect.

The third difference is related to statistical analysis. In the Lawshe technique, it is focused on the ratio of decisions of the experts, whereas in the neutrosophic logic we focus on the importance and correlation level of each item for the analysis. In the Lawshe technique, there is no distinction between the importance level and correlation, so it means that the item that is seen as important by experts might not be correlated with the content in the actual applications (*Fig. 8*). In daily life, we wonder about particular features and we seek them in particular sets, but the items of the set can be seen as important but are not relevant to what we want to seek. For example, we may meet a close relative whom we have not seen in a long time and look for him/her in a specific location, and the individuals resembling our relative are important to us, but the importance is diminished when we discover that there is no correlation between the actual close relative and the similar person resembling him/her.

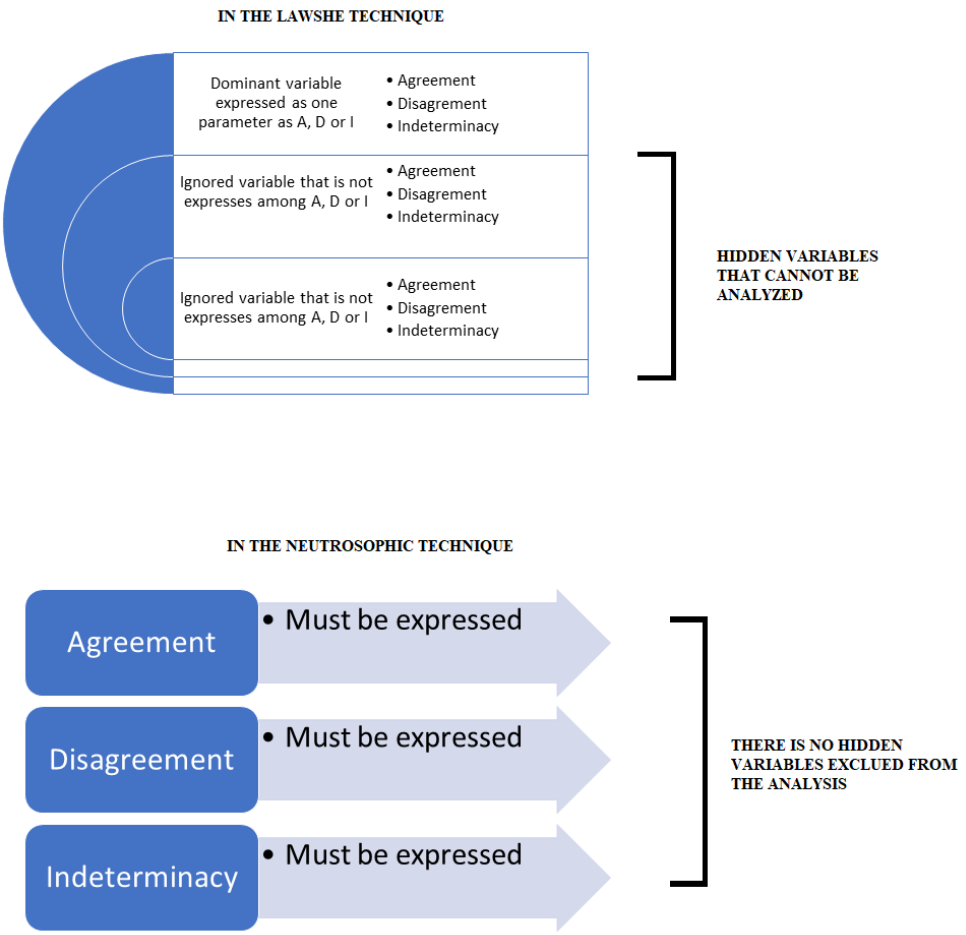

Fig. 7. There is no hidden variable in the neutrosophic technique but there are hidden variables in the Lawshe technique.

Actually Sartre's vivid description [29] regarding his hypothetical appointment with Pierre can be given as a more explicit example for the importance and correlation as follows:

I have an appointment with Pierre at four o'clock. I arrive at the cafe a quarter of an hour late. Pierre is always punctual. Will he have waited for me? I look at the room, the patrons, and I say, "he is not here." Is there an intuition of Pierre's absence, or does negation indeed enter in only with judgment? At first sight it seems absurd to speak here of intuition since to be exact there could not be an intuition of nothing and since the absence of Pierre is this nothing…..

Similarly Pierre's actual presence in a place which I do not know is also a plenitude of being. We seem to have found fullness everywhere. But we must observe that in perception there is always the construction of a figure on a ground. No one object, no group of objects is especially designed to be organized as specifically either ground or figure; all depends on the direction of my attention. When i enter this cafe to search for PIerre, there is formed a synthetic organization of all the objects in the cafe, on the ground of which Pierre is given as about to appear. This organization of the cafe as the ground is an original nihilation. Each element of the setting, a person, a table, a chair, attempts to isolate itself, to lift itself upon the ground constituted by the totality of the other objects, only to fall back once more into the undifferentiation of this ground; it melts into the ground. For the ground is that which is seen only in addition, that which is the object of a purely marginal attention. Thus the original nihilation of all the figures which appear and are swallowed up in the total neutrality of a ground is the necessary condition for the appearance of the principle figure, which is here the person of Pierre. This nihilation is given to my intuition; i am witness to the successive disappearance of all the objects which i look at-in particular of the faces, which detain me for an instant (could this be Pierre?) and which as quickly decompose precisely because they "are not" the

face of Pierre. Nevertheless, if i should finally discover Pierre, my intuition would be filled by a solid element, i should be suddenly arrested by his face and the whole cafe would organize itself around him as a discrete presence.

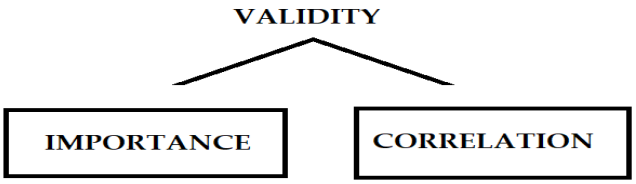

Fig. 8. There is a distinction between the concept of importance and correlation in neutrosophic logic.

Therefore, when experts make a decision, there is no clear distinction between their decision-making process in terms of importance or correlation.

The fourth one is related to expert opinion. Lawshe technique focuses on expert opinion, but the term expert is not clear in many respects. For example, if somebody studies a novel concept that has not been studied previously, how an expert decides whether the item is suitable or not besides deciding on its grammar or meaning. Furthermore, we need different experts for decision-making about the suitability of the item, but the ratio of those experts shouldn't be equal in the proportion of the decision-making process. For example, on some scales, the opinion of a psychologist might be more important than the other experts and their contribution should vary by this. However, in the neutrosophic scales, we mainly aim at the real participants so that we can understand to the extent whether the item is understood or objected or vague.

3| Methodology

In the methodology, first, the items of the Satisfaction with Life Scale were converted into the neutrosophic form where each item has three independent components referring to the agreement, disagreement, and indeterminacy. However, to compare the neutrosophic scale, the classical scale were also used as well. Secondly, each item of neutrosophic scale were analyzed in terms of classical scale in terms of neural networks and Spearman correlation constant. In the second part of the study, the Neutrosophic Life Satisfaction Scale were analyzed in terms of whole structure for confirmatory factor analysis. Finally, the decision-making formula were created to decide to remove or keep the items on the neutrosophic scale (*Fig. 9*).

In this analysis var1 refers to the variable number and a (such as var1a) stands for agreement b stands for indeterminacy and c refers to disagreement. In the neural network analysis for the study, for the level of the analysis of each item, the input variables are three sub-items of each item on the neutrosophic scale and the output variable is each classical scale. Similarly, for the whole structure for confirmatory factor analysis, the input variables are all the items on the neutrosophic scale and output variables are the classical items of the classical scale. The activation function both for the hidden and output layer was chosen as the sigmoid function. The number of hidden layers in each analysis was chosen to be two (*Fig. 10*). Criteria training=batch optimization=gradientdescent was chosen as the criterion. In the analysis of the data, independent variable importance analysis was used.

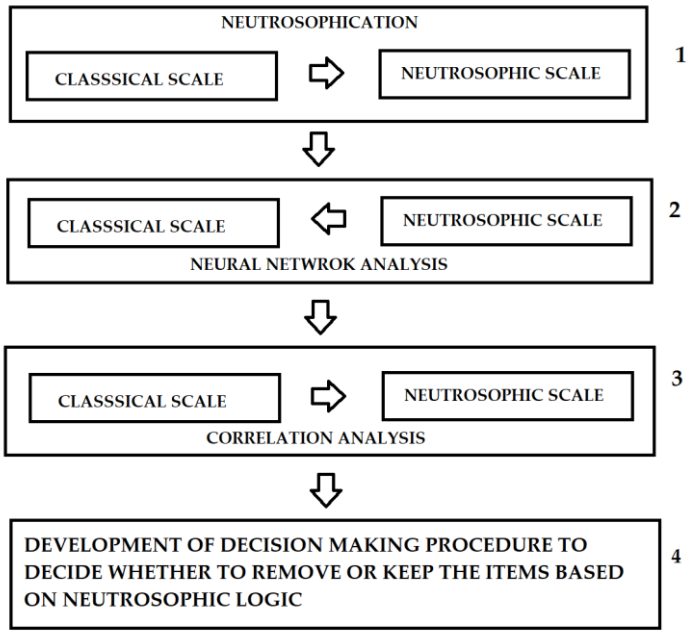

Fig. 9. The procedure for the development of neutrosophic scale.

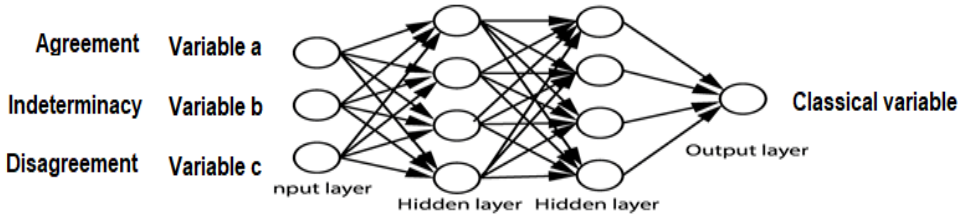

Fig. 10. The general structure of the Convolutional Neural Network (CNN) we used in this study is a three-layer neural network with three input neurons, two hidden layers of four neurons each, and one output layer [30].

Independent variable importance analysis performs a sensitivity analysis, which computes the importance of each predictor in determining the neural network. The importance of an independent variable is a measure of how much the network's model-predicted value varies with different values of the independent variable. Normalized importance is just the importance values that are grouped by and represented as percentages of importance values. In another words, the importance of an independent variable is a measure of how much the network's model-predicted value changes for different values of the independent variable. Normalized importance is simply the importance values divided by the largest importance values and expressed as percentages. However, it should be underlined that you cannot tell is the "direction" of the relationship between these variables and the predicted probability of default" [31], [41]. The importance chart is simply a bar chart of the values in the importance table, sorted in descending value of importance. It allows to guess that a larger amount of debt indicates a greater likelihood of default, but to be sure, you would need to use a model with more easily interpretable parameters [41]. Therefore, the spearman correlations between the variables are examined to see the direction and relationship of the items to decide whether they are suitable or not.

3.1| Measurement Tools

In this study, the satisfaction with Life Scale adapted into Turkish by Dağlı and ve Baysal [24] which was developed by Diener et al. [23] was converted into the neutrosophic form and the results were compared in terms of confirmatory analysis by convolutional neural networks. One might ask why an adapted version of a scale was chosen rather than adapting or developing a new scale in the neutrosophic form. The first reason for this is that the method based on neutrosophic logic is a very new one so that in more grounded

levels it must be tested rather than directly using it to assess and develop scales. Secondly, the neutrosophic form could be compared with the classical one and infer the advantageous and disadvantageous sides of the neutrosophic scale in terms of its different aspects. Thirdly, this study is aimed at conducting confirmatory analysis so that a particular measurement tool must be used to assess whether the neutrosophic form can be used for the analysis. In classical confirmatory analysis, similar measurement tools can be used to analyze this, but in this article, the main aim is to use the neutrosophic form to conduct confirmatory analysis.

4| Findings

In this section, we give our findings.

4.1| Analysis of Neutrosophic Life Satisfaction Scale in terms of Reliability

Before using the neutrosophic scale it can be wondered about its reliability before comparing it with the classical one. Cronbach's Alpha constant can be used for the neutrosophic scale. However, it should be noted that Cronbach's Alpha constant should be used three times for three independent factors as given in *Table 1* below.

Table 1. Cronbach's Alpha constant for three dimensions.

Cronbach's Alpha Constant	Variables
0.863	VAR1a VAR2a VAR3a VAR4a VAR5a
0.777	VAR1b VAR2b VAR3b VAR4b VAR5b
0.792	VAR1c VAR2c VAR3c VAR4c VAR5c

Results show that our neutrosophic scale is also reliable which also supports the reliability of the classical scale because Cronbach's Alpha constant is an acceptable level for three dimensions.

4.2| Analysis of Neutrosophic Life Satisfaction Scale in terms of Items of Validity

According to Spearman's rho correlation coefficient, classical variable 1 has a high positive significant correlation with var1a which is related to the agreeing level of the participants and it has an average level negative significant level of correlation variable 1c which is related to the disagreeing level of the participants. Both correlations can be related to the points of a participant who has either a high level of life satisfaction or not. Besides, no correlation between vagueness and classical items shows that there is no indeterminacy about this item.

Table 2. Correlation among neutrosophic item 1 and classical item 1.

		VAR1a	VAR1b	VAR1c
VAR1	Correlation Coefficient	0.678**	-0.022	-0.417**
	Sig. (2-tailed)	0.000	0.768	0.000
	N	189	189	189

Neural network analysis of the items reveals that participants with positive life satisfaction for item 1a contribute 100% to classical variable 1 and participants with negative life satisfaction for item 1c contribute 26.4% to classical variable 1. This might be related to the differentiation of the number of participants having high-level life satisfaction and a low level of life satisfaction. However, it should be noted that the vagueness of this item is 57.5% implies that there is a moderate level of confusion about this article either because of meaning or the usage of the words or some unknown parameters, although there is no correlation between var1b and classical variable.

Table 3. Independent variable importance for classical item 1 in terms of neutrosophic items.

Independent Variable Importance		
	Importance	Normalized Importance
VAR1a	0.544	100,0%
VAR1b	0.313	57,5%
VAR1c	0.143	26,4%

According to Spearman's rho correlation coefficient, classical variable 2a has a significant positive correlation with var2a, which is related to the participants' agreeing level, and variable 2c has a negative significant low level of correlation, which is related to the participants' disagreeing level. Both correlations can be related to the points of participants who have either a high level of life satisfaction or not. Besides, no correlation between vagueness and classical items shows that there is no indeterminacy about this item.

Table 4. Correlation among neutrosophic item 2 and classical item 2.

		VAR2a	VAR2b	VAR2c
VAR2	Correlation Coefficient	0.732**	0.120	-0.277**
	Sig. (2-tailed)	0.000	0.099	0.000
	N	189	189	189

Neural network analysis of the items reveals that participants with positive life satisfaction for item 2a contribute 100% to classical variable 2 and participants with negative life satisfaction for item 2c contribute 26.6% to classical variable 2. This might be related to the differentiation of the number of participants having high-level life satisfaction and a low level of life satisfaction. However, it should be noted that the vagueness of this item is 31.7% implies that there is a weak level of confusion about this article either because of meaning or the usage of the words or some unknown parameters, although there is no correlation between var1b and classical variable.

Table 5. Independent variable importance for classical item 2 in terms of neutrosophic items.

Independent Variable Importance		
	Importance	Normalized Importance
VAR2a	0.632	100,0%
VAR2b	0.200	31,7%
VAR2c	0.168	26,6%

According to Spearman's rho correlation coefficient classical variable 3 has a moderate positive significant correlation with var3a which is related to the agreeing level of the participants and it has a negative significant moderate level of correlation which is related to the disagreeing level of the participants. Both correlations can be related to the points of participants who have either a high level of life satisfaction or not. However, the weak level of significant correlation between vagueness and classical item shows that there is an indeterminacy about this item.

Table 6. Correlation among neutrosophic item 3 and classical item 3.

		VAR3a	VAR3b	VAR3c
VAR3	Correlation Coefficient	0.474**	-0.178*	-0.430**
	Sig. (2-tailed)	0.000	0.014	0.000
	N	189	189	189

According to the results of the neural network analysis for the items, participants with positive life satisfaction for item 3a have a 100% contribution to classical variable 3, while participants with negative life satisfaction for item 3c have a 38, 0% contribution to classical variable 3. This might be related to the differentiation of the number of participants having high-level life satisfaction and a low level of life satisfaction. However, it should be noted that the vagueness of this item 3c, which is 21,7%, implies that there is a weak level of confusion about this article either because of meaning or the usage of the words or some unknown parameters. It should be noted that there is also a weak level significant correlation between item 3b and item 3.

Table 7. Independent variable importance for classical item 3 in terms of neutrosophic items.

Independent Variable Importance		
	Importance	Normalized Importance
VAR3a	0.626	100,0%
VAR3b	0.136	21,7%
VAR3c	0.238	38,0%

According to Spearman's rho correlation coefficient classical variable 4 has a high-level significant correlation with var4a which is related to agreeing on the level of the participants and it has a negative moderate level significant correlation which is related to the disagreeing level of the participants. Both correlations can be related to the points of participants who have either a high level of life satisfaction or not. Besides, no correlation between vagueness and classical items shows that there is no indeterminacy about this item (*Table 8*).

Table 8. Correlation among neutrosophic item 4 and classical item 4.

		VAR4a	VAR4b	VAR4c
VAR4	Correlation Coefficient	0.715**	-0.115	-0.475**
	Sig. (2-tailed)	0.000	0.115	0.000
	N	189	189	189

Neural network analysis of the items reveals that participants with positive life satisfaction for item 4a contribute 95.8% to classical variable 4 and participants with negative life satisfaction for item 4c contribute 100.0% to classical variable 4. This might be related to the differentiation of the number of participants having high-level life satisfaction and a low level of life satisfaction. However, it should be noted that the vagueness of this item 4c is 27,0%, implies that there is a weak level of confusion about this article either because of meaning or the usage of the words or some unknown parameters, although there is no correlation between variable 4b and classical variable (*Table 9*).

Table 9. Independent variable importance for classical item 4 in terms of neutrosophic items.

Independent Variable Importance		
	Importance	**Normalized Importance**
VAR4a	0.430	95,8%
VAR4b	0.121	27,0%
VAR4c	0.449	100,0%

According to Spearman's rho correlation coefficient classical variable 5 has a high level of positive significant correlation with var5a which is related to the agreeing level of the participants and it has a weak level of negative significant correlation which is related to the disagreeing level of the participants. Both correlations can be related to the points of participants who have either a high level of life satisfaction or not. Besides, there is a weak level significant correlation between variable 5 and variable 5b. Therefore, the weak level significant correlation between vagueness and classical item shows that there is an indeterminacy about this item (*Table 10*).

Table 10. Correlation among neutrosophic item 5 and classical item 5.

		VAR5a	**VAR5b**	**VAR5c**
VAR5	Correlation Coefficient	0.706**	0.149*	-0.347**
	Sig. (2-tailed)	0.000	0.040	0.000
	N	189	189	189

The results of the neural network analysis for the items show that participants with positive life satisfaction for item 5a have a 100% contribution to the classical variable 4 and participants with negative life satisfaction for item 5c have an 84.2% contribution to the classical variable 4. This might be related to the differentiation of the number of participants having high-level life satisfaction and a low level of life satisfaction. However, it should be noted that the vagueness of this item 4c is 39,6%, implies that there is a weak level of confusion about this article either because of the meaning of the usage of the words or some unknown parameters (*Table 11*).

Table 11. Correlation among neutrosophic item 5 and classical item 5.

Independent Variable Importance		
	Importance	**Normalized Importance**
VAR5a	0.447	100,0%
VAR5b	0.177	39,6%
VAR5c	0.376	84,2%

4.3| Analysis of Neutrosophic Life Satisfaction Scale in terms of whole Structure for Confirmatory Factor Analysis

Neural network analysis results for two scales can be given as follows. It seems that variable 2 and variable 5 might be problematic when considering the overall contribution of the items for the whole scale since variable …b items are related to the vagueness of the participants. (*Table 12*).

Table 12. Independent variable importance for the whole scales.

Independent Variable Importance		
	Importance	Normalized Importance
VAR5c	0.162	100.00%
VAR2a	0.133	82.30%
VAR5a	0.121	74.70%
VAR3a	0.1	61.50%
VAR1c	0.096	59.30%
VAR2b	0.09	55.70%
VAR5b	0.083	51.10%
VAR4a	0.075	46.60%
VAR3c	0.035	21.50%
VAR1a	0.032	20.00%
VAR2c	0.022	13.30%
VAR4b	0.018	11.20%
VAR4c	0.015	9.00%
VAR1b	0.013	7.80%
VAR3b	0.005	2.90%

5 | Discussion and Conclusion

Content validity refers to how appropriate and representative the measurements collected are for the desired assessment purpose. Content validity refers to how appropriate and representative the measurements obtained are for the desired assessment purpose. The representativeness criterion may have two definitions. Quantifying the extent of sampling is one of them. The second is the extent to which items reflect the structures of the whole scale [15]. In this regard, the most obviating factor in determining whether an item should be removed or not is to use the participants' vagueness choices for each item. In this respect, we have two kinds of variables to formalize our decision-making as correlation constant and importance level. If the decision function is labelled as d where r stands for correlation constant and I stands for importance level, the function for decision making can be written as like this:

$$D=R*I. \tag{1}$$

The interpretation of this formula can be given in *Table 1*. It should be noted that the correlation constant is the absolute value of r as $|R|$.

Table 13. The interpretation of the formula D=R*I.

The Interpretation of The Correlation Coefficient (r)	The Interpretation of The Importance Level	Decision Criteria for Accepting or Rejecting The Item where 0<cc<1 Decision=[correlation coefficient for vagueness (r)]*[Importance level for vagueness]
Very weak correlation or no correlation if r <0.2	Very weak importance level if <20%	if 0≤cc≤20, item acceptable
Weak correlation between 0.2-0.4	Weak importance level 20%-40%	if 20<cc≤40, item acceptable
A moderate correlation between 0.4-0.6	Moderate importance level 40%-60%	if 40<cc≤60, the item should be modified or removed
The high correlation between 0.6-0.8	High importance level 60%-80%	if 60<cc≤80, the item should be modified or removed
If r>0.8, it is interpreted that there is a very high correlation	If 80%>, it is interpreted that there is a very high importance level	if 80<cc≤100, the item should be removed

The formula 5.1 can be applied for the findings of the items of the neutrosophic Life Satisfaction Scale for confirmatory analysis. Let's look at our findings based on item levels with the *Eq. (1)* as given in *Table 14*. The results show that this scale is valid because all the items are at an acceptable level.

Table 14. Application of the Eq. (1) for each item.

	Importance Level (i)	Correlation Constant (r)	Decision Result (d=i*r)	
Var1	57.5	0.22	12.65	Acceptable
Var2	31.7	0.12	3.804	Acceptable
Var3	21.7	0.178	3.8626	Acceptable
Var4	27	0.115	3.105	Acceptable
Var5	39	0.149	5.811	Acceptable

In *Table 11*, independent variable importance for the whole scale shows that variable 2 and variable 5 might be problematic when considering the overall contribution of the items for the whole scale since variable …b items are related to the vagueness of the participants. However, formula 4.1 shows that although the importance level is high, it is not significant, so that all the items on the scale are valid. Finally, one might ask that if the item related to vagueness is only focused on, why do we need the other two items regarding agreement and disagreement ? Although on this scale such a conflict is not seen, this data can be used to evaluate the validity and reliability of the scale. For instance, if both agreement and disagreement items have a similar sign to the target item, it can be concluded that this item is also problematic because it reflects both agreement and disagreement at the same time, implying that there is confusion about it for determining the aimed question. Let label that the correlation of agreement item is α and the correlation of disagreement item is β since these items are opposite to each other their correlation should naturally be opposite to each other so that $\alpha*\beta=-1$. If $\alpha*\beta=+1$ it can be concluded that there is a contradiction in this item. If the *Eq. (1)* is modified for these values where i_1 is the importance level of the first item and i_2 is the importance level of the second item as follows:

$$i_1 *\alpha* i_2* \beta)/100= d. \quad (2)$$

Because we don't want to deal with huge numbers in all the importance levels 100 and correlations 1 or-1, the multiplication is divided by 100 simply by scaling the value into a more simple form.Let apply the rule of our correlation constants in the finding section for each item in *Table 3*. An opposite sign indicates that our data is consistent. Otherwise, the effect of the correlations can be examined and evaluated to be whether the item should be removed or not just as in the classification given in *Table 13*.

Table 15. Decision matrix evaluating the consistency of the items in terms of agreement and disagreement items of the neutrosophic scale.

	i_1	A	i_2	β	$i_1 *\alpha* i_2* \beta$	Decision
Variable 1	100	0.678	26.4	-0.417	-7.4639664	Acceptable
Variable 2	100	0.732	26.6	-0.277	-5.3935224	Acceptable
Variable 3	100	0.474	38	-0.430	-7.74516	Acceptable
Variable 4	95.8	0.715	100	-0.475	-32.536075	Acceptable
Variable 5	100	0.706	84.2	-0.347	-20.6274844	Acceptable

5.1| Future Directions

A neutrosophic scale can be used to confirm the reliability of the classical one because the neutrosophic scale is just an extended form of the classical one. The results show that our neutrosophic scale is also reliable, which also supports the reliability of the classical scale because Cronbach's Alpha constant is an acceptable level for three dimensions. In this respect, it can be understood the Agreement dimension of reliability because the classical scale can be extended into the neutrosophic one and assess the closeness of

two measurements made on the same subject as opposed to one another. The repeatability of the scale can be also assessed because the same variable can be measured again and again for the same circumstances [9]. The reproducibility of the scale can be also tested because the variations in test results can also be tested while tests are performed on subjects on different occasions.

Validity simply means "measure what is intended to be measured" [13]. To decide whether a scale is valid or not, its validity can be compared by comparing similar scales or decisions based on expert opinion can be made. In this study, it is offered an alternative method for developing a valid scale where first the scale is converted into a neutrosophic one and then they are compared through neural networks. It can be inferred that any scale to assess how appropriate and representative the measurements collected are for the desired assessment purpose so that its content validity can be evaluated. It can bee can understood how well a concept, idea, or behavior is translated or transformed that is a construct into a functioning and operating reality, the operationalization [14] on any scale so that its construct validity can be understood. This method can also be used for criterion validity because how well one measure predicts another measure can also be calculated.

This research is limited by Three-Valued Logic but it can be extended higher n-valued logics as well. It is limited by classical statistics such as correlation or neural networks but neutrosophic statistics can be also used or the whole data. It is limited by investigating the validity in terms of neutrosophy but this research can be extended into more broader concepts in education. Additionally, more sophisticated formulas can be also developed for subsequent analysis.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

Authorship Contributions

The authors declare that they contribute equally to the study.

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