Faculty of Computers and information
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Learning Management Systems Evaluation

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the PhD Degree in Information Systems

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But those who had been given knowledge said, "Woe to you! The reward of Allah is better for he who believes and does righteousness. And none are granted it except the patient."

Surah Al-Qasas [80]

Dedication

This dissertation is dedicated to:

Allah my creator, my strong pillar and my source of understanding.

The loving memory of my grandmother.

My beloved Parents who never stop giving of themselves in countless ways.

My dearest husband, Hussein who leads me through the valley of darkness with light of hope and support.

My beloved brother who stands by me when things look bleak.

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Declaration

I declare that this dissertation was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

Nouran Mohamed Radwan Hussein

Abstract

Evaluation process studies concern gathering information that assist in decision making about a specific situation concerning measurement, selection, and assessment process. In measurement process, the preferences that influence the situation to establish standard rules are determined. The selection process concerns the selection of the most proper option by collecting decision makers' knowledge. Finally, Assessment process gathers implicit and explicit information to ensure that defined objective has been attained.

Learning management systems (LMSs) are software tools used to assist in the designing, delivery, and management of learning materials for learners. Therefore, LMSs evaluation process becomes important requirement in educational institution. LMSs evaluation previous studies are implemented under complete information, while many uncertainty aspects do exist in the real world. As LMSs systems were described by decision makers and experts with vague, imprecise, ambiguous, and inconsistent terms, it is comprehensible that traditional methods may not be effective.

In this dissertation, LMSs evaluation model is presented which concerns three challenges: exploring the factors affects the success of LMS, seeking to determine the most suitable alternative that meets institution's requirements, and assessing the LMS quality.

Due to the first challenge, as success is not measurable with a single factor such as intention of use or user satisfaction, several researches have been identified different factors for the success of information systems and eLearning systems. In this side of study, an investigation of the LMSs success critical factors from different perspectives and development of a comprehensive model for measuring success of LMSs based on previous researches and experts in the context of eLearning practices in higher education based on neutrosophic sets are presented based on neutrosophic

logic as a better option to simulate human thinking to address indeterminacy of information. The findings show that learner characteristics, information quality and service quality factors have the most important concern on LMSs success studies.

Due to the second challenge, this part of study develops a novel hybrid neutrosophic analytic hierarchy process method to support handling uncertainty in the decision-making process to address indeterminacy of information. To show the applying of the developed method, a numerical example of an LMS selection is made using the method of neutrosophic analytic hierarchy process. In results, it is shown that the neutrosophic logic can represent uncertainty manner by human thinking. Obtained results have shown that Moodle is the most suitable LMS that meets defined criteria.

Due to the third challenge, this portion of dissertation presents neutrosophic expert system for learning management systems quality assessment. As neutrosophic logic is an approach to simulate human reasoning as it can handle indeterminacy of information which indicates the percentage of anonymous parameters. Building and validating information of the neutrosophic expert system are collected from eight experts using semi-structured questionnaire, and then analysis is done. Finally, the comparison between fuzzy expert system and neutrosophic expert system results show that the neutrosophic logic is capable of representing uncertainty in human thinking for evaluating LMSs.

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List of Abbreviations

AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
CR	Consistency Ratio
LMS	Learning Management System
MCDM	Multi-Criteria Decision Making
NAHP	Neutrosophic Analytical Hierarchy Process
TAM	Technology Acceptance Model

Chapter 1
Introduction

Chapter 1: Introduction

1.1 Motivations

Most of the Learning Management Systems (LMSs) are web based applications that are being used to in designing, sharing, delivering, and managing learning materials. There has been a rapid raise in applying LMSs in higher education as many universities recognize the importance of LMSs to raise motivation of learners. Therefore, LMSs evaluation process becomes significant requirement in higher education institution. The LMSs evaluation is a decision-making process including LMSs success achievement, LMSs selection procedure and LMSs assessment method.

1.2 Problem Statement

Many Universities recognize the necessity of using Learning Management Systems (LMSs) to increase motivation of learners and provide support during the learning process. Previous studies in LMSs evaluation are implemented under the condition of full information availability, while many uncertainty aspects do exist in the real world. As LMSs are described by decision makers and experts with vague, imprecise, ambiguous, and inconsistent terms; therefore the traditional methods may not be effective. LMSs evaluation process seeks to identify the critical factors that affect LMSs success measurement, select the most suitable LMS option due to organization requirements, and assess LMSs system quality.

LMSs evaluation process includes LMSs success measurement, LMSs selection and LMSs quality assessment. Evaluation process collects information and knowledge that help in making a decision about a given situation regarding the appropriateness of something. Measurement process includes determining attributes or preferences that affect the objective to some establish rule. Selection process includes choosing the most suitable option by collecting available information. Assessment process collects implicit or explicit information relative to well-known goal.

1.3 Objectives

The Dissertation concerns LMSs evaluation process to help educational institutions to achieve the success of LMSs, select the most suitable LMSs according to requirements and assess LMSs quality. These can be expressed in the following lines:

- Exploring critical factors that affect the success of LMSs implementation.
- Developing a comprehensive model for LMSs success measurement.
- Developing and applying an intelligent decision making method for LMSs selection.
- Identifying the most important system quality dimensions which is valuable to learners.
- Developing an expert system for assessing LMSs Quality.

1.4 Dissertation Contribution

LMS evaluation process becomes a significant task in educational organizations due to the raising number of LMSs software usage. LMSs evaluation task in previous studies is performed under condition of the availability of full information. Real environment is characterized by vague, imprecise, ambiguity and inconsistency data and information. The dissertation concerns LMSs evaluation process under uncertainty which includes three procedures: presenting LMSs success measurement model, developing LMSs selection method that meets organization's requirements, and building system for LMSs quality.

In this dissertation, LMSs evaluation is a process concerns three procedures:

First, the dissertation presents the critical factors that affect LMSs success and a survey for LMSs success models survey presented previously. The study presents an overall model for LMSs success measurement that shows the relationships among the constructs of the model.

Second, the study develops a novel multi-criteria decision making method for LMSs selection. One of the most multi-criteria decision making method is AHP which deals with quantitative and qualitative attributes using hierarchical structure. The major AHP deficiency is its weakness of representing human's uncertain thoughts, thus the study extends the AHP method via the neutrosophic set to express human's preferences. The presented method provides reliable results by expressing uncertain and checking inconsistency during the pairwise comparisons.

Third, the dissertation presents a neutrosophic expert system for LMSs quality assessment that takes in account uncertainty that is a feature of real environment. The neutrosophic logic is capable of expressing uncertainty in human thinking for assessing LMSs. The system simulation has been carried out by Fuzzytech 5.54 application by building three fuzzy inference systems representing the true, indeterminate, and false value. While the information needed for building and validating the system is collected by eight experts' semi-structured questionnaires.

1.5 Dissertation Outline

The dissertation is organized into seven chapters as follows:

Chapter 2 presents different multivalued logic models that handle uncertainty and gives a hint about dissertation challenges. Chapter 3 presents an illustration for the critical factors of LMSs success and introduces LMSs success measurement model. Chapter 4 presents a neutrosophic analytical hierarchy process method as a novel approach for decision making for LMSs selection. In Chapter 5, neutrosophic expert system for LMSs quality assessment is presented. Chapter 6 includes the dissertation discussion and results; Chapter 7 includes conclusion and future work.

Chapter 2 Background and Related Work

Chapter 2: Background and Related Work

2.1 Introduction

Learning Management Systems (LMSs) are software applications used to help in the designing, sharing, delivery, management, and assessment of learning resources to all learners [1]. A sudden increase of the LMSs usage in higher education is observed [2]. With the ever-growing number of LMSs, educational institutions try seriously to determine which LMS able to achieve success for their case [3]. There is a need to assist educational universities with comprehensive model for LMSs evaluation [4]. LMSs evaluation process seeks to identify the critical factors that affect LMSs success, determine the most appropriate LMS software from a set of options due to organization requirements, and assess LMSs system quality [5].

Previous studies have used information system success models in the learning field, but many researchers express their need to propose an IS success model for e- learning purposes and especially for LMS. In [6] system quality, service quality, information quality, learner perspective, instructor attitudes, and supportive issues had a considerable effect on the learner's perceived satisfaction. Results of [7] reveals six factors including user characteristics, extrinsic motivation, service quality, system quality, and information quality that influence the acceptance of eLearning systems in developing countries. Perceived ease of use, user satisfaction, learner characteristics, instructor, LMS characteristics and organization characteristics have influence on LMSs success [8]. System quality is very important factor in relation to the service quality, information quality and learning community [9] [10]. The success of LMSs in higher education institutions initiated by instructors; however, the use of LMSs is sustained by learners. Therefore, the need for exploring the critical factors and developing a comprehensive model that measure the success of LMS from different perspectives is emerged [9].

There is much software of LMSs available in marketplace; this makes educational institutions attempt industriously to determine which LMS is the most appropriate for their needs [3]. The most suitable LMS selection that meets the organization needs is a decision making problem [11]. One of the approaches of decision making is multi-criteria decision making methods which help in taking decisions including many criteria contains functional and non-functional requirements [5]. Decision process could correspond to choose the most alternative or ranking a set of good alternatives by analyzing different criteria [12]. Previous studies in LMSs selection are implemented using traditional multi criteria decision making methods that may not be effective as these systems were described by decision makers with uncertainty terms [13].

There has been a sudden increase in the usage of LMSs applications to support learner's learning process in higher education. Many studies in LMS assessment are implemented under the assumption of full information availability, while the real world has uncertainty sides [14]. Previous evaluation models for eLearning quality attributes developed under full information availability condition. Imprecise knowledge, incomplete information and uncertain data are characteristics of real environment; this leads researchers to turns into other approaches that handle uncertainty like fuzzy logic [15, 16] and to suggest neutrosophic logic that handle uncertainty for eLearning quality evaluation [17]. Expert system simulates human expert thinking to solve problem and take decision domain which is mainly composed of the user interface, knowledge base, and inference engine [18]. Expert system aims to represent the problem of uncertainty in knowledge to draw conclusion with the same level of accuracy as would a human expert do [19]. Designing an expert system depends on personnel interaction; expert who has knowledge and solves the problems, knowledge engineer who encodes the expert’s knowledge in inference engine and knowledge base; user who uses the system to get advice and information needed [18, 20].

2.2 Learning Management Systems

Learning Management Systems (LMSs) are web based applications used today in eLearning that supports teaching and learning activities associated with them [2]. LMSs are gaining interest as a management and communication tools for instructors, learners and trainers. LMSs are information systems that assist in designing, sharing, delivering, managing and evaluating of educational resources to all learners [1]. LMSs provide universities with a set of tools such as discussion forums, chats, automated testing, assessing tools and student tracking. The LMSs provide instructors and learners with a user-friendly, and a comprehensive interactive interface for managing course catalogues, recording data and providing reports [21].

Management information systems are computer based systems that provide managers with tools help in managing departments and taking better decisions. This includes transaction processing system, decision support system, expert system, or executive information system. LMS are information systems that support management and communication associated with learning process [22, 23]. Management information systems development needs to visualize the complete functionality of the system. As LMS software is suitable and successful in one education institution, it does not mean that will be successful for other institutions [24]. There could be more studies needed in different aspects like extra modules for indicating the best content of similar subjects, transmission any information from the participating universities, and checking the quality of the content [2].

2.3 Evaluation Methods for Learning Management Systems

Software evaluation is a process that seeks to determine if software is the most suitable from a set of alternatives due to institution functional and non-functional requirements. A prepared list of software criteria is helpful to determine if the software would be suitable to the user or not. Evaluation process includes decision making process that is needed to select the most convenient LMS option from available possibilities due to organization needs and requirements [5]. Taking a decision could correspond to select the fit alternative from a set of alternatives or to choose a small group of most suitable alternatives by analyzing different criteria [12].

Evaluation process concerns collecting information that help in decision making about a given state regarding measurement, selection, and assessment process. Measurement process determines attributes or preferences that affect the state to some establish rules or standard. Selection process includes choosing the most suitable option by obtaining knowledge from decision makers. Assessment process collects implicit or explicit information to ensure that determined goal has been achieved [5,12,25,26].

Evaluation includes measurement process which helps in separating normal from unusual situations and determining set goals. A measure is a mapping from a set of attributes in the real world to a representation in the mathematical world [25]. Software measurement is a field of software engineering; it provides support for planning, controlling, and improving the software development process [26]. Software evaluation methods include formal experiment, case study, survey or feature analysis as following [25]:

- Formal Experiments: In a formal experiment, changes are observed to determine the effect of inputs on the output and the relationship between them. Methods are used to eliminate confusing factors so that output can be evaluated with confidence. It is important to ensure that the output is the result of inputs changes so the process is replicated several times instead of just once to be more certain that the output resulted from the changes of inputs rather than by chance. The instances observed in formal experiment should be representative as possible.
- Case Studies: In a case study, factors that affect the process outcome are determined and then document. Case study steps includes: conception, hypothesis, design, preparation, execution, analysis, dissemination, and decision making. Hypothesis guides what to be measured and how the results be analyzed. The case study must be chosen carefully to represent what is exemplary in organizations. A case study mostly compares the results of using method or tool a situation with the results of another.

- Surveys: A survey records relationships and outcomes in a given situation. Surveys are overwhelmingly used in the social sciences to define how a population perceives a particular set of matters. The surveys help to discover trends and relationships. For example, surveys are used in software engineering to determine how users reacted to a particular tool. When performing a survey, there is no control over the situation. As information about a situation is recorded and compared with similar ones, but variables cannot be handled; for that, case studies and formal experiments are needed.
- Feature Analysis: A type of assessment used to rank the attributes of various alternatives so we can tell which alternative is the best suitable to buy or use. It is useful for narrowing down which alternatives to select according qualitative and quantitative requirements. Feature analysis does not evaluate behavior in terms of inputs and output.

TOPSIS is proposed as a feature analysis method for selection and evaluation of LMSs [27]. Criteria are identified and weighted by experts where the score weight of the criteria is given 1 to 9. The findings show that the model can be flexibly applied and changed. The author recommends in future studies the using of fuzzy set theory to support the uncertainty in the decision making process. A survey paper that reviews and compares the multi criteria decision making methods is presented [12]. Then the paper suggests approaches to identify most suitable LMS which can be obtained by analyzing the different scope for the criteria, weights for the criteria. The paper adds the fuzzy dimension which is one of uncertainty models to the multi criteria decision making. Fuzzy multi criteria decision making can solve the problem by analyzing quantitative and qualitative data of different applications and perform better than traditional methods.

Other studies focused on the critical factors that affect success of LMSs. LMSs characteristics which are system quality, service quality and information quality play an important role in evaluating LMSs. Fuzzy TOPSIS as feature analysis method which handles uncertainty was presented to evaluate LMSs, where all factors have been ranked using a pair-wise survey. Then a survey is performed to get the real level of factors [7][9]. Valdez-Silva et al. in 2012 [28], attend to the importance of quality in selecting learning management systems as there are many LMSs available. The study presented expert system based on a traceability model which takes into consideration users' perceptions and system criteria. The study considers quality standards from software engineering perspectives and quality aspects of the LMSs.

2.4 Multivalued Logic Models for handling Uncertainty

Handling uncertainty for solving true life problems is one of the most significant problems of artificial intelligence [29]. Uncertainty is deficiency of accurate knowledge, perfect information, and certain data, all of which describe the state of the environment regardless of what is the cause of this shortage [30]. Varying approaches have been proposed to handle uncertainty found in real life problems by emulating the process of human thinking [31]. Bayes theory, Dempster-Shafer theory, and certainty factor have been used in former studies for dealing with uncertainty, but these models cannot express grey areas where it is not false or true. This leads to emerging new approaches to support decision making process by increasing the understanding of the cognitive outcome such as fuzzy, type2 fuzzy, intuitionistic fuzzy, vague and neutrosophic logics [32, 33]. Lotfi Zadeh presented fuzzy set which reflects the grade of the membership of objects in a set [34]. Zadeh also introduced type2 fuzzy set in which membership grades themselves are fuzzy [35]. Intuitionistic fuzzy set theory presented by Attanssov as an extension of fuzzy set to present true and false membership [36]. Florentin Smarandache proposed neutrosophic set which is able to handle the percentage of unknown parameters [37]. In this section, an exploration of multivalued logic models definitions, basic properties and differences for handling uncertainty.

2.4.1 Uncertainty Types

The notion of uncertainty is addressing with uncertain data and incomplete information. The four main uncertainties types that can arise includes *vagueness* when available information is normally graded, *imprecision* when the obtainable information is not defined, *ambiguity* when information causes various possible interpretations, and *inconsistency* when available information is contradicted and cannot be true at the same time [38,39]. An example of vague information:

"the boy is nearly tall", fuzzy set can address this type of uncertainty. Imprecise example could be as following: "the machine temperature is between 87-93°C", this type can be handled by intuitionistic fuzzy set. The ambiguity information example can be as follows: "The flower color may be yellow or red" and a case of inconsistence: "the chance of raining tomorrow is 70%, it does not mean that the chance of not raining is 30%, since there might be unknown factors that is not informed about", this can be addressed by neutrosophic set [37].

2.4.2 Fuzzy Set

Crisp set concerns objects belong to or exclude from a set. Fuzzy set considers that the object has a degree of membership in the set related value between 0 and 1 as shown in Figure 2.1. Each element $x \in U$ (Universe of discourse) has a membership degree in fuzzy set. A fuzzy set $A = \{< x, \mu A(x) > | x \in U\}$ while a membership function describes a universe of discourse U, μA, as follows [34]: $\mu A: U \rightarrow [0, 1]$.

Fuzzy inference system is the controller of converting a stated input to an output which consists of input fuzzification unit, knowledge based system, and output defuzzification unit as shown in Figure 2.2 [20]. The fuzzy knowledge base includes the fuzzy membership functions and rules that are used to convert the crisp input to a fuzzy output in fuzzification process. There are different methods that are used to get the crisp output from a fuzzy output in defuzzification process [14].

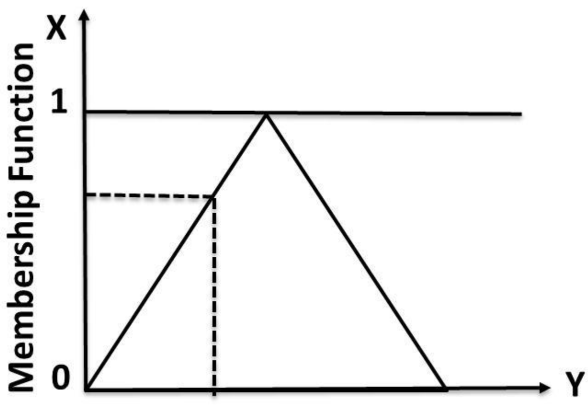


Figure 2.1 Fuzzy Set [30]

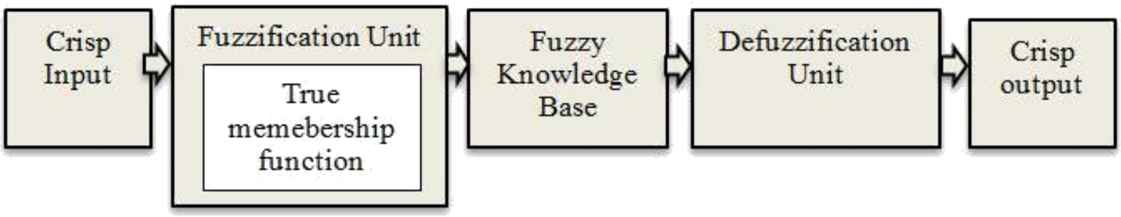


Figure 2.2 Fuzzy Inference System Diagram

2.4.3 Type 2 Fuzzy Set

Type-2 fuzzy set is useful when it is difficult to determine the exact membership function for a fuzzy set. This set can be used in problem state when there is uncertainty about the membership degree themselves [35]. A Type-2 fuzzy set U as shown in Figure 2.3 is characterized by a membership function which itself is fuzzy as follows [40, 41]: $\mu A: U(x, u) \rightarrow [0, 1]$, where $0 \leq U(x, u) \leq 1$.

Type2 fuzzy inference system is presented in processes as fuzzification of input, inference engine, reduction and defuzzification as shown in Figure 2.4. The membership functions and rules in knowledge base is used to convert the crisp input is converted to a fuzzy output in fuzzification process. Type-reducer is used to reduce type-2 fuzzy set to type-1 fuzzy set. In defuzzification, as well as fuzzy set, the fuzzy output is transformed to a crisp output.

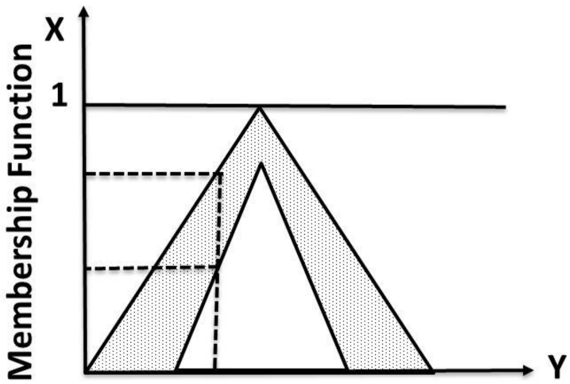


Figure 2.3 Type 2 Fuzzy Set [40]

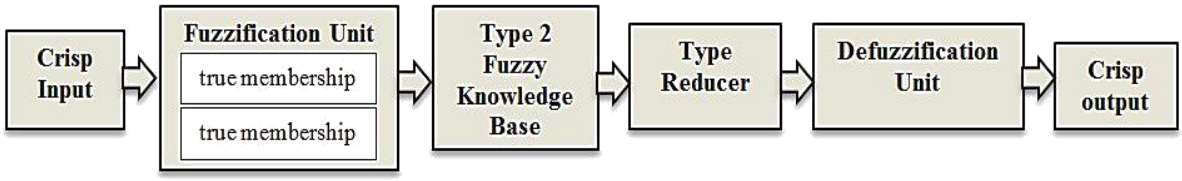


Figure 2.4 Type 2 Fuzzy Inference System Diagram

2.4.4 Intuitionistic Fuzzy Set

Attanassov recommended a second degree for fuzzy set concept which is a non-membership as he presented the notion of intuitionistic fuzzy set [42]. An intuitionistic fuzzy set describes the relationship of an element to a set, so that the sum of these degrees is always less or equal to 1 as shown in Figure 2.5. An intuitionistic fuzzy set A = {<u, μA(u), vA(u) > |u ∈ U} in a universe of discourse U is characterized by a membership function μA, and a non-membership function vA, as follows [43]: μA: U → [0, 1], vA : U → [0,1],and 0 ≤ μA(u) + vA(u) ≤ 1.

In fuzzy set, the membership of an element to a fuzzy set is a single value between [0,1]. In reality, there may be some hesitation degree so it is not always being true that the degree of non-membership of an element in a fuzzy set is equal to 1 minus the membership degree. Intuitionistic fuzzy set is appropriate in emulating imprecise human understanding [44]. Intuitionistic fuzzy inference system is shown in Figure 2.6. The true and the false memberships of the intuitionistic fuzzy sets and rules are included in fuzzy knowledge base.

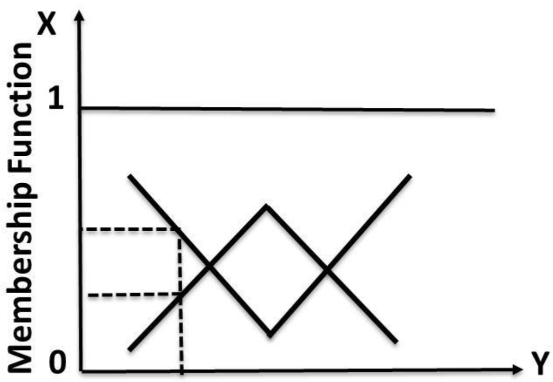


Figure 2.5 Intuitionistic Fuzzy Set [43]

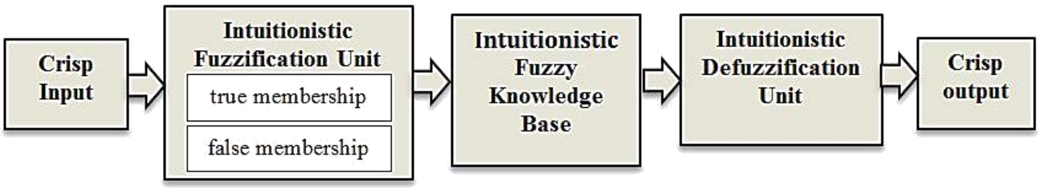


Figure 2.6 Intuitionistic Fuzzy Inference System Diagram

2.4.5 Neutrosophic Logic

Neutrosophy means knowledge of neutral thought. The first part “neutro” comes from "neuter" which means neutral and the second part “sophy” comes from "Sophia" which means wisdom. Neutrosophic logic is an extent of fuzzy and intuitionistic fuzzy logic which is proposed by Smarandache [45]. As it is a better option to emulate human reasoning than fuzzy logic. Neutrosophic logic is able to address information indeterminacy which represents the unknown parameters percentage while fuzzy logic is not able to [46]. The variable x in neutrosophic logic is described by triple values which are the level of truth, the level of false and indeterminacy level as shown in Figure 2.7 [47].

Expert systems, decision support systems and belief systems which are dedicated to emulate human reasoning are constrained with strict conditions, whereas, current systems tend to rely not only on truth membership degree , but also on indeterminacy and falsity. Neutrosophic logic can handle inconsistencies which are true and false as the same time, so it holds the chance to simulate human reasoning for real world executions [44]. For example; a vote with two symbols which are: A and B is occurred, in which some votes are not determined if it A or B. These are indeterminate votes that can be represented with neutrosophic logic while other models cannot [45].

Neutrosophic inference system contains three components which are neutrosophication unit which receives the crisp data and allocates the appropriate membership, knowledge base which extracts output variable from input one, and deneutrosophication unit that transforms neutrosophic membership to crisp variable as shown in Figure 2.8 [46]. Neutrosophic knowledge base includes the neutrosophic sets (true, indeterminacy, false) memberships and neutrosophic rule base. The crisp input is received by neutrosophication unit to allocate the appropriate truth, indeterminacy, and false membership. By using the neutrosophic rule base, the input variables are mapped to output. The output is mapped to crisp value in deneutrosophication step [47].

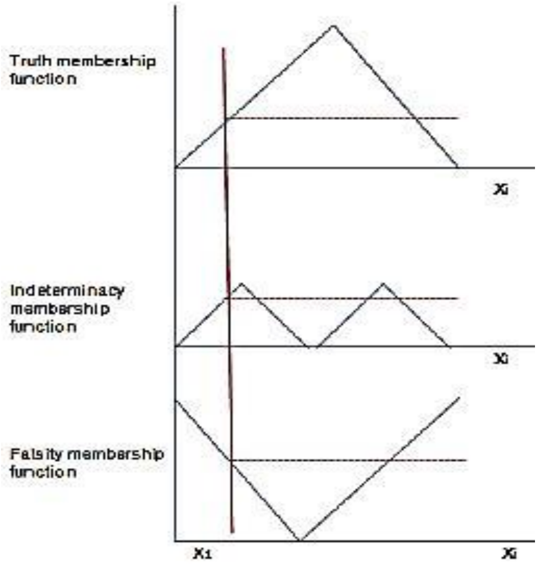


Figure 2.7 Neutrosophic Set [47]

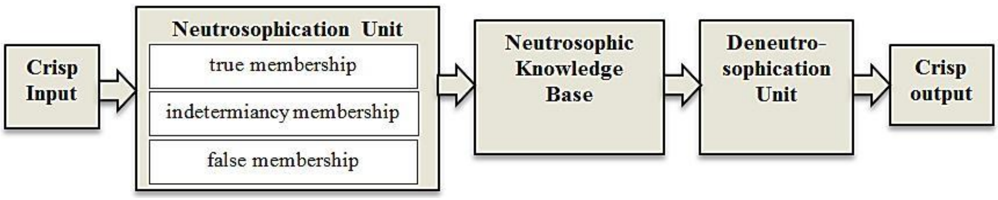


Figure 2.8 Neutrosophic Inference System Diagram

2.5 Uncertainty and Multivalued Logic Models

Fuzzy set expresses only membership grade and not the non-membership grade, so it has no answer when experts or decision makers have a confusion to determine membership. Vagueness is described by fuzzy set, but not imprecision, ambiguity, and inconsistent. Type 2 fuzzy set, as well as, Intuitionistic fuzzy set represents vagueness and imprecision. Type 2 fuzzy set expresses uncertainty by a range of membership values. Intuitionistic fuzzy set represents hesitation degree as in uncertainty as the grade of non-membership of an object is equals to 1 minus the membership grade is not right in all situations. Neutrosophic set can handle vague, imprecise, ambiguous, and inconsistent information which exists in real world as neutrosophic idea is based on indeterminacy. For example, when an expert is asked about his thought in particular statement, then he may express his view that the statement is true, false and indeterminacy is 0.7, 0.4 and 0.5 respectively. This case is able to be suitably addressed by neutrosophic logic [13,14]. Table 2.1 presents multivalued logic models and their capability to convey different uncertainty data types.

Table 2.1 Multivalued Logic Models and Uncertainty Data Types

Uncertainty Data Types	**Multivalued Models Handling Uncertainty Data Types**			
	Fuzzy	**Type 2 Fuzzy**	**Intuitionistic Fuzzy**	**Neutrosophic**
Vagueness	✓	✓	✓	✓
Imprecision	___	✓	✓	✓
Ambiguity	___	___	___	✓
Inconsistency	___	___	___	✓

2.6 Learning Management Systems Evaluation

In this dissertation, LMSs evaluation is a process concerns three challenges: exploring and measuring the factors affects the success of LMS, seeking to determine the most suitable alternative that meets institution’s functional requirements and non-functional requirements, and assessing the system quality of LMS.

2.6.1 Learning Management Systems Success

Learning Management Systems (LMSs) are software applications used to administer the eLearning process, and support students and instructors to design, share and deliver learning materials [48]. Many universities are conscious about using LMSs as a useful tool to help in disseminating educational materials, quizzes and assignments [24,49,50]. Universities try seriously to implement LMSs and determine what factors affect the LMSs success. LMSs success is the ability of the system to provide users with their requirements to perform the needed educational activities [50]. Previous studies [6-10] used the DeLone and McLean's information systems success model in the learning field and other previous studies investigated the information systems success in education from the learner's perspective without providing an examination of all major issues related to LMSs success. Other researches show that system quality, information quality, service quality has the most effect on learners' understanding and LMSs success.

Former studies reveal factors affecting LMSs success such as system quality, service quality, information quality, learner perspective, instructor attitudes, and supportive issues had a considerable effect on the LMSs success [6,7]. Ease of use has a considerable effect on LMSs success [8]. The system quality has a significant impact in relation to the information quality and service quality. The success of LMSs is affected by instructors' and learners' characteristics [9, 10].

As success is not measurable with a single factor such as intention of use or user satisfaction, several researches have been identified different factors for the success of information systems and eLearning systems [51]. A comprehensive model is needed for measuring the LMSs success as many researchers express their need to propose an information system success model especially for LMS. Also, the necessity of studying other factors for measuring the success of LMSs from different perspectives such as learner, instructor and organization needed to be discussed [6-10]. The challenge concerns critical factors affecting LMSs success from different perspectives and presenting LMSs success measurement model.

2.6.2 Learning Management Systems Selection

The use of Learning Management Systems (LMSs) applications has increased in higher education to manage the eLearning process, and assist instructors and learners [48]. In the marketplace, there are many available LMS products. What type of LMS is most appropriate for educational institutions requirements is an important question to answer [3]. Evaluating the effectiveness of LMSs is a need for educational institutions [4, 11]. The LMS selection is a problem of multi-criteria decision making (MCDM). The traditional crisp MCDM methods are not enough to solve these problems as they cannot address the uncertainty present in real life cases, when vague, imprecise, ambiguous and inconsistent information are usually used by decision makers and experts [52]. Thus, it is more reasonable to find a better method to collect the opinions of the decision makers [53].

A decision-making process is needed to select the most appropriate LMS software from a group of options, due to organizational requirements. Taking a decision requires one to select the fit choice from a group of alternatives or a group of good alternatives; by testing the different criteria present [54]. The process of an LMS selection is costly, timely and exhausting [55]. Eliciting of judgments from decision makers is one of the key issues in decision making. When the problem elements are numerous, and the interrelationships among the elements are complicated, MCDM methods help in decision theory and analysis [56].

Analytical Hierarchy Process (AHP) is one of the most popular MCDM methods that divides the problem into a system of hierarchies of objectives, attributes and alternatives. AHP is a scalable method and although it requires enough data to properly perform pairwise comparisons. AHP is flexible and intuitive method that adjusts decision making problems due to its hierarchical structure, and checking inconsistencies which are not achieved in other multi criteria decision making such as ANP, TOPSIS, VIKOR, PROMETHE and ELECTRE. Analytic Network Process (ANP) is a more general form of AHP used in MCDM as it structures the problem as a network, but ANP is time consuming and hard to convince decision making. While AHP checks inconsistencies, handles tangible and non-tangible attributes and compares alternatives. The traditional AHP considers the definite judgments of decision makers, but in real world the decision makers' preferences are not certain. This study focuses on the AHP main disadvantage which is incapability of reflecting human’s thoughts uncertainty [12,54].

The purpose of this study is extending the AHP method via the neutrosophic set as a novel approach for LMSs selection according to the decision makers’ preferences. There are a large number of LMSs which have many functional and non-functional features [3]. How decision makers select the most suitable LMS to meet the preferences and priorities of the educational institutions [54].

2.6.3 Learning Management Systems Quality Assessment

LMS is an information system that supports teaching and learning activities management. Information systems development needs to visualize the complete information system with proper functionality. System quality is a wide concept which is associated with system performance and user interface as it defined as an assessment of an information system from technical and design perspectives [57,58]. User satisfaction and perceived usefulness are affected by important determinative which is system quality [10]. It can be clarified as the usability, availability, response time, stability, reliability and suitability of the system [58]. System quality of LMS is defined as the usability, accessibility, reliability of the system. Usability factor is an important factor that increases or decreases the LMS efficiency [59]. Usability, availability, reliability, completeness, system flexibility, response time and security are concerned in system quality [50]. In this study, the concern is on three system quality attributes which are usability, reliability, and accessibility.

Multi criteria decision making and fuzzy logic approach are proposed for LMSs software evaluation which requires complete information availability [60,61]. Multi criteria decision making cannot handle uncertainty, whereas, fuzzy logic presents a poor representation of uncertain data as it expresses the true membership degree in a value between 0 and 1. Fuzzy sets has not answer to represent experts' confusion for determining membership as it does not express the degree of false membership. This problem demands new approaches based on many valued logic models that deal~~s~~ with uncertainty [62].

The previous studies conducted for eLearning quality attributes are developed under the assumption of whole information obtainability. Imprecise knowledge, incomplete information and uncertain data are characteristics of real environment. This problem guides researchers to use approaches that handle vagueness like fuzzy logic [15,16]. Expert systems and decision support systems tend to rely not only on true membership, but also on false value membership. Current systems which are dedicated to emulate human reasoning are constrained with strict conditions and to be utilized for real life problems [47]. A novel idea for expert system is proposed to assess LMS system quality considering three main attributes: usability, accessibility and reliability.

The study presents a neutrosophic expert system to assess LMS system quality which uses neutrosophic logic to map the inputs into true, indeterminacy and false membership functions. Neutrosophic sets used to handle the uncertainty associated with human thinking. Neutrosophic The system inputs, knowledge base and outputs are obtained from domain experts to develop neutrosophic expert system for evaluating the LMS. The proposed expert system for LMSs quality evaluation using a neutrosophic logic approach based usability; reliability; and accessibility is presented. Neutrosophic expert system validation to ensure that the output of the expert system is nearly the same as experts when the same inputs are given is applied.

2.7 Summary

Learning Management Systems are applications used to support designing, sharing, delivery, and managing learning resources to all learners. LMSs evaluation process seeks to identify the critical factors that have impact on LMSs success, determine the most appropriate LMS software from a set of options due to institution requirements, and assess LMSs system quality. The increase of many LMSs software leads educational institutions to try earnestly to set which LMS is the most appropriate for their requirements. Previous studies in LMS evaluation are performed under the condition of full information availability, while the real world has uncertainty features.

This chapter presents various multivalued logic models that handle uncertainty found in life problems by simulating human reasoning. Prior studies for handling uncertainty used Bayes theory, Dempster-Shafer theory, and certainty factor, but these models cannot express vague, imprecise, ambiguity and inconsistent knowledge. Then new approaches are emerged to support decision making process by increasing the representing of the recognition outcome such as fuzzy, type2 fuzzy, intuitionistic fuzzy and neutrosophic logic.

Previous studies conducted to evaluate LMSs are characterized by unilateral view, no comprehensive model and full information availability assumption. In this dissertation, LMSs evaluation is a process concerns three challenges:
The LMSs success in educational institutions initiated by instructors and the use of LMSs is sustained by learners. Prior studies express their need to propose an information system success model for e- learning purposes and especially for LMS. The need for exploring the critical factors and developing an overall model that measure the success of LMS is emerged.

Choosing the most suitable LMS that meets the organization needs is a problem of decision making. Decision making process helps in selection of the most alternative or ranking a set of alternatives by examining different criteria. Former researches in LMSs selection used conventional multi-criteria decision making that may not be operative as LMSs systems described by experts with uncertainty terms.

Previous eLearning assessment models developed under the condition of full information. Expert system depends on expert knowledge to solve problems, knowledge engineer to encode the expert's knowledge in inference engine and knowledge base; and user who gets advice and information from the system.

Chapter 3
Learning Management Systems Success Measurement Model

Chapter 3: Learning Management Systems Success Measurement

***Model* 3.1 Learning Management Systems Success**

LMS is an information system that manages teaching, learning activities and communication associated with them [24]. LMSs success means the system's capability to support users including instructors and learners with their needs to precede the required educational activities [50]. One of the most widely used information system success model is DeLone and McLean. The model includes three components: the creation of a system, the use of the system, and the consequences of the use of the system [63]. DeLone and McLean's model adapted by Holsapple and Lee-Post for use in the eLearning to be: system design, system usage, and system outcome [64].

From former researches [6-10] [65-79], the critical factors that affect LMSs success are identified and discussed in this section as shown in Figure 3.1: personal factors which includes learner's and instructor's characteristics, system factors which includes system quality, information quality, service quality, organizational factors like management support and training, and supportive factors such as ethical and legal issues together with privacy, plagiarism and copyright concepts, and cost.

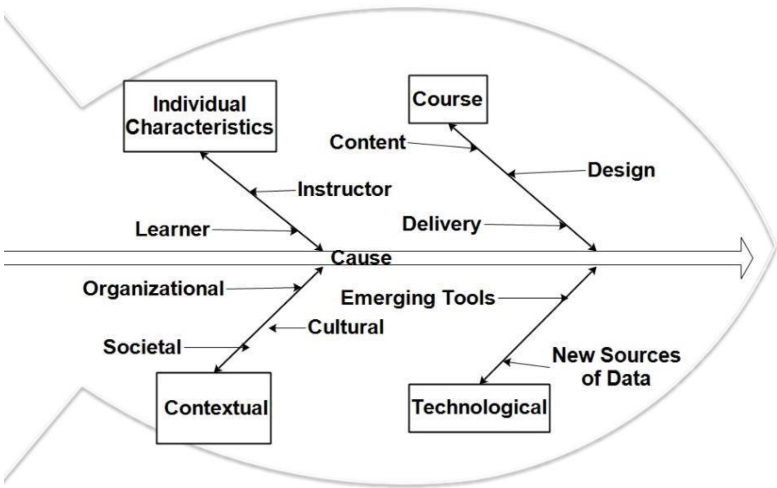


Figure 3.1 Factors Affecting LMSs success

System quality, service quality, information quality, learner perspective, instructor attitudes, and support issues had a significant impact on the LMSs success [6]. Six factors including user characteristics, extrinsic motivation, service quality, information quality and system quality influence the acceptance of LMS in developing countries was revealed by [7]. Perceived usefulness, perceived ease of use, user satisfaction, learner and instructor characteristics, LMS characteristics and organization characteristics had an influence on the LMSs success [8]. System quality is considerable factor in relation to the service quality, information quality and learning community [9,10].

3.2 Learning Management Systems Success Critical Factors

Personal factors including learner and instructor characteristics importance in LMSs success have been illustrated in many previous studies [66,68,71,72]. System factors including, service quality, information quality and system quality has a great influence on the acceptance of LMS [71,72,77]. Organization factors including management and training needs a concern in future studies as they had an impact on the LMSs sustainability [66,75]. Supportive factors considered as significant factor in LMSs success [66,71,72]. An integration of different validated eLearning success models from previous studies to illustrate the success factors of LMS is symbolized by x, where no model has a complete set of factors as shown in Table 3.1.

Table 3.1 Success Factors and References

Author, Year	***Personal Factors***		***System Factors***			***Organizational Factors***		***Support -ive Factors***
	ar ne r	st ru ct or	S y st e m		QualityService		Traini ng	
Chiu et al., 2007 [65]				x		x		
Selim, 2007 [66]	x	x				x	x	x
Lee, 2008 [67]							x	

Masrom et al., 2008 [68]	x	x		x		x		
Raaij & Schepers, 2008 [69]	x							
Shee & Wang, 2008 [70]	x			x				
Sun et al., 2008 [71]	x	x	x	x	x			x
Ozokan & Koseler, 2009 [72]	x	x	x	x	x			x
Al-Busaidi, 2009 [73]	x		x	x				
Klobas, 2010 [22]	x	x	x	x				
Lee, 2010 [74]	x			x	x			
Mosakhani & Jamporazmey, 2010 [75]	x	x		x		x	x	
Cheng, 2011 [76]	x		x	x				
Wang & Chiu, 2011 [77]			x	x	x			
Al-Busaidi, 2012 [12]	x	x	x	x	x	x		
Bhuasiri, 2012 [7]	x	x	x	x	x	x	x	
Zanjani et al., 2013 [78]	x	x	x	x				
Fard et al., 2014 [9]	x	x	x	x	x			
Lwoga, 2014 [10]		x	x	x	x			
Jafari et al., 2015 [51]			x	x				
Salem & Salem, 2015 [79]				x				
Total = 21 Papers	15	11	12	18	8	6	4	2

The feedback resulted from previous studies as shown in Table 3.1 show that information quality and system quality are the most regarded critical success factors for LMSs. The previous researches give less importance to the organizational and supportive factors, although it affects system usage and system outcome. Thus, it is recommended by the study that educational institutions give more concern to organizational and supportive factors to ensure more successful implementation of LMSs system.

3.3 Learning Management Systems Success Models

Previous studies used different LMSs success models that have different perspectives of eLearning concepts such as: DeLone & McLean model; Holsapple & Lee-Post; Technology Acceptance Model (TAM); Roca model and Lee& Lee. DeLone and McLean model [63] is one of the most used models for success measurement of LMSs in many scientific researches. The model covers six interrelated components as shown in Figure 3.2 which are: information quality, system quality, system use, user satisfaction, individual and organizational impact. The model presents an information system containing various features of system and information quality when users try out the system feature that may be satisfied or dissatisfied. The system usage affects the individual user in doing their tasks which consequently has an impact on organizational impacts. The relation between model components and other learner characteristics related to system acceptance, and instructor's perspective is a missing consideration in this model.

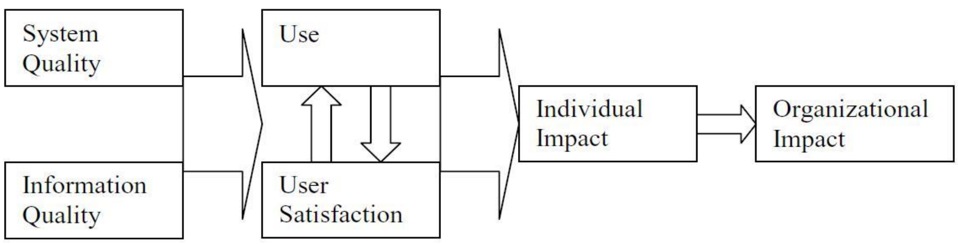


Figure 3.2 DeLone and McLean Success Model [63]

Holsapple and Lee-Post [64] updated DeLone and McLean model for LMSs success measurement. The model as shown in Figure 3.3 takes in three success elements: system design, system delivery and system outcome. System design success is affected by three success dimensions: system quality, information quality, and service quality. Two success factors use and user satisfaction have impact on system delivery. Finally, system outcome is estimated by the net benefits dimension which takes in consideration positive and negative aspects of eLearning. Holsapple and Lee-Post concluded that integral, comprehensive, and methodical approach to develop success model is needed for further practicality. The TAM [80] shows how users accept and use technology. The model presents the critical success factors that have an impact on users to use a new technology which are: perceived usefulness and perceived ease-of-use. A new model by integrating expectancy disconfirmation theory and the technology acceptance model for the intention to use of LMSs measurement is presented [81]. The study concluded that users are interested to how eLearning system provides information and how it will make users achieve their tasks.

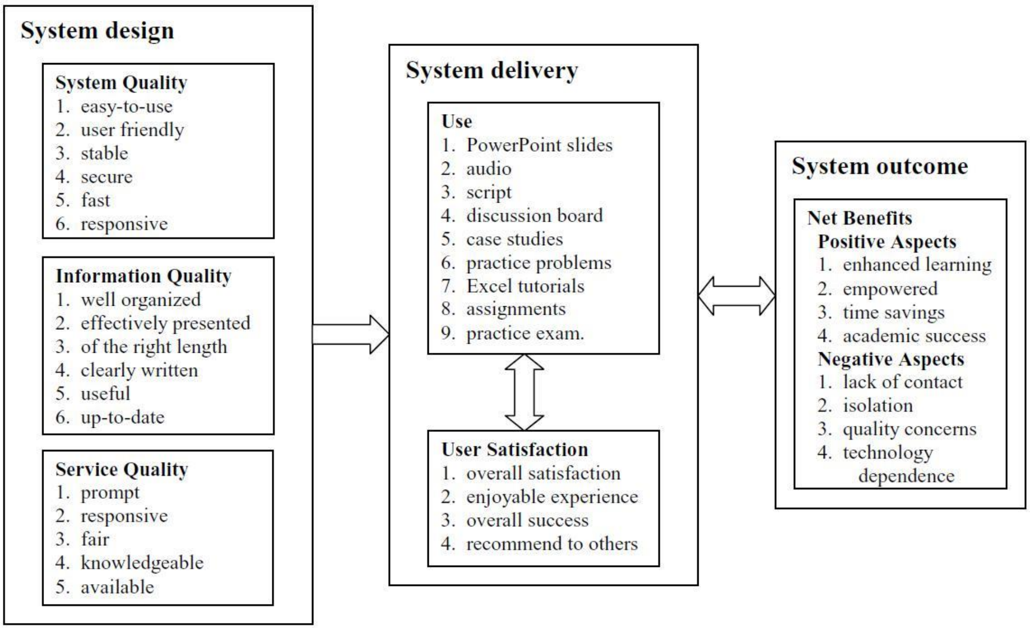


Figure 3.3 Holsapple and Lee-Post Success Model [64]

Intrinsic changes are added to the success model by concerning new dimensions like: instructor, learner, technology and support. The study explored the eight categories of critical factors that have impact on eLearning technology acceptance from learners' perspective. The study suggested that the model needed to be extended to develop an overall structural equation model that includes all factors [66]. Sun et al. as shown in figure 3.4 concerned six critical factors for learners' satisfaction guiding to the success of LMSs which are: learner, instructor, information quality, system design, technology and environmental [71]. The study results provide eLearning organizations with the keys to enhance learner's satisfaction and support eLearning success. Sun et al. research presented a model discussing different but it is not comprehensive as many other factors could be added and the dependent variable is a single indicator which learner satisfaction. A success measurement model presented by Lee presents as an extension of TAM model that focused on system quality and not only on the service quality. Lee model has provided forethought key factors for usage behaviour, perceived usefulness and perceived ease of use, although it is needed to refine the determinants within the model [67].

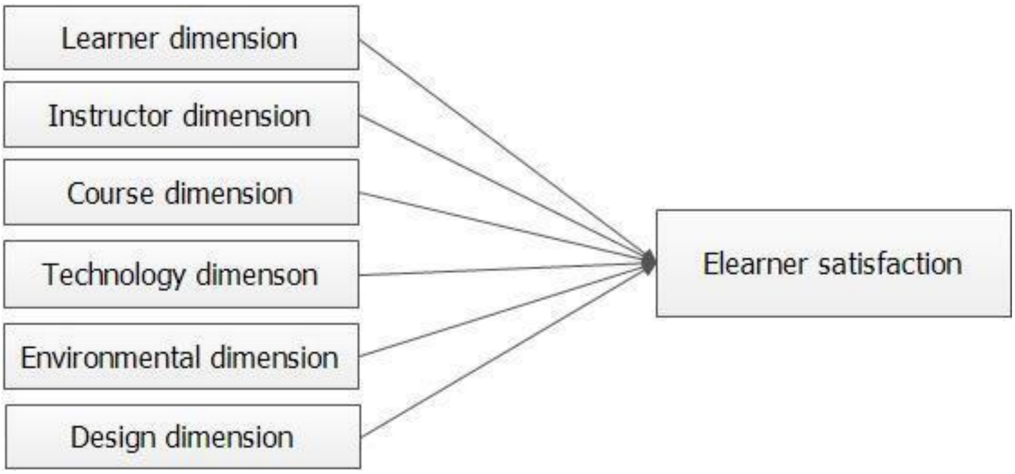


Figure 3.4 Sun et al. Success Model [71]

3.4 The Proposed Learning Management Systems Success Measurement Model

From previous studies, it can be concluded that the critical factors that affect LMSs success are identified as following: system design includes personal factors, system factors, organizational factors and supportive factors; system usage includes perceived ease of use and perceived usefulness; and system outcome includes user satisfaction and intention to use. The following section illustrates the proposed model's factors:

3.4.1 System Design

Personal factors

- Learner characteristics (F1): includes three dimensions which are learner's experience includes negative or positive aspects according to intimacy with the system, learner's qualifications includes the ability to perform actions required to fulfill the course; and personal creativity which indicates learner's capability to take on new technologies distinctly and reveals usefulness, acceptance, and satisfaction of LMSs [8].
    - W1: Learner characteristics including experience, competency and creativity have positive effect on perceived usefulness.
    - W2: Learner characteristics positively influence on perceived ease of use.
- Instructor characteristics (F2): Instructors' role is very important in shaping the learners' point of view to the course. Instructor quality metrics include teaching style, monitoring way and feedback procedure through the eLearning process [10].
    - W3: Instructor characteristics positively affect perceived usefulness.
    - W4: Instructor characteristics including teaching style, control and feedback have a positive effect on perceived of use.

System Factors

- System quality (F3): concerns system performance and user interface as important features. System quality measures in the LMS include response time, usability, availability, reliability, completeness, and security [58].
  - W5: System quality characteristics positively affect perceived usefulness.
  - W6: System quality has a positive effect perceived usefulness.

- Information Quality (F4): concerns with quality measures derived the content of information systems and user perspectives. The criteria for measuring information quality are multidimensional such as speed of access to information, accuracy and clarity [82].
  - W7: Information quality of the content of information systems has positive effect on perceived usefulness.
  - W8: Information quality affect positively on perceived ease of use.

- Service quality (F5): concerns with the assistance offered by LMSs service provider that can be delivered by university or other outside providers. It considers significant element in studies regarding information systems [83].
  - W9: Service provider quality support affect positively perceived usefulness.
  - W10: Service Quality has a positive effect on perceived ease of use.

Organizational Factors

- Management support (F6): considers as important factor that make learners adopt LMS deployment and make eLearning a part institution's culture. In the eLearning context, Management support has a considerable effect on users' satisfaction [8].
  - W11: Management support has a positive impact on perceived usefulness.
  - W12: Management support affect positively on perceived ease of use.

- Training (F7): this process provides the skills needed by learners for LMSs usage. Training availability and configuration offers learners satisfaction with LMSs software applications usage. ELearning courses are a training method which has an impact on the learners' acceptance to the technology [84].
  - W13: training positively affects Perceived usefulness of learners.
  - W14: Training availability has a positive impact on perceived ease of use.

Supportive Factors

- Ethical and Legal Issues (F8): cover ethics, trends, and laws issues. The ability of the system to enable users to access the LMS easily and quickly is affected by technological developments and LMSs tools popularity. LMSs have numerous text generated from e-mail, forum and other communication tools which create personal opinions and thoughts that should be controlled by institutions to determine whether or not their confidential information will be shared. Clear and distinct information regarding plagiarism and copyright policy should be provided by eLearning institution. Social influence, learners' interactions, assessment diversity, and perceived support are surrounding issues that consider important factor [71,72].
  - W15: Clear ethical and legal issues positively affect perceived usefulness of learners.
  - W16: Ethics, trends, and laws issues have a positive impact on perceived ease of use.
- Cost (F9): The deployment of LMS is costly as it requires new skills for content production and Learners' responsibility and self-discipline [67,72].
  - W17: Cost positively affects perceived usefulness of learners.
  - W18: Cost has a positive effect on perceived ease of use.

3.4.2 System Usage

- Perceived usefulness (F10): is the extent to which a learner and instructor believe that by using the LMS will enhance his performance. Learner characteristics such as learner history, learner competency and personal creativity reveal LMSs usefulness, acceptance, and satisfaction with it. Also, instructors have an important part in forming the learners’ behavior and view in the LMSs. Instructor quality includes teaching way, directing and response towards affect learner’s usefulness through LMSs [8,10].
    - W19: Perceived usefulness positively influence user satisfaction.
    - W20: Perceived usefulness has a positive effect on intention to use.

- Perceived ease-of-use (F11): is the learner’s and instructor’s recognition to use the system with less effort and accomplish the needed tasks. Ease of use is a technological dimension that influenced by system quality which measures features including system performance and user interface, service quality which concerns service provider’s support and information quality which concerns the quality of the information provided. Ease of use points to the access simplicity for users to log into the system at any time to take full advantage of the access provided [8].
    - W21: Perceived ease of use positively has an impact on user satisfaction.
    - W22: Perceived ease of use has a positive effect on intention to use.

3.4.3 System Outcome

- User Satisfaction (F12): concerns with the general users’ point of view on the system. It is considered as one of the most significant feature for LMSs success measurement. Users characteristics, system factors and training needs are all related to learners’ satisfaction [8,10].
    - W23: User satisfaction has a positive impact on LMSs success.

- Intention to use (F13): is regarding the perceived behavior and the actual behavior of the system user. The system frequency use and duration can indicate this use [8].
  - W24: Intention to use of the system positively affects LMSs success.

3.4.3 Overall Structure Model

The eLearning previous studies issue is separating factors from the action of other factors in the environment. In this study, the critical success factors of LMSs are investigated from different point of view by investigating previous researches to examine system design, system usage and system outcome. The findings as displayed in Table 3.1 reveal that learner characteristics, information quality and service quality factors have the most significant impact on LMS success.

The proposed LMSs success measurement overall model collected from previous studies [6-10] [65-79] is presented in Figure 3.5. Personal factors, system factors, organizational factors and supportive factors have important effect on LMS perceived usefulness and perceived ease of use which directly affect the user satisfaction and intention of use of the LMS. Consequently, user satisfaction and intention of system use have the considerable impact on the LMSs success. The model has been developed to present the relationships among the model dimensions.

The model is obtained by investigating the studies that concern with critical factors affecting LMSs success. The model is represented in Figure 3.5 that shows the factors numbered from F1 to F 13 and the relationship between these factors numbered from W1 to W24. According to the proposed model, the structural equations of the model are as follows in which F is for the factor importance and W is for weight of this factor to affect the other:

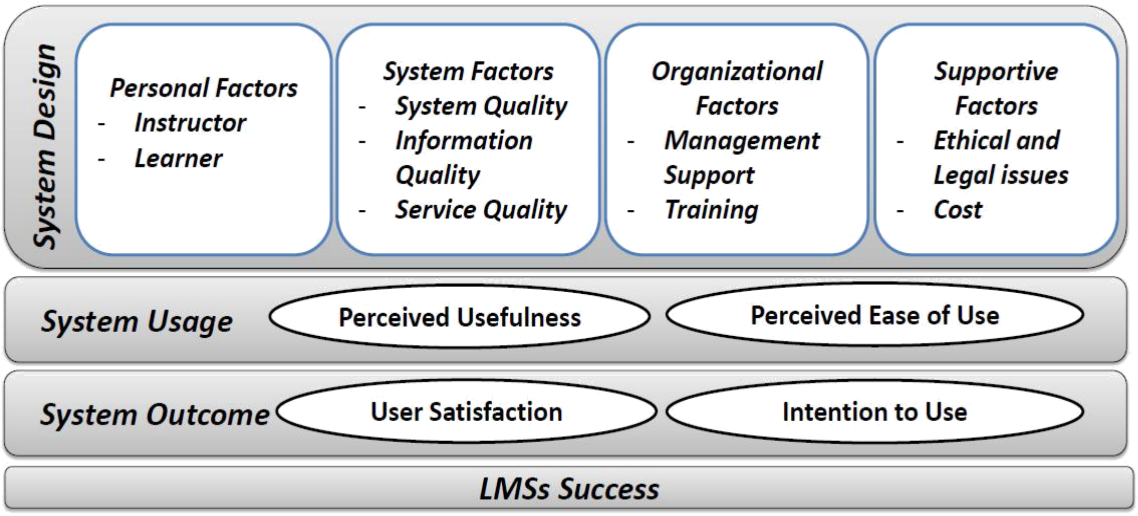


Figure 3.5 LMSs Success Proposed Model

This model presents a convenient way to represent the relationship between factors which further helps to support in decision making. Fuzzy set was used in previous studies represent the importance of factors and the weight that express the relationship between factors. Fuzzy set represents only the true membership and not the non-member ship or the hesitancy that decision makers may have to define membership. It's helpful to use neutrosophic sets in this case as it can represent and handle indeterminate relations. Neutrosophic set is able to handle inconsistencies which are true and false at the same time, as the sum of components of any number is between –0 and 3+ [13,14].

A semi-structured questionnaire is conducted for collecting information needed to validate the proposed LMSs success measurement model. The experts represent their answers using fuzzy set and neutrosophic set which includes true, indeterminate, and false values. A questionnaire for factor analysis is executed by collecting information from eight experts. The study considers 13 factors including 24 weight dimensions. Table 3.2 and Table 3.3 summarize the comparison between fuzzy set and neutrosophic set of factor importance and relationship between factors for items presented in the proposed model.

Table 3.2 Factors Importance

Dimension	Factor Importance		
	Fuzzy set	Neutrosophic set	Deneutro-sophied number
System Design			
Personal Factors			
F1: Learner Characteristics	64%	(0.66, 0.35, 0.27)	67%
F2: Instructor Characteristics	74%	(0.75, 0.36, 0.26)	70%
System Factors			
F3: System Quality	64%	(0.66, 0.36, 0.31)	66%
F4: Information Quality	62%	(0.64, 0.32, 0.29)	68%
F5: Service Quality	64%	(0.66,0.36,0.30)	66%
Organizational Factors			
F6: Management Support	74%	(0.75, 0.35, 0.28)	70%
F7: Training	60%	(0.61, 0.34, 0.31)	65%
Supportive Factors			
F8: Ethical and Legal issues	65%	(0.67, 0.32, 0.27)	68%
F9: Cost	61%	0.63, 0.36, 0.35)	64%
Relation between System Design Factors			
R1: Positive relationship between responsiveness of instructors and satisfaction level of learners	64%	(0.66,0.36,0.30)	66%
R2: Service quality affects information quality	65%	(0.67, 0.32, 0.27)	68%
R3: Service quality affects system quality	64%	(0.66,0.39,0.34)	63%
R4: System quality affects information quality	74%	(0.75, 0.30, 0.33)	71%
R5: System quality affects service quality	74%	(0.75, 0.35, 0.28)	70%

R6: Positive relationship between management support and instructors attitude	62%	(0.64, 0.32, 0.34)	66%
R7: Positive relationship between training and satisfaction level of learners	70%	(0.61, 0.37, 0.20)	67%
System Usage			
F10: Perceived Usefulness	74%	(0.75, 0.30, 0.20)	73%
F11: Perceived Ease of Use	70%	(0.61, 0.37, 0.20)	67%
System Outcome			
F12: User Satisfaction	58%	(0.59, 0.41, 0.28)	62%
F13: Intention to Use	74%	(0.75, 0.32, 0.27)	71%

Table 3.3 Weight importance between factors

Dimension	**weight importance**		
	Fuzzy set	**Neutrosophic set**	**Deneutro-sophied number**
System Design			
Personal Factors			
W1: Learner effect on perceived usefulness.	62%	(0.64, 0.32, 0.20)	70%
W2: Learner influence on perceived ease of use.	64%	(0.66,0.39,0.34)	63%
W3: Instructor effect on perceived usefulness.	63%	(0.53, 0.25, 0.23)	70%
W4: Instructor effect on perceived of use.	58%	(0.61, 0.37, 0.20)	67%
System Factors			
W5: System quality affect perceived usefulness.	70%	(0.61, 0.37, 0.20)	67%
W6: System quality affects perceived ease of use.	64%	(0.66,0.39,0.34)	63%
W7: Information quality effect on perceived usefulness.	70%	(0.72, 0.34, 0.29)	69%
W8: Information quality effect on perceived ease of use.	52%	(0.53, 0.31, 0.39)	63%

W9: Service affect perceived usefulness.	62%	(0.64, 0.32, 0.34)	66%
W10: Service Quality effect on perceived ease of use.	61%	(0.63, 0.32, 0.37)	65%
Organizational Factors			
W11: Management support impact on perceived usefulness.	58%	(0.61, 0.37, 0.38)	62%
W12: Management support effect on perceived ease of use.	74%	(0.75, 0.30, 0.20)	73%
W13: Training effect on perceived usefulness.	62%	(0.64, 0.32, 0.20)	69%
W14: Training influence on perceived ease of use.	61%	(0.62, 0.35, 0.35)	64%
Supportive Factors			
W15: Ethical and legal issues affect perceived usefulness.	74%	(0.75, 0.30, 0.20)	73%
W16: Ethics, laws, and surrounding issues has impact on perceived ease of use.	63%	(0.65, 0.35, 0.33)	65%
W17: Cost affect perceived usefulness of learners.	61%	(0.63, 0.35, 0.37)	64%
W18: Cost has effect on perceived ease of use.	63%	(0.65, 0.36, 0.29)	66%
System Usage			
W19: Perceived usefulness positively influence user satisfaction.	64%	(0.66,0.39,0.34)	63%
W20: Perceived usefulness has a positive effect on intention to use.	74%	(0.75, 0.30, 0.33)	71%
W21: Perceived ease of use positively influences user satisfaction.	70%	(0.72, 0.32, 0.32)	69%
W22: Perceived ease of use has a positive effect on intention to use.	61%	(0.62, 0.32, 0.24)	68%
System Outcome			
W23: User satisfaction effect on LMS success.	70%	(0.72, 0.37, 0.28)	68%
W24: Intention to use of the system affects LMS success.	74%	(0.75, 0.32, 0.24)	72%

3.5 Summary

The information systems susceptibility that aid different users to complete the required educational activities is the LMSs success. This chapter reviewed the critical factors such as personal factors, system factors, organizational factors, and supportive factors of LMSs success from various perspectives by investigating former studies. The findings show that learner characteristics, information quality and service quality factors have the most important concern on LMSs success studies. The previous studies show that information quality and system quality are the most significant success factors for LMSs. Less concern was given to the organizational and supportive factors, although it affects system usage and system outcome.

DeLone and McLean information system success model one of the most used IS success model. Holsapple and Lee-Post updated DeLone and McLean's model to be used in eLearning systems. TAM model presents the factors that affect users' acceptance and usage of a new technology which are: perceived usefulness and perceived ease-of-use. The model presented by Roca et al. integrates technology acceptance model with expectancy disconfirmation theory for LMSs success measurement. New dimensions such as instructor, learner, technology and support are added by Selim study to the LMSs success model. Lee model was as an extension of TAM model which provided forethought key factors for usage behaviour, perceived usefulness and perceived ease of use.

Four views have been considered in designing the proposed LMSs success model: personal, system, organizational, and supportive issues. The model has been adopted to show the relationships among the constructs of the model. This chapter concerns three dimensions of LMS which are system design including personal factors, system factors, organizational factors and supportive factors; system usage including perceived usefulness and perceived ease of use; and system outcome including user satisfaction and intention to use.

Chapter 4
Learning Management Systems Selection

Chapter 4: Learning Management Systems Selection

4.1 Learning Management Systems Selection

Multi criteria decision making (MCDM) methods concern structuring the case and solving problem which includes multiple attributes to support decision making process [12]. LMSs selection is an MCDM issue in eLearning field. The traditional MCDM methods depend on crisp values that are not appropriate to solve the problems including uncertainty existing in real world [52]. As real environment is characterized by decision makers with vague, imprecise, ambiguity and inconsistent knowledge, this problem makes studies go towards approaches that deal with uncertainty. Therefore, it is reasonable to find a new method to gather uncertain decision makers' opinions [53]. One of the most distinguished MCDM methods is analytical hierarchy process (AHP) that breaks down the problem into a set of hierarchies of goals, criteria and available choices. AHP handles tangible and non-tangible criteria and inconsistencies in decision makers' judgments [12,53]. The shortcoming of AHP is that uncertainty is not taking into account which will be solved in this chapter by presenting a MCDM based on neutrosophic sets.

Fuzzy and intuitionistic fuzzy sets offer a poor representation of uncertain data, as fuzzy set represents the membership in a crisp value between 0 and 1 and intuitionistic fuzzy set is suitable in simulating human impreciseness in decision making [13,14]. The decision-making process depends not only on information that is either true or false, but ignorance value between true and false called on indeterminacy. For example, if decision maker is asked about his opinion for the importance of certain attribute, he might say that the possibilities are as follows: it is true by 0.75, false, by 0.45 and indeterminate by 0.55. This can be addressed by neutrosophic logic, which have the truthfulness, indeterminacy and false values independent of each other [46,47].

Neutrosophic logic is a novel philosophy branch that concerns with the neutralities nature and their interactions with various intellectual ideas [47]. Current methods dedicated to simulate the human thinking that are obliged with rigorous conditions, whereas neutrosophic logic is capable of handling uncertainty in human thinking. In neutrosophic logic, the sum of the components is not necessarily like those in fuzzy and intuitionistic fuzzy logic, but they are a number between –0 and 3+ [85,86].

There are a large number of LMSs which present many technical and pedagogical features [3]. The purpose of this chapter is extending the AHP method via the neutrosophic set. Thus, how decision makers select the most fitting LMS to meet user priorities of the educational institution is the concern of the study [54]. The AHP main limitation is its incapability of representing uncertain data which is suggested to be solved with neutrosophic set theory to express decision makers' preferences. The other limitation is related to deriving neutrosophic division operations which are not presented before [12,86]. Neutrosophic analytic hierarchy process is developed and applied to the LMSs selection problem as a novel hybrid method.

4.2 Analytical Hierarchy Process

The AHP is MCDM method developed by Saaty which is used in management science to decompose complex problem into a hierarchical structure, and to derive a scale of relative priorities to rank criteria and alternatives [87]. AHP is popular in addressing MCDM problems, but it is criticized for its incapability to handle uncertainty in human judgments. To control this issue, Researchers presents fuzzy AHP where each pairwise comparison judgment is represented as fuzzy membership function which is not enough in some cases and intuitionistic fuzzy AHP sets that are characterized by a true membership function and false membership function as well in which decision makers should be able to determine the values with different criteria. In a real environment, it is difficult due to the lack of information availability [88,89].

The AHP method is proposed for the evaluation of the selected LMS products because it provides a less complex, and a more appropriate way to analyse the LMSs criteria. It is more natural to decision makers to give flexible judgments than a fixed one. The traditional AHP method considers the definite judgments of decision makers. While the neutrosophic set theory makes the experts judgments more flexible [12,54].

The procedures of the neutrosophic analytic hierarchy process are as shown in Figure 4.1 where neutrosophic numbers instead of Saaty scale are used.

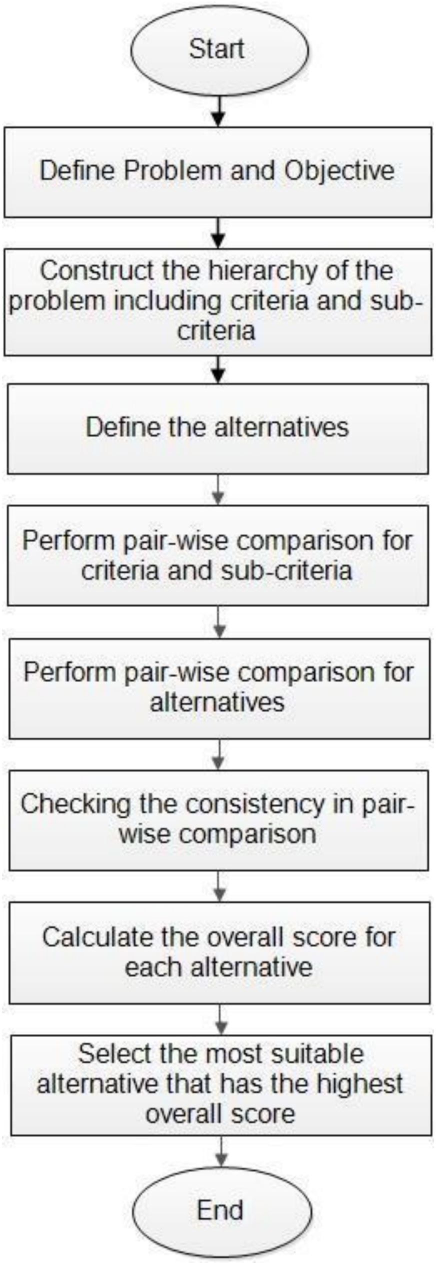


Figure 4.1 Analytical Hierarchy Process

4.3 Some Concepts of Neutrosophic Set

Neutrosophic set describes variable x by triple values x= (t, i, f) where “t” it is the degree of truth, “f” is the degree of false, and “i” is the level of indeterminacy. Neutrosophic logic deals with inconsistencies which are true and false at the same time, as the sum of the components is any number between –0 and 3+ [37]. A brief review of the general concepts of neutrosophic set is presented in this section [45, 86]:

Let X be the space of the objects, and x ∈ X. A neutrosophic set A in X is defined by three functions: truth membership function $T_A(x)$, an indeterminacy membership function $I_A(x)$ and false membership function $F_A(x)$.

Definition 1: If $N_1= (t_1, i_1, f_1)$ and $N_2 = (t_2, i_2, f_2)$ are two single valued neutrosophic numbers, then the addition of $N_1$and N_2can be expressed as follows:

$$N_1+N_2= (t_1+t_2-t_1t_2, i_1i_2, f_1f_2) \quad (1)$$

Definition 2: If $N_1= (t_1, i_1, f_1)$ and N2 = (t_2, i_2, f_2) are two single valued neutrosophic numbers, then the multiplication between N_1 and N_2 can be expressed as follows:

$$N_1 \text{ X } N_2= (t_1t_2, i_1+i_2 -i_1i_2, f_1+f_2- f_1f_2) \quad (2)$$

From equation (2), the division operation is derived which is not presented in previous researches as following:

If $N_1= (t_1, i_1, f_1)$, $N_2 = (t_2, i_2, f_2)$ and $N_3 = (t_3, i_3, f_3)$ are three single valued neutrosophic numbers, *then it is concluded that* the division of N_2 on N_1 can be expressed as follows:

Suppose $N_1 \text{ X } N_2 = N_3$

$(t_1, i_1, f_1) \text{ X } (t_2, i_2, f_2) = (t_3, i_3, f_3)$

$(t_1, i_1, f_1) \text{ X } (t_2, i_2, f_2) = (t_1t_2, i_1+i_2 -i_1i_2, f_1+f_2- f_1f_2)$

For indeterminacy value

$i_3 = i_1+ i_2 – i_1 i_2$

$i_3+ (- i_1) = (i_1 + i_2 - i_1i_2) + (- i_1)$

$i_3 – i_1= i_1 + i_2 – i_1i_2 – i_1$

$i_3 - i_1 = i_2 - i_1 i_2$

$i_2 - i_1 i_2 = i_3 - i_1$

$i_2 (-i_1+1) / - i_1+1 = i_3- i_1/ i_1+1$

$i_2 = i_3 - i_1 / 1- i_1$, also this is applied for calculation of false value.

Therefore, $N_3/ N_2= (t_3/t_2, i_3 - i_2/1-i_2, f_3-f_2/1-f_2)$ (3)

Definition 3: If $N_1= (t_1, i_1, f_1)$ is a single valued neutrosophic number and A is an arbitrary positive real number, then the multiplication of N_1 and A can be expressed as follows:

$A \times N_1 = (1-(1-t_1)^{A}, i_1^{A}, f_1^{A})$, Where $A > 0$ (4) Therefore, If $N_1= (t_1, i_1, f_1)$ is a single valued neutrosophic number and A is an arbitrary positive real number,

From equation (4), the division operation is derived which is not presented in previous researches as following:

Therefore, the division of N_1 over A can be expressed as follows:

$N_1 / A = (1-(1-t_1)^{1/A}, i_1^{1/A}, f_1^{1/A})$, Where $A > 0$ (5)

Definition 4: If N_1 is a single valued neutrosophic number, a score function is mapped N_1 into the single crisp output as $S(N_1)$ follows:

$S(N_1) = (3+t_1-2i_1-f_1)/4$ (6)

4.4 Neutrosophic Analytical Hierarchy Process (NAHP) for Learning Management Selection

In this section, LMSs selection problem is solved using the proposed method neutrosophic analytical hierarchy process is solved in order to demonstrate aspects of the neutrosophic sets implementation. *The first step* deals with decision makers who determined the criteria which are: cost, evaluative tools, computability, support, and sustainability, sub criteria which are: The student tracking and exam pool as a sub criteria of the evaluative tools, complying with the platform and content development tools as a sub criteria of compatibility, documentation and technical as a sub criteria of support, alternatives for LMSs that are available in this case: Moodle, Sakai, Atutor, ILIAS, and Dokeos, and problem hierarchy as shown in Figure 4.2.

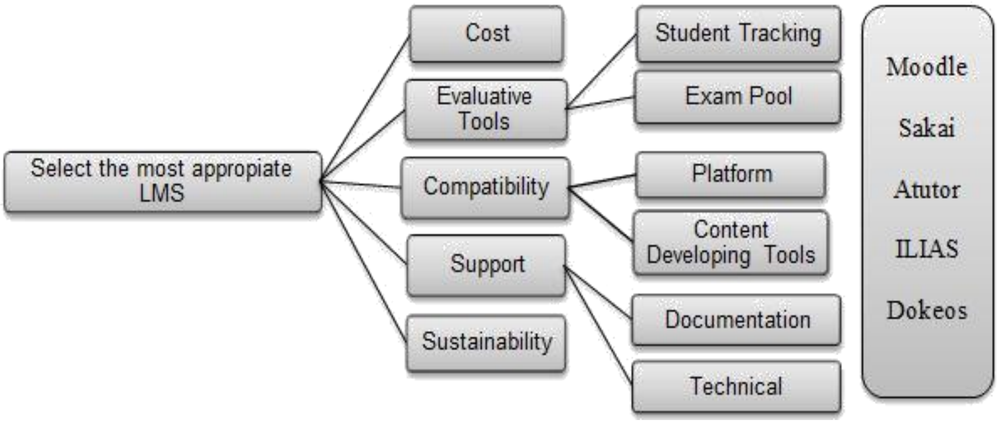


Figure 4.2 Decision Hierarchy Model of LMS

The second step concerns matrix construction in terms of each criterion using the relative importance of the alternatives. The importance of one element over another is expressed in relation to the element in the higher level using Saaty 9-point scale. A set of linguistic variables used by decision makers and importance weight based on neutrosophic values are as shown in Table 4.1.

Table 4.1: Linguistic variables and Importance weight based on neutrosophic values

Linguistic Term	**Neutrosophic Set**	**Linguistic Term**	**Reciprocal Neutrosophic Set**
Extremely Highly Preferred	(0.90, 0.10, 0.10)	Mildly Lowly Preferred	(0.10, 0.90, 0.90)
Extremely Preferred	(0.85,0.20, 0.15)	Mildly Preferred	(0.15,0.80, 0.85)
Very Strongly to Extremely Preferred	(0.80, 0.25, 0.20)	Mildly preferred to Very Lowly Preferred	(0.20, 0.75, 0.80)
Very Strongly Preferred	(0.75,0.25, 0.25)	Very Lowly Preferred	(0.25,0.75, 0.75)
Strongly Preferred	(0.70, 0.30, 0.30)	Lowly Preferred	(0.30, 0.70, 0.70)
Moderately Highly to Strongly Preferred	(0.65, 0.30, 0.35)	Moderately Lowly Preferred to Lowly Preferred	(0.35, 0.70, 0.65)
Moderately Highly Preferred	(0.60, 0.35, 0.40)	Moderately Lowly Preferred	(0.40, 0.65, 0.60)

Equally to Moderately Preferred	(0.55, 0.40, 0.45)	Moderately to Equally Preferred	(0.45, 0.60, 0.55)
Equally Preferred	(0.50, 0.50, 0.50)	Equally Preferred	(0.50, 0.50, 0.50)

The third step handles the comparison carried out by decision makers, in pairs, of the first criteria versus the goal, then of the sub criteria versus the criteria, and finally of the alternatives versus each of the sub criteria. There are 12 pairwise comparison matrices in total. One was for the criteria with respect to the goal, which is shown in Table 4.2, and three for the sub criteria, the first of which are those for the sub criteria under evaluative tools which are student tracking and exam pool; the second for the sub criteria under compatibility which are platform and content developing tools, and the third for the sub criteria under support which are documentation and technical. Then, there are eight comparison matrices for the five alternatives with respect to all the criteria and sub-criteria connected to the alternatives.

Table 4.2: Pairwise Comparison Matrix with Respect to the Goal

	1Cost	2 ToolsEvaluative	3Compatibility	4Support	5Sustainability	Weight
Cost 1	(0.50, 0.50, 0.50)	(0.25, 0.75, 0.75)	(0.40, 0.65, 0.60)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.4292, 0.5902, 0.5708)
Evaluative tools 2	(0.75, 0.25, 0.25)	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.60, 0.35, 0.40)	(0.60, 0.35, 0.40)	(0.6382, 0.3298, 0.3618)
Compatibility 3	(0.60, 0.35, 0.40)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.60, 0.35, 0.40)	(0.5632, 0.4087, 0.4368)
Support 4	(0.60, 0.35, 0.40)	(0.40, 0.65, 0.60)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.5011, 0.5027, 0.4989)
Sustainability 5	(0.50, 0.50, 0.50)	(0.40, 0.65, 0.60)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.4779, 0.5404, 0.5221)

The fourth step includes checking the consistency for each pairwise comparison neutrosophic preference relation as it is important action to ensure decision makers' reliability., Saaty provided a Consistency Ratio (CR) in the traditional AHP to measure consistency degree for a multiplicative preference relation as to be less than 0.1. It can be concluded that in our work there are two methods for checking consistency [52,53]:

First, by converting the neutrosophic reference relations into their corresponding crisp preference relations, and then using the Saaty method to check the consistency ratio as to be less than 0.1 [88].

By modifying the method used by Zeshui and Liaoto suit neutrosophic method [89]. This algorithm is developed to construct a perfect consistent neutrosophic preference relation where (T'xk, I'xk, F'xk) is an acceptable consistent neutrosophic reference relation as follows:

Step 1: For k > x + 1, let Nxk = (T'xk, I'xk, F'xk), where y= x+1

$$T'_{xk} = \frac{\sqrt[k-x-1]{T_{xy}\;T_{yk}\;T_{x\,k-1}\;T_{k-1\,k}}}{\sqrt[k-x-1]{T_{xy}\;T_{yk}\;T_{i\,k-1}\;T_{k-1\,k}} + \sqrt[k-x-1]{(1-T_{xy})\,(1-T_{yk})\,(1-T_{x\,k-1})\,(1-T_{k-1\,k})}} \qquad (7)$$

$$I'_{xk} = \frac{\sqrt[k-x-1]{I_{xy}\;I_{yk}\;I_{x\,k-1}\;I_{k-1\,k}}}{\sqrt[k-x-1]{I_{xy}\;I_{yk}\;I_{x\,k-1}\;I_{k-1\,k}} + \sqrt[k-x-1]{(1-I_{xy})\,(1-I_{yk})\,(1-I_{x\,k-1})\,(1-I_{k-1\,k})}} \qquad (8)$$

$$F'_{xk} = \frac{\sqrt[k-x-1]{F_{xy}\;F_{yk}\;F_{x\,k-1}\;F_{k-1\,k}}}{\sqrt[k-x-1]{F_{xy}\;F_{yk}\;F_{x\,k-1}\;F_{k-1\,k}} + \sqrt[k-x-1]{(1-F_{xy})\,(1-F_{yk})\,(1-F_{x\,k-1})\,(1-F_{k-1\,k})}} \qquad (9)$$

Step 2: For k = x + 1, let $N_{xk} = (T_{xk}, I_{xk}, F_{xk})$, where y= x+1

Step 3: For k < x, let $N_{xk} = (F'_{xk}, 1- I'_{xk}, T'_{xk})$, where y= x+1

$$\text{Consistency Ratio (CR)} = \frac{1}{2(n-1)(n-2)} \sum_{x=1}^{n} \sum_{k=1}^{n} \left(|T'_{xk}-T_{xk}|+|I'_{xk}-I_{xk}|+|F'_{xk}-F_{xk}|\right) \quad (10)$$

should be less than 0.1.

According to (7), (8), (9) and (10) equations, the neutrosophic pairwise comparison matrix with respect to the goal consistency is constructed as shown in Table 4.3.

Table 4.3: Consistency Pairwise Comparison Matrix with Respect to the Goal

	1Cost	2 ToolsEvaluative	3Compatibility	4Support	5Sustainability
Cost 1	11 (0.50, 0.50, 0.50)	12 (0.25, 0.75, 0.75)	13 (0.4142, 0.5597, 0.5858)	14 (0.4142, 0.5597, 0.5858)	15 (0.4095, 0.5905, 0.5905)
Evaluative Tools 2	21 (0.75, 0.25, 0.25)	22 (0.50, 0.50, 0.50)	23 (0.60, 0.35, 0.40)	24 (0.60, 0.35, 0.40)	25 (0.6475, 0.2832, 0.3525)
Compatibility 3	31 (0.5858, 0.4403, 0.4142)	32 (0.40, 0.65, 0.60)	33 (0.50, 0.50, 0.50)	34 (0.60, 0.35, 0.40)	35 (0.5505, 0.4232, 0.4495)
Support 4	41 (0.5858, 0.4403, 0.4142)	42 (0.40, 0.65, 0.60)	43 (0.40, 0.65, 0.60)	44 (0.50, 0.50, 0.50)	45 (0.50, 0.50, 0.50)
Sustainability 5	51 (0.5905, 0.4095, 0.4095)	52 (0.3525, 0.7168, 0.6475)	53 (0.4495, 0.5768, 0.5505)	54 (0.50, 0.50, 0.50)	55 (0.50, 0.50, 0.50)

For example, to calculate T_{25} =

2 √T23 T3 T24 T4

2 2 √T23 T3 T24 T4 + √(1-T23) (1- T3) (1-T24) (1-T4) =

2 √0. 0 0. 0 0. 0 0. 0

2 2 √0. 0 0. 0 0. 0 0. 0 + √0.40 0.40 0.40 0. 0 = 0.6475

Then CR is calculated as follows

Consistency Ratio (CR) =

$\sum^{n}_{x=1} \sum^{n}_{k=1} (|12. \ -12. \ |+|12. -12. \ |+|12. \ -12. \ |) = 0$ which is less

than 0.1

The one for the criteria with respect to the goal is shown in Table 4.4, and three pairwise comparison for the sub criteria after checking consistency are as following: student tracking and exam pool under evaluative tools shown in Table 4.4; platform and content developing tools under compatibility shown in Table 4.5, documentation and technical under support shown in Table 4.6.

Table 4.4: Pairwise Comparison Matrix for the Sub Criteria Under Evaluative Tools

	Exam Pool	Student Tracking	Weight
Exam Pool	(0.50,0.50,0.50)	(0.75, 0.25, 0.25)	(0.8309 0.1691, 0.1691)
Student Tracking	(0.25,0.75,0.75)	(0.50,0.50,0.50)	(0.4929 0.5071, 0.5071)

Table 4.5: Pairwise Comparison Matrix for the Sub Criteria Under Compatibility

	Content development tools	Platform	Weight
Content development tools	(0.50,0.50,0.50)	(0.60,0.35,0.40)	(0.7328 0.2345, 0.2672)
Platform	(0.40,0.65,0.60)	(0.50,0.50,0.50)	(0.5991 0.4355, 0.4009)

Table 4.6: Pairwise Comparison Matrix for the Sub-criteria under Support

	Documentation	Technical	Weight
Documentation	(0.50,0.50,0.50)	(0.35, 0.70, 0.65)	(0.5645, 0.4697, 0.4355)
Technical	(0.65, 0.30, 0.35)	(0.50,0.50,0.50)	(0.7655 0.2017, 0.2345)

The overall weight calculations of the criteria and the sub criteria based on the neutrosophic numbers is *The fifth step* can be seen in Table 4.7. The relative weight is calculated by the summation of each column in the matrix, and then each number in the matrix is divided by the calculated sum of its column, then getting the average of the rows.

Table 4.7: The Overall Priority of the Criteria and the Sub Criteria

Criteria	Criteria Weight (CW)	Sub Criteria	Sub Criteria Weight (SCW)	Overall Weight= CW x SCW
Cost	(0.4292, 0.5902, 0.5708)			(0.4292, 0.5902, 0.5708)
Evaluative Tools	(0.6382, 0.3298, 0.3618)	Student Tracking	(0.4929, 0.5071, 0.5071)	(0.3146, 0.6697, 0.6854)
		Exam Pool	(0.8309, 0.1691, 0.1691)	(0.5303, 0.4331, 0.4697)
Compatibility	(0.5632, 0.4087, 0.4368)	Platform	(0.5991, 0.4355, 0.4009)	(0.3374, 0.6662, 0.6626)
		Content Developing Tools	(0.7328, 0.2345, 0.2672)	(0.4127, 0.5474, 0.5873)
Support	(0.5011, 0.5027, 0.4989)	Documentation	(0.5645, 0.4697, 0.4355)	(0.2829, 0.7363, 0.7171)
		Technical	(0.7655, 0.2017, 0.2345)	(0.3836, 0.6030, 0.6164)
Sustainability	(0.4779, 0.5404, 0.5221)			(0.4779, 0.5404, 0.5221)

The sixth step compares the alternatives under each criterion or sub criterion. For the five alternatives, there are eight comparison matrices which illustrate the value of achieved criteria and sub criteria for each recommended alternative as following: under cost as shown in Table 4.8, student tracking show in Table 4.9, exam pool shown in Table 4.10, platform shown in Table 4.11, content developing tools in Table 4.12, documentation shown in Table 4.13, technical shown in Table 4.14, sustainability shown in Table 4.15.

Table 4.8: Pairwise Comparison Matrix for the Alternatives Under Cost

Cost	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.50, 0.50, 0.50)	(0.55, 0.40, 0.45)	(0.60, 0.35, 0.40)	(0.5701 0.3973, 0.4299)
Sakai	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.40, 0.65, 0.60)	(0.45, 0.60, 0.55)	(0.50, 0.50, 0.50)	(0.4663 0.5623, 0.5337)
Atutor	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.50, 0.50, 0.50)	(0.55, 0.40, 0.45)	(0.60, 0.35, 0.40)	(0.5701 0.3973, 0.4299)
ILIAS	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.45, 0.60, 0.55)	(0.50, 0.50, 0.50)	(0.55, 0.40, 0.45)	(0.5181 0.4762, 0.4819)
Dokeos	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.40, 0.65, 0.60)	(0.45, 0.60, 0.55)	(0.50, 0.50, 0.50)	(0.4663 0.5622, 0.5337)

Table 4.9: Pairwise Comparison Matrix for the Alternatives Under Student Tracking

Student Tracking	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50, 0.50)	(0.70, 0.30, 0.30)	(0.55, 0.40, 0.45)	(0.65, 0.30, 0.35)	(0.60, 0.35, 0.40)	(0.6262 0.3423, 0.3738)
Sakai	(0.30, 0.70, 0.70)	(0.50, 0.50, 0.50)	(0.35, 0.70, 0.65)	(0.45, 0.60, 0.55)	(0.40, 0.65, 0.60)	(0.4170 0.6127, 0.5830)
Atutor	(0.45, 0.60, 0.55)	(0.65, 0.30, 0.35)	(0.50 ,0.50, 0.50)	(0.60, 0.35, 0.40)	(0.55, 0.40, 0.45)	(0.5736 0.3997, 0.4264)
ILIAS	(0.35, 0.70, 0.65)	(0.55, 0.40, 0.45)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.45, 0.60, 0.55)	(0.4691 0.5459, 0.5309)

Dokeos	(0.40, 0.65, 0.60)	(0.60, 0.35, 0.40)	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.50, 0.50, 0.50)	(0.5211 0.4719, 0.4789)

Table 4.10: Pairwise Comparison Matrix for the Alternatives under Exam Pool

Exam Pool	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.55, 0.40, 0.45)	(0.65, 0.30, 0.35)	(0.65, 0.30, 0.35)	(0.6128, 0.3423, 0.3872)
Sakai	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.55, 0.40, 0.45)	(0.5092 0.4848, 0.4908)
Atutor	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.60, 0.35, 0.40)	(0.5611 0.3871, 0.4389)
ILIAS	(0.35, 0.70, 0.65)	(0.45, 0.60, 0.55)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.4571 0.5713, 0.5429)
Dokeos	(0.35, 0.70, 0.65)	(0.45, 0.60, 0.55)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.4571 0.5713, 0.5429)

Table 4.11: Pairwise Comparison Matrix for the Alternatives under Platform

Platform	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.55, 0.40, 0.45)	(0.55, 0.40, 0.45)	(0.50, 0.50, 0.50)	(0.5374 0.4400, 0.4626)
Sakai	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.55, 0.40, 0.45)	(0.55, 0.40, 0.45)	(0.45, 0.60, 0.55)	(0.5228 0.4573, 0.4722)
Atutor	(0.45, 0.60, 0.55)	(0.45, 0.60, 0.55)	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.45, 0.60, 0.55)	(0.4857 0.5427, 0.5143)
ILIAS	(0.45, 0.60, 0.55)	(0.45, 0.60, 0.55)	(0.50, 0.50, 0.50)	(0.50, 0.50, 0.50)	(0.45, 0.60, 0.55)	(0.4857 0.5427, 0.5143)
Dokeos	(0.50, 0.50, 0.50)	(0.55, 0.40, 0.45)	(0.55, 0.40, 0.45)	(0.55, 0.40, 0.45)	(0.50, 0.50, 0.50)	(0.5478 0.4189, 0.4522)

Table 4.12: Pairwise Comparison Matrix for the Alternatives
Under Content Developing Tools

Content Developing Tools	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50, 0.50)	(0.65, 0.30, 0.35)	(0.55, 0.40, 0.45)	(0.60, 0.35, 0.40)	(0.60, 0.35, 0.40)	(0.6019 0.3532, 0.3981)
Sakai	(0.35, 0.70, 0.65)	(0.50, 0.50, 0.50)	(0.40, 0.65, 0.60)	(0.45, 0.60, 0.55)	(0.40, 0.65, 0.60)	(0.4359 0.6033, 0.5641)
Atutor	(0.45, 0.60, 0.55)	(0.60, 0.35, 0.40)	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.55, 0.40, 0.45)	(0.5611 0.4128, 0.4389)
ILIAS	(0.40, 0.65, 0.60)	(0.55, 0.40, 0.45)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.45, 0.60, 0.55)	(0.4782 0.5368, 0.5218)
Dokeos	(0.40, 0.65, 0.60)	(0.60, 0.35, 0.40)	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.50, 0.50, 0.50)	(0.5207 0.4718, 0.4793)

Table 4.13: Pairwise Comparison Matrix for the Alternatives Under Documentation

Document-ation	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50, 0.50)	(0.55, 0.40, 0.45)	(0.55, 0.40, 0.45)	(0.60, 0.35, 0.40)	(0.60, 0.35, 0.40)	(0.5798, 0.3768, 0.4202)
Sakai	(0.45, 0.60, 0.55)	(0.50, 0.50, 0.50)	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.60, 0.35, 0.40)	(0.5304, 0.4635, 0.4694)
Atutor	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.50, 0.50, 0.50)	(0.60, 0.35, 0.40)	(0.55, 0.40, 0.45)	(0.5478, 0.4246, 0.4522)
ILIAS	(0.40, 0.65, 0.60)	(0.45, 0.60, 0.55)	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.45, 0.60, 0.55)	(0.4556, 0.5839, 0.5444)
Dokeos	(0.40, 0.65, 0.60)	(0.40, 0.65, 0.60)	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.50, 0.50, 0.50)	(0.4779, 0.5441, 0.5221)

Table 4.14: Pairwise Comparison Matrix for the Alternatives under Technical

Technical	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50, 0.50)	(0.65, 0.30, 0.35)	(0.55, 0.40, 0.45)	(0.70, 0.30, 0.30)	(0.60, 0.35, 0.40)	(0.6252, 0.3423, 0.3748)
Sakai	(0.35, 0.70, 0.65)	(0.50, 0.50, 0.50)	(0.40, 0.65, 0.60)	(0.55, 0.40, 0.45)	(0.45, 0.60, 0.55)	(0.4690, 0.5459, 0.5310)
Atutor	(0.45, 0.60, 0.55)	(0.60, 0.35, 0.40)	(0.50, 0.50, 0.50)	(0.65, 0.30, 0.35)	(0.55, 0.40, 0.45)	(0.5736, 0.4234, 0.4264)
ILIAS	(0.30, 0.70, 0.70)	(0.45, 0.60, 0.55)	(0.35, 0.70, 0.65)	(0.50, 0.50, 0.50)	(0.40, 0.65, 0.60)	(0.4117, 0.6126, 0.5833)
Dokeos	(0.40, 0.65, 0.60)	(0.55, 0.40, 0.45)	(0.45, 0.60, 0.55)	(0.60, 0.35, 0.40)	(0.50, 0.50, 0.50)	(0.5211 0.4715, 0.4789)

Table 4.15: Pairwise Comparison Matrix for the Alternatives under Sustainability

Sustainability	Moodle	Sakai	Atutor	ILIAS	Dokeos	Weight
Moodle	(0.50, 0.50 ,0.50)	(0.60, 0.35, 0.40)	(0.45, 0.60, 0.55)	(0.65, 0.30, 0.35)	(0.55, 0.40, 0.45)	(0.5736, 0.3997, 0.4264)
Sakai	(0.40, 0.65, 0.60)	(0.50, 0.50, 0.50)	(0.35, 0.70, 0.65)	(0.55, 0.40, 0.45)	(0.45, 0.60, 0.55)	(0.4690, 0.5459, 0.5310)
Atutor	(0.55, 0.40, 0.45)	(0.65, 0.30, 0.35)	(0.50, 0.50, 0.50)	(0.70, 0.30, 0.30)	(0.60, 0.35, 0.40)	(0.6252, 0.3423, 0.3748)
ILIAS	(0.35, 0.70, 0.65)	(0.45, 0.60, 0.55)	(0.30 0.70, 0.70)	(0.50, 0.50, 0.50)	(0.40, 0.65, 0.60)	(0.4169, 0.6126, 0.5831)
Dokeos	(0.45, 0.60, 0.55)	(0.55, 0.40, 0.45)	(0.40, 0.65, 0.60)	(0.60, 0.35, 0.40)	(0.50, 0.50, 0.50)	(0.5211, 0.4715, 0.4789)

Finally, the overall priorities of the alternatives will be calculated as follows:
Overall Weight= Weight Subcriteria X Weight Alternatives

(0.4292, 0.5902, 0.5708)
(0.3146, 0.6697, 0.6854)
(0.5303, 0.4331, 0.4697)
(0.3374, 0.6662, 0.6626)
(0.4127, 0.5474, 0.5873)
(0.2829, 0.7363, 0.7171)
(0.3836, 0.6030, 0.6164)
(0.4779, 0.5404, 0.5221)

X

(0.5701, 0.3973, 0.4299)	(0.6262, 0.3423, 0.3738)	(0.6128, 0.3423, 0.3872)	(0.5374, 0.4400, 0.4626)	(0.6019, 0.3532, 0.3981)	(0.5798, 0.3768, 0.4202)	(0.6252, 0.3423, 0.3748)	(0.5736, 0.3997, 0.4264)
(0.4663, 0.5623, 0.5337)	(0.4170, 0.6127, 0.5830)	(0.5092, 0.4848, 0.4908)	(0.5228, 0.4573, 0.4722)	(0.4359, 0.6033, 0.5641)	(0.5304, 0.4635, 0.4694)	(0.4690, 0.5459, 0.5310)	(0.4690, 0.5459, 0.5310)
(0.5701, 0.3973, 0.4299)	(0.5736, 0.3997, 0.4264)	(0.5611, 0.3871, 0.4389)	(0.4857, 0.5427, 0.5143)	(0.5611, 0.4128, 0.4389)	(0.5478, 0.4246, 0.4522)	(0.5736, 0.4234, 0.4264)	(0.6252, 0.3423, 0.3748)
(0.5181, 0.4762, 0.4819)	(0.4691, 0.5459, 0.5309)	(0.4571, 0.5713, 0.5429)	(0.4857, 0.5427, 0.5143)	(0.4782, 0.5368, 0.5218)	(0.4556, 0.5839, 0.5444)	(0.4117, 0.6126, 0.5833)	(0.4169, 0.6126, 0.5831)
(0.4663, 0.5622, 0.5337)	(0.5211, 0.4719, 0.4789)	(0.4571, 0.5713, 0.5429)	(0.5478, 0.4189, 0.4522)	(0.5207, 0.4718, 0.4793)	(0.4779, 0.5441, 0.5221)	(0.5211, 0.4715, 0.4789)	(0.5211, 0.4715, 0.4789)

According to the given priorities shown in the criteria and sub criteria, the most appropriate choice for the project was Moodle then followed by Atutor as shown in Table 4.16 which is accepted by experts and decision makers. Using neutrosophic sets for LMS selection is a better option than the fuzzy and intuitionistic fuzzy logic, as it simulates the indeterminacy in human thinking as showed from the result. The results differ when a change of goals is done.

Table 4.16: The Overall Score of Different Alternatives

Alternatives	Neutrosophic Set	Deneutrosophied Number	Ranking
Moodle	(0.8838, 0.0949, 0.1162)	0.8945	1
Atutor	(0.8709, 0.1120, 0.1291)	0.8795	2
Dokeos	(0.8315, 0.1655, 0.1685)	0.8330	3
Sakai	(0.8147, 0.1895, 0.1853)	0.8126	4
ILIAS	(0.8020, 0.2096, 0.1980)	0.7962	5

4.5 Summary

Fuzzy logic offers a poor representation of uncertain data, as it presents the membership in a membership degree of a given element but it does not present the corresponding degree of false membership. Intuitionistic fuzzy logic expresses the decision makers’ opinion to a certain degree as it presents the concept of variability. Indeterminate information which is an ignorance value between truth and falsehood can be appropriately addressed by neutrosophic logic.

This chapter presents a neutrosophic analytical hierarchy process method as a novel approach for decision making for LMSs selection according to decision makers’ priorities and preferences. The results of the study cannot be generalized, due to the fact that the neutrosophic analytical hierarchy process cannot evaluate products by itself. According to the determined priorities, Moodle proved to be the most suitable software that met the predefined criteria, after that comes Atutor, Dokeos, Sakai, Ilias orderly.

Chapter 5
Learning Management Systems Quality Assessment

Chapter 5: Learning Management Systems Quality Assessment

5.1 Learning Management Systems Quality

LMSs factors play an important role in evaluating LMS as mentioned in Chapter 2 which includes system quality, service quality and information quality [9]. System quality in a LMS measures the essential features including system performance and user interface. Service quality is concerned with the support given by the service provider of LMS, whether the service is delivered by the university organization or external providers [58]. Information Quality is concerned quality measures derived from user perspectives [83] is a term to describe the quality of the content of information systems including information accuracy and clarity [82]. System quality is very important factor in relation to the service quality, information quality and learning community [59] and has the most affirmative impact on learners understand of eLearning system [7].

LMSs quality assessment helps organizations to achieve the quality aspects for user satisfaction is a challenge [50]. System quality defined as an assessment of technical and design viewpoints of information system [57]. As system quality is a main factor that has an impact on user satisfaction and perceived usefulness [10]. LMSs quality is defined as the usability, accessibility, reliability, and stability of the system. As usability is an important factor that affects the LMS efficiency [59]. In this dissertation, the concern is on three system quality attributes which are usability, reliability, and accessibility.

ELearning quality attributes assessment developed under the condition of complete information availability. Traditional approaches like fuzzy logic for LMSs software assessment used by previous studies cannot handle uncertainty or adapt variations and changes [60-62]. While incomplete information and uncertain data are characteristics of real environment which make researchers suggest neutrosophic logic that address uncertainty for eLearning quality assessment [17].

This chapter presents expert system for LMSs quality assessment based on neutrosophic logic as a novel approach for expert systems. Building and validating the neutrosophic expert system information are collected from eight experts using semi-structured questionnaire and then application is implemented by using Fuzzytech 5.54d software. The results of neutrosophic expert system is compared to fuzzy expert system results to show that the neutrosophic logic capability of representing uncertainty in human reasoning.

In the following lines the chapter illustrates the three system quality attributes which are usability, reliability, and accessibility that the study concerns.

5.1.1 Usability

Usability is a significant quality attribute that handles the continuous use of LMSs application [61]. LMSs usability is related to how the user can interact with system to learn through it [90]. Many models define usability quality factors as following [91, 92]:

- Efficiency: refers to user understanding of the software. It shows if the system is able to achieve users' objectives. Number of goals/task not achieved, time taken for task completion, unproductive period, and percentage of task not completed are the most common measures of efficiency taken by usability researchers.
- Error tolerance: this dimension concerns to the number of times the user couldn’t continue the task, number of actions taken that do not solve the problem, time spent on one error recovery, and number of times the user has to restart the application are the common measures of error tolerance.
- Learnability: This dimension concerns with the ability of user to understand and learn software in a suitable time frame.
- Memorability: This dimension deals with the possibility of the user to remember basic functions of software even after some period of time.
- User Satisfaction: refers to software ease of use. When the previous four requirements are achieved, user satisfaction is met.

5.1.2 Reliability

Software reliability are affected by some uncertainty factors such as probability of failure, average time to repair and average time between system failures, whereas, the conventional models concern with software failures [93]. The software reliability assessment is characterized uncertain data, imprecise information, incomplete knowledge, therefore, the uncertainty models is better to be used [94]. LMSs Reliability related to minimum loss in case of software failure, whereas, data recoverability is very important. It is defined as:

- Fault tolerance: It is the software capability to recover from failure.
- Maturity: It deals with software failure frequency, where increasing maturity is associated with decreasing of failure.
- Recoverability: It concerns with the capability of failed system to return back in full functionality.

5.1.3 Accessibility

Accessibility is concerning with the individual allowance to take full advantage of information and services provided by the system [95]. In eLearning, accessibility refers to learner competency to access eLearning resources with minimal effort [96]. Accessibility is defined by Tamara et al. in [97] as learners to obtain the learning materials in any time or place without losing important information.

The concept of accessibility in eLearning systems deals with:

- Navigability: This concerns user interface and navigation that should be working. The system interface cannot require operation that a user cannot perform.
- Robustness: Content must be capable to be accessed by different users including evolving technologies.
- Understandability: user interface and information content must be presentable to users in an appreciable way.

5.2 Neutrosophic Expert System

Neutrosophic logic is an extension of the intuitionistic fuzzy logic and fuzzy logic. In neutrosophic logic, the variable x is described by triple values t is the truth degree, i is for the indeterminacy degree, and f is the false degree. For example, the presumption "Tomorrow it will be raining" does not denote a constant-valued components structure; this presumption may be 55% true, 40% indeterminate and 45% false at a time; but at in another time may alter to 50% true, 49% indeterminate, and 40% false [47]. It is suggested for future work in [85] to apply neutrosophic decision making, and neutrosophic expert systems in eLearning [86]. The membership of inputs for each logical variable x is described by the truth, false and indeterminacy degree as shown in Figure 5.1.

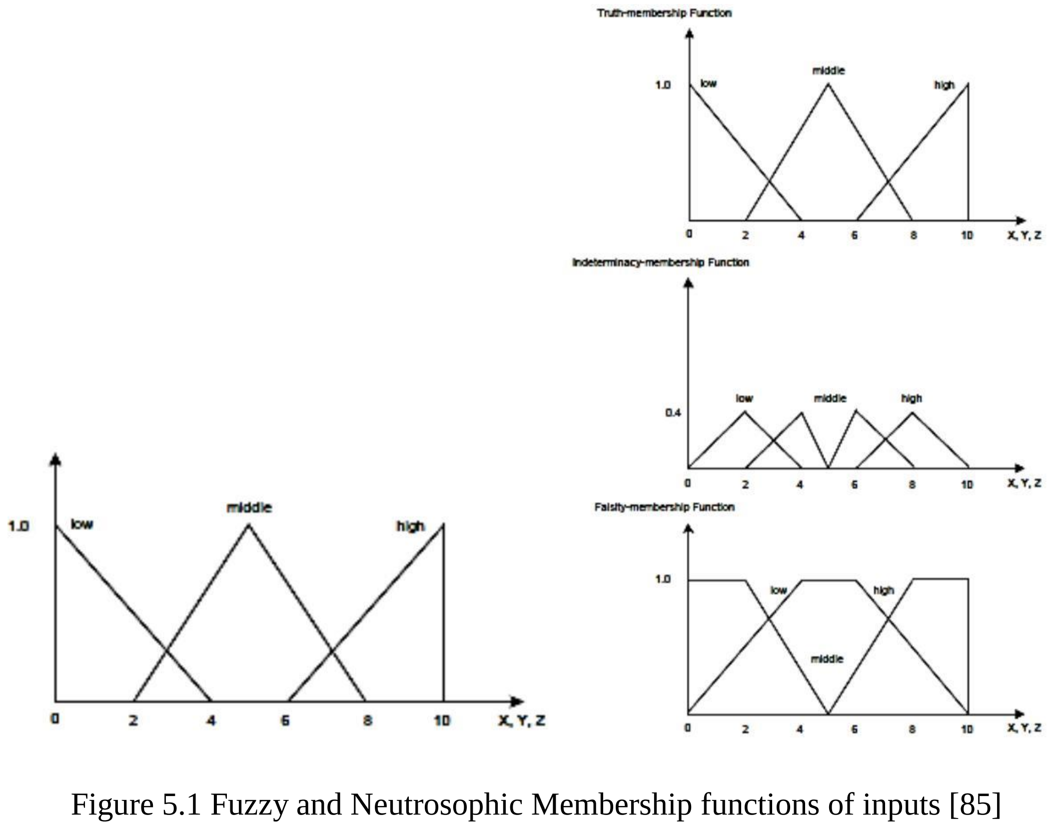


Figure 5.1 Fuzzy and Neutrosophic Membership functions of inputs [85]

Expert systems imitate human expert reasoning to take decision in certain domain which is mainly composed of the user interface, knowledge base, and inference engine [18]. Experts systems represent the uncertainty in knowledge to draw conclusion with the accuracy degree as human expert do [19]. Personnel interaction is the main issue in designing an expert system. These include expert who has knowledge for solving the problems, knowledge engineer who encodes the expert's knowledge in inference engine and knowledge base; user who uses the system to get problem solution and information needed [20].

Neutrosophic sets handle indeterminate information when expert is asked to give a degree about the truth, falseness and indeterminacy of certain statement. Neutrosophic expert system consists of neutrosophication unit that accepts three inputs including true, indeterminacy and false membership functions, knowledge base that maps input to output variable depending on rules defined in neutrosophic values and deneutrosophication unit that converts neutrosophic value to a value having a triplet format (true, indeterminacy, false); this differs from fuzzy expert system which assigns a true input membership value as shown in Figure 5.2 [13, 14].

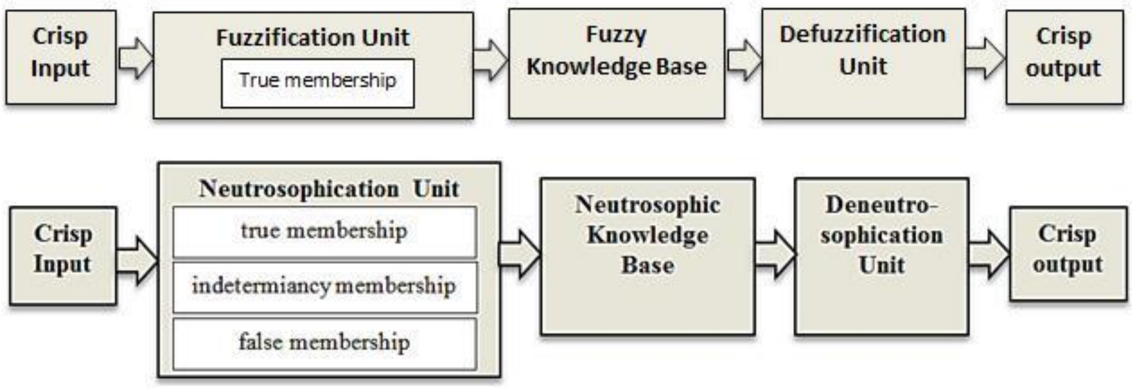


Figure 5.2 The Difference between Fuzzy Expert System and Neutrosophic Expert System [14]

5.3 Neutrosophic Expert System for LMSs Quality Assessment

Neutrosophic expert system is proposed in this section to assess LMSs quality considering three main attributes: usability, accessibility and reliability. Neutrosophic logic is used in neutrosophic expert system to map the inputs membership functions to true, false and indeterminacy. The inputs memberships are obtained from some domain experts using questionnaire; their option is of degree of truth, indeterminacy and false. Eight experts define the membership function for inputs, knowledge base and membership of output to develop neutrosophic expert system for assessing the LMSs quality. Two questionnaires are carried out, the first is for collecting the data needed to build the rules of LMS expert system evaluation and the second is for validating the system rules and results after building it. It was suggested in [47,98] to simulate neutrosophic inference system by designing three fuzzy inference systems representing true, indeterminate and false value as currently no software is available for it. Each inference can be executed independently of each other using MATLAB fuzzy logic toolbox.

There is no need to develop a new tool from scratch as Simulation of neutrosophic expert system has been performed by Fuzzytech 5.54 software [99]. Actually Fuzzytech does not provide the neutrosophication possibility but it could simulate it by three fuzzy inferences representing true, indeterminate and false values. Fuzzytech permits more building and connecting for neutrosophication values better than other fuzzy inference systems, as it allows the implementing of true, indeterminacy, and false memberships freely without applying fuzzy membership restrictions which is not provided in the Matlab fuzzy logic toolbox.

5.3.1 Neutrosophic Expert System Algorithm

Algorithm of the proposed neutrosophic expert system for LMS quality assessment is illustrated as below [14]:

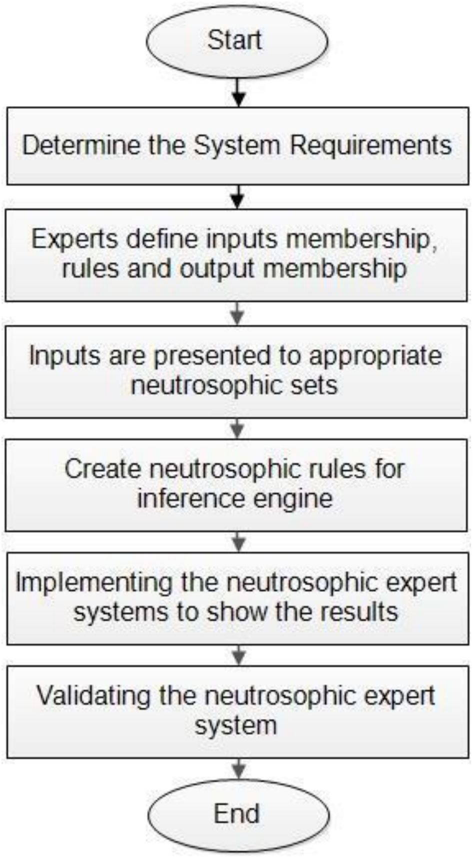


Figure 5.3 Neutrosophic Expert System Steps

5.3.2 Membership Functions for Input Parameters

As mentioned before the study concerns three main variables; usability, reliability, and accessibility to assess system quality in which true, indeterminate and false values inference systems have been created as shown in Figure 5.4 Usability is affected by efficiency, learnability, memorability, error tolerance and user satisfaction, reliability is affected by fault tolerance, maturity and recoverability, whereas, accessibility is affected by navigability, robustness and understandable.

The linguistic values input attributes were defined by experts as low, medium and high. True, indeterminacy and false membership values for efficiency inputs are shown in Figure 5.5, Figure 5.6, and Figure 5.7, respectively. The other membership values given by a degree of true, indeterminate and false for other input attributes are defined as efficiency which depends on information collected from experts.

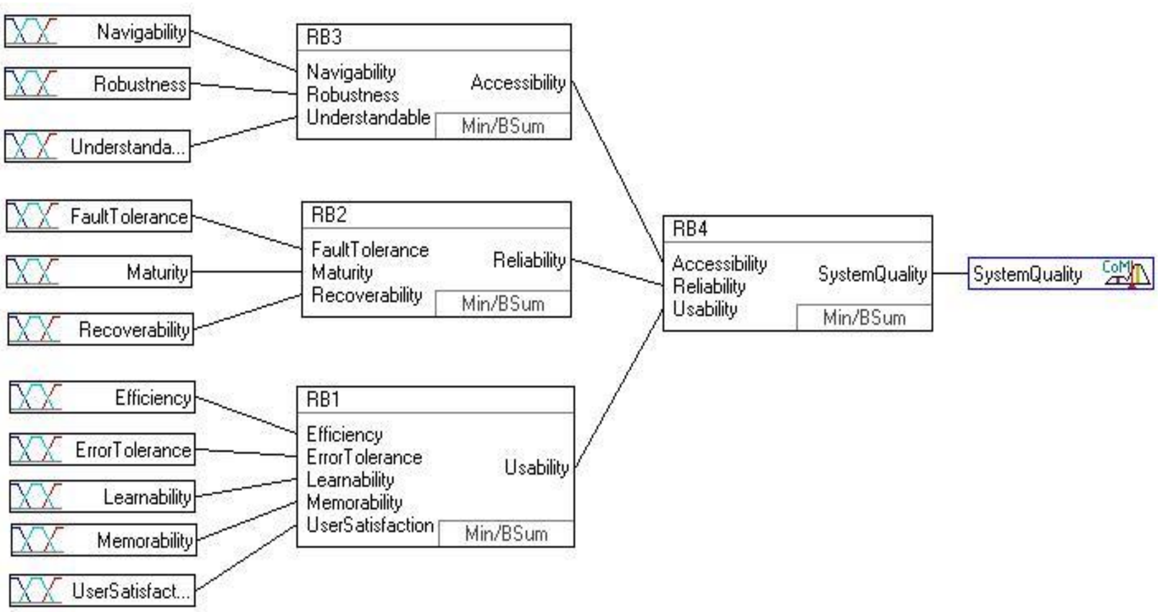


Figure 5.4 LMSs System Quality of Neutrosophic Expert System

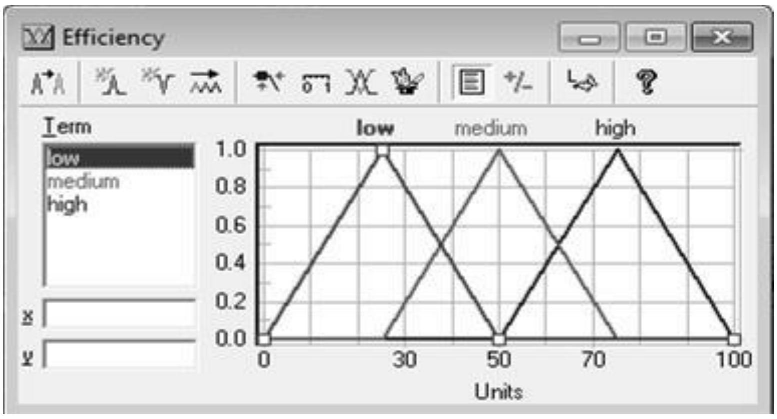


Figure 5.5 Efficiency True Input Membership

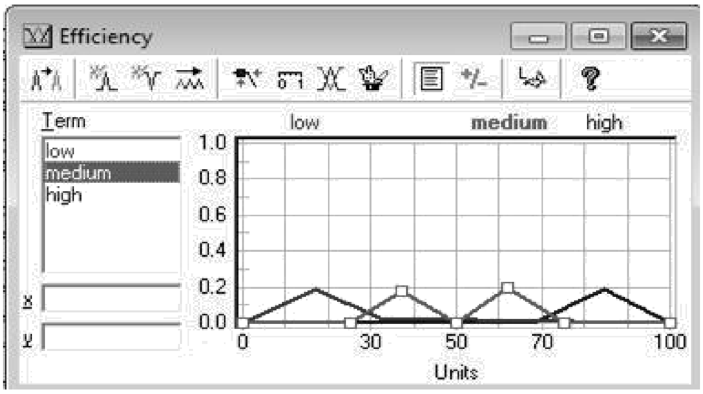


Figure 5.6 Efficiency Indeterminacy Input Membership

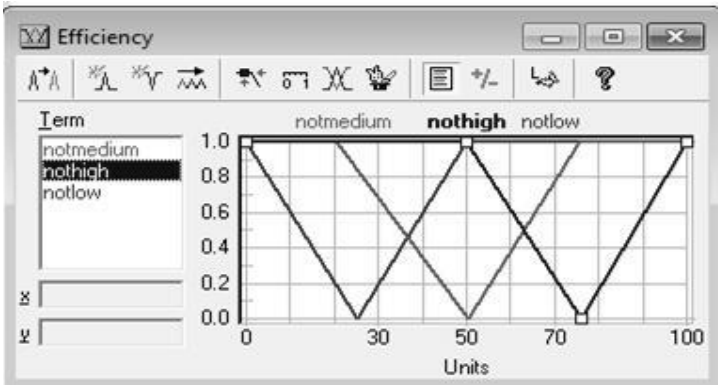


Figure 5.7 Efficiency False Input Membership

5.3.3 Knowledgebase and Evaluation Process

In the presented neutrosophic model, usability knowledge base includes five inputs; each consisting of true, indeterminacy, false values consisting of 3^5= 243 rules after considering all the possible combinations of inputs. While reliability knowledge base consists of 3^3=27 rules after considering all the possible combinations of inputs, as reliability considered three inputs; each consisting of three terms, each true, indeterminacy, and false. Accessibility is like usability as it considers three inputs which are true, indeterminacy, and false consisting of 243 rules. Reliability knowledge base consists of 3^3=27 rules after considering all the possible combinations of inputs. On the basis of experts' knowledge in eLearning field collected, the knowledge base rules are designed. A sample of the rules is listed in Figure 5.8, 5.9, 5.10, 5.11, 5.12, 5.13 for system quality knowledge base; also, there are other three knowledge bases for usability, reliability and accessibility. Degree of Support (DoS) is the degree to which the Fuzzytech software supports a specific rule in a rule base when calculating an inference from the fuzzy rule. The degree of support allows attaching individual weights to each rule in a rule base range from 0.00 to 1.00. Degree of support is not required in neutrosophic expert system as neutrosophic sets and rules are represented by degree of true, indeterminacy and false.

#	IF					THEN	
	Efficiency	ErrorTolerance	Learnability	Memorability	UserSatisfaction	DoS	Usability
1	low	low	low	low	low	1.00	very_low
2	low	low	low	low	medium	1.00	low
3	low	low	low	low	high	1.00	low
4	low	low	low	medium	low	1.00	low
5	low	low	low	medium	medium	1.00	low
6	low	low	low	medium	high	1.00	medium
7	low	low	low	high	low	1.00	low
8	low	low	low	high	medium	1.00	low
9	low	low	low	high	high	1.00	medium
10	low	low	medium	low	low	1.00	low

Figure 5.8 True Usability Knowledge Base

#	IF					THEN	
	Efficiency	ErrorTolerance	Learnability	Memorability	UserSatisfaction	DoS	Usability
1	low	low	low	low	low	1.00	very_low
2	low	low	low	low	medium	1.00	low
3	low	low	low	low	high	1.00	low
4	low	low	low	medium	low	1.00	low
5	low	low	low	medium	medium	1.00	low
6	low	low	low	medium	high	1.00	medium
7	low	low	low	high	low	1.00	low
8	low	low	low	high	medium	1.00	low
9	low	low	low	high	high	1.00	medium
10	low	low	medium	low	low	1.00	low

Figure 5.9 Indeterminacy Usability Knowledge Base

#	IF					THEN	
	Efficiency	ErrorTolerance	Learnability	Memorability	UserSatisfaction	DoS	Usability
1	notlow	notlow	notlow	notlow	notlow	1.00	notvery_low
2	notlow	notlow	notlow	notlow	notmedium	1.00	notlow
3	notlow	notlow	notlow	notlow	nothigh	1.00	notlow
4	notlow	notlow	notlow	notmedium	notlow	1.00	notlow
5	notlow	notlow	notlow	notmedium	notmedium	1.00	notlow
6	notlow	notlow	notlow	notmedium	nothigh	1.00	notmedium
7	notlow	notlow	notlow	nothigh	notlow	1.00	notlow
8	notlow	notlow	notlow	nothigh	notmedium	1.00	notlow
9	notlow	notlow	notlow	nothigh	nothigh	1.00	notmedium
10	notlow	notlow	notmedium	notlow	notlow	1.00	notlow

Figure 5.10 False Usability Knowledge Base

#	IF Accessibility	Reliability	Usability	THEN DoS	SystemQuality
1	very_low	very_low	very_low	1.00	very_low
2	very_low	very_low	low	1.00	low
3	very_low	very_low	medium	1.00	low
4	very_low	very_low	high	1.00	low
5	very_low	very_low	very_high	1.00	medium
6	very_low	low	very_low	1.00	low
7	very_low	low	low	1.00	low
8	very_low	low	medium	1.00	low
9	very_low	low	high	1.00	medium
10	very_low	low	very_high	1.00	medium

Figure 5.11 True System Quality Knowledge Base

#	IF Accessability	Reliability	Usability	THEN DoS	SystemQuality
1	very_low	very_low	very_low	1.00	medium
2	very_low	very_low	low	1.00	low
3	very_low	very_low	medium	1.00	low
4	very_low	very_low	high	1.00	low
5	very_low	very_low	very_high	1.00	medium
6	very_low	low	very_low	1.00	low
7	very_low	low	low	1.00	low
8	very_low	low	medium	1.00	low
9	very_low	low	high	1.00	medium
10	very_low	low	very_high	1.00	medium

Figure 5.12 Indeterminacy System Quality Knowledge Base

#	IF Accessability	Reliability	Usability	THEN DoS	SystemQuality
1	notvery_low	notvery_low	notvery_low	1.00	very_low
2	notvery_low	notvery_low	notlow	1.00	low
3	notvery_low	notvery_low	notmedium	1.00	low
4	notvery_low	notvery_low	nothigh	1.00	low
5	notvery_low	notvery_low	notvery_high	1.00	medium
6	notvery_low	notlow	notvery_low	1.00	low
7	notvery_low	notlow	notlow	1.00	low
8	notvery_low	notlow	notmedium	1.00	low
9	notvery_low	notlow	nothigh	1.00	medium
10	notvery_low	notlow	notvery_high	1.00	medium

Figure 5.13 False System Quality Knowledge Base

5.3.4 Membership and Knowledge Base for Output

The presented neutrosophic expert system assesses system LMSs system quality considering three main criteria which are usability, reliability, and accessibility. Three inputs for system quality are considered; consisting of five terms, then each true, indeterminacy, and false system quality knowledge base consists of 243 rules after considering all the possible combinations of inputs. Three inputs for reliability are considered; each consisting of three terms, true, indeterminacy, and false reliability knowledge base consists of 125 rules after considering all the possible combinations of inputs. True, indeterminacy, and false membership values for the system quality are shown in Figure 5.14, 5.15 and 5.16 respectively.

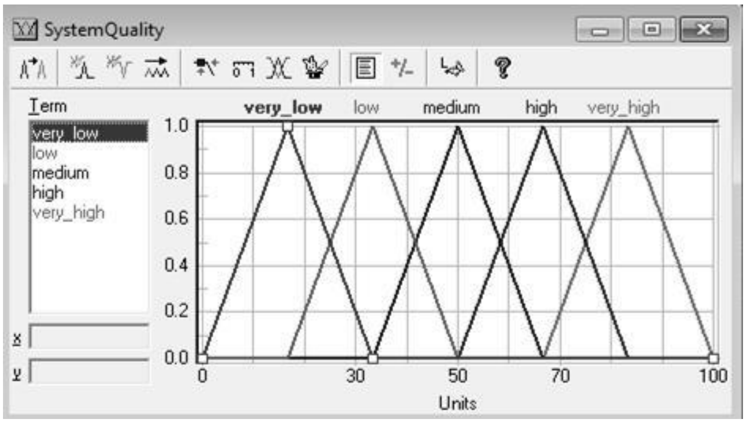


Figure 5.14 System Quality True Membership

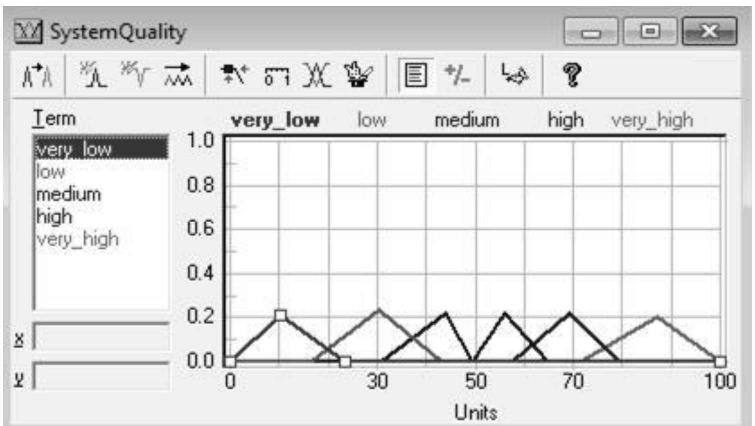


Figure 5.15 System Quality Indeterminacy Membership

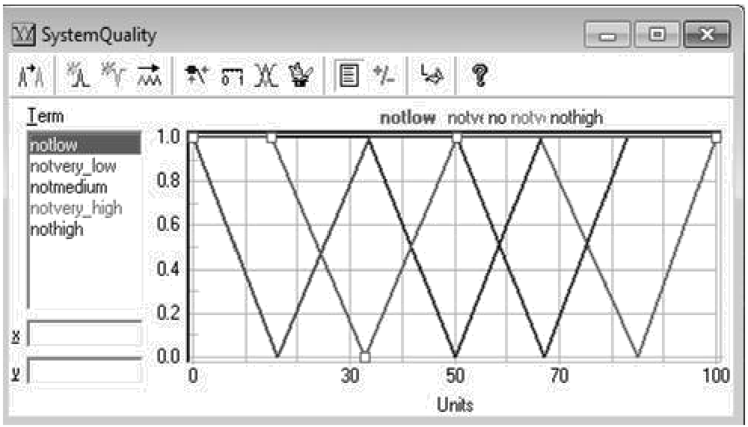


Figure 5.16 System Quality False Membership

5.3.5 Validating Neutrosophic Expert System

In uncertain environments, system validation includes thorough testing to assure that the system provides like an expert the correct decisions in the same field. Gonzalez and Barr said that validation process is ensuring that the output of the expert system is equivalent to those of human experts when given the same inputs [100]. The testing process compares the system's results with that of experts expected results [101]. Knauf et al. and Jiri Bartos at al. present methodologies for assessing system quality under uncertainty where functional and non-functional requirements can be tested [102-104]. These methods involve steps which are: criteria identification for testing that cover the domain, a set of questions to validate neutrosophic knowledge base generation, different tests are prepared that evaluates whether the system is compatible with predefined criteria, where the test doesn't involve subjective opinions of the tester. A comparison then is performed between system responses and Eight experts' (the same experts who helped in creating the knowledge base referred in the acknowledgments) responses. The experts' responses express solutions and admit indeterminacy rating of solutions. Last the results of experimentation steps are used to determine and fix errors to improve the knowledge base.

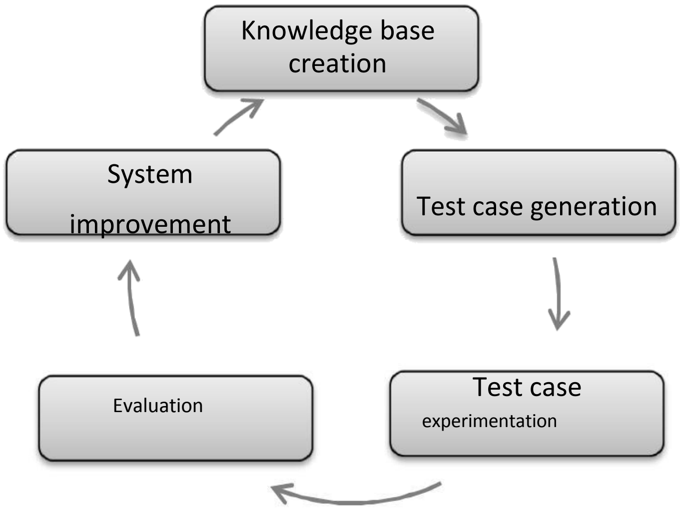


Figure 5.17 Knauf Validation Framework [102]

5.4 Neutrosophic Expert System

The goal of this study is to present a neutrosophic expert system to assess LMSs quality. According to the experts' opinions, seven examples for LMSs assessment are performed and the following results have been deducted. The presented neutrosophic expert system for assessing LMSs quality as illustrated in this chapter and fuzzy expert system which is used to compare the final results. The results generated by neutrosophic expert system have three components of truth, indeterminacy, and falsity unlike in fuzzy expert system which represents the true membership value only and has no solution when experts have a hesitancy to define membership. The comparison of the results obtained by fuzzy expert system and the proposed neutrosophic expert system show that fuzzy system is limited as it cannot represent paradoxes as a feature of human thinking. Neutrosophic expert system gives obvious intuition of true, indeterminacy and false associate with inputs, rules and outputs.

5.5 Summary

There has been unexpected increase for LMSs usage to support learner's learning process in higher education. Previous studies in learning management system assessment are implemented under assumption of complete information, while the real environment has uncertainty aspects. Therefore, traditional evaluation methods are not effective in all cases. As previous studies suggested neutrosophic expert systems as future work in eLearning applications, this chapter shows neutrosophic expert system for learning management systems assessment.

Expert systems did not depend on true and falsity information, but also on indeterminate information which is the unawareness value between true and false. Neutrosophic logic can handle indeterminacy information where statement can be described by truth, indeterminacy and false membership functions independent of each other. Therefore, it is a better option to emulate human expert thought than fuzzy logic because unlike fuzzy logic as it is able to express the percentage of unknown parameters. As an example, if an expert is asked about his opinion about certain statement, then he may say that the prospects that the statement is true, false and indeterminacy are 0.8, 0.4 and 0.5 respectively.

In this chapter, an expert system for LMSs quality evaluation using a neutrosophic logic approach based on eleven performance criteria which are efficiency, learnability, memorability, error tolerance and user satisfaction for usability; fault tolerance, maturity and recoverability for reliability; and navigability, robustness and understandable for accessibility is presented. Information is collected from eight experts using questionnaires for building and validating the neutrosophic expert system using Fuzzytech 5.54d software. Neutrosophic expert system validation has been performed based on Knauf validation framework to improve knowledge base.

Chapter 6
Results and Discussion

Chapter 6: Results and Discussion

6.1 Introduction

The dissertation presents neutrosophic logic as a better option to simulate human reasoning which proposed by Smarandache in 1998. Neutrosophic logic is an extension of the fuzzy logic, intuitionistic logic which describes the variable with three values which are truth, false and indeterminacy. The neutrosophic logic addition from other logics is the degree of indeterminacy which presents the percentage of unknown parameters. The results illustrate that fuzzy and intuitionistic fuzzy sets are limited as they cannot represent contradictions of human thinking. Neutrosophic logic is needed in real life problems such as expert system, belief system and information fusion for suitable description of an object in uncertain environment.

The dissertation concerns LMSs evaluation under uncertainty which includes three challenges: exploring the factors affects the success of LMS and presenting LMS success measurement model, determining the most suitable LMS that meets organization's requirements, and assessing the LMS quality.

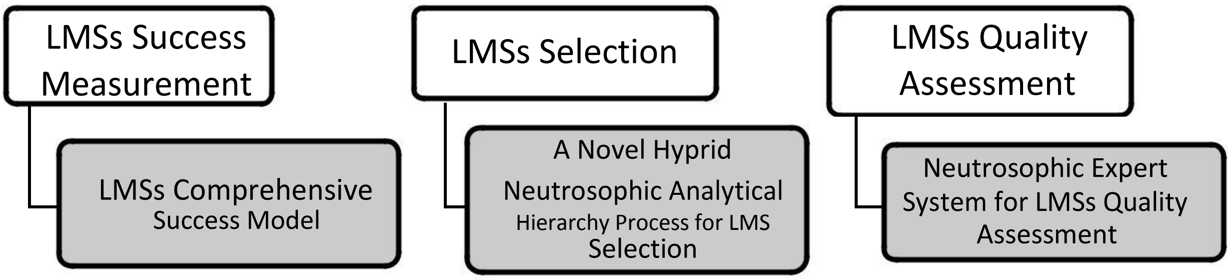


Figure 6.1 LMSs Evaluation

6.2 Learning Management Systems Success

The first challenge of the dissertation investigated LMS success critical factors by former studies and experts from different point of views. The study considers system design, system usage and system outcome dimensions for LMSs success model. System design includes personal factors, system factors, organizational factors and supportive factors. The results show that information quality, system quality and service quality factors have the most important concern on LMSs success studies. The importance of factors and relationship between them presented by neutrosophic values rather than fuzzy values as it can represent contradictions which are true and false at the same time. The model resolved the weaknesses point of previous models by illustrating the relationships among the constructs of the model. Figure 6.2 presents the comparison of the factor importance obtained by the fuzzy set and neutrosophic set of system dimensions.

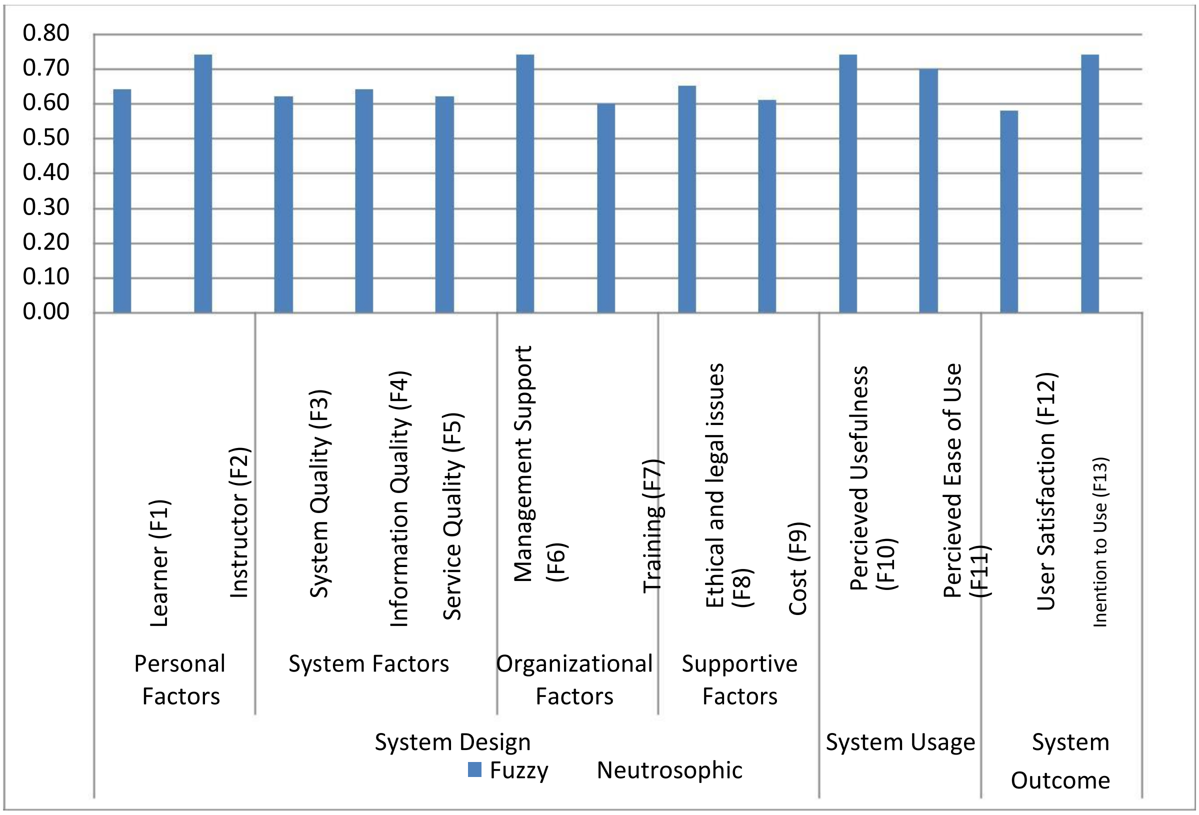
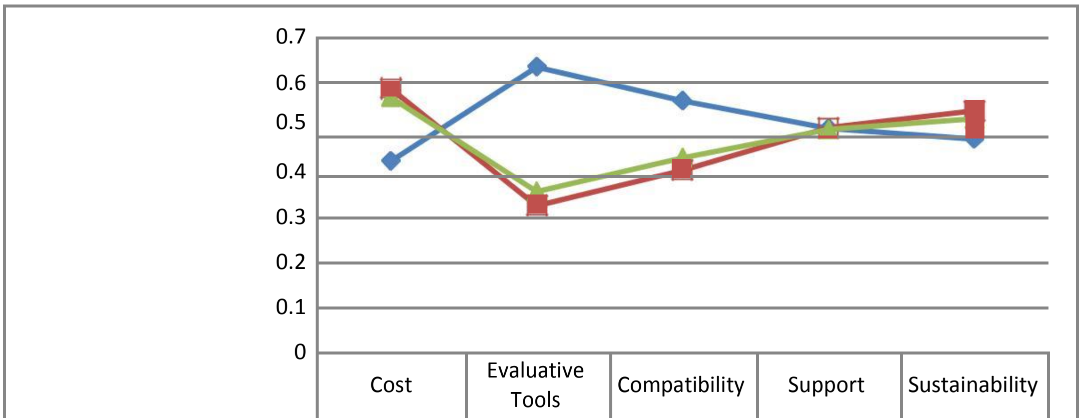


Figure 6.2 Results of the Factor Importance by Fuzzy Set and Neutrosophic Set

6.3 Learning Management Systems Selection

The second challenge of the dissertation presents a neutrosophic multi criteria decision making method to be applied for selecting a learning management system according to the decision makers' preferences. The LMSs software taken the study are Moodle, Sakai, Atutor, ILIAS, and Dokeos and the main criteria used are cost, evaluative tools, computability, support, and sustainability. Figure 6.3 and Figure 6.4 shows the results of weight percentages of the neutrosophic and deneutrosphied values scale based on judgements of the criteria.



	Cost	Evaluative Tools	Compatibility	Support	Sustainability
TRUE	0.4292	0.6382	0.5632	0.5011	0.4779
INDETERMINANACY	0.5902	0.3298	0.4087	0.5027	0.5404
FALSE	0.5708	0.3618	0.4368	0.4989	0.5221

Figure 6.3 Weight Percentages presented in Neutrosophic values

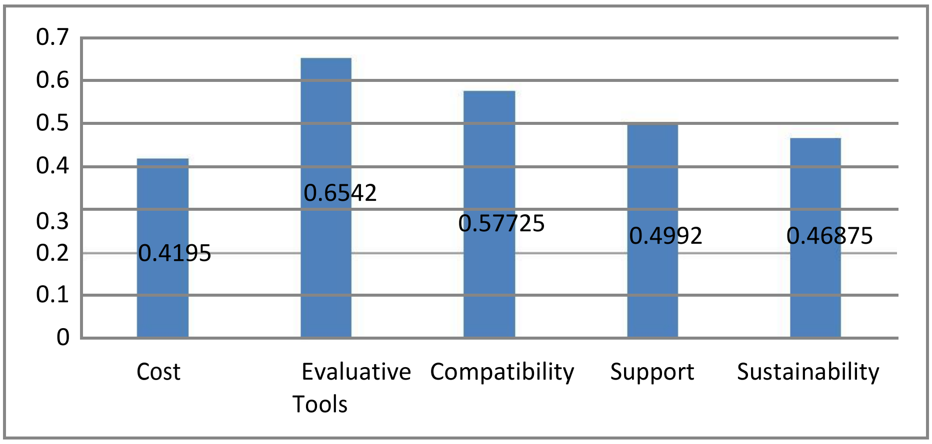
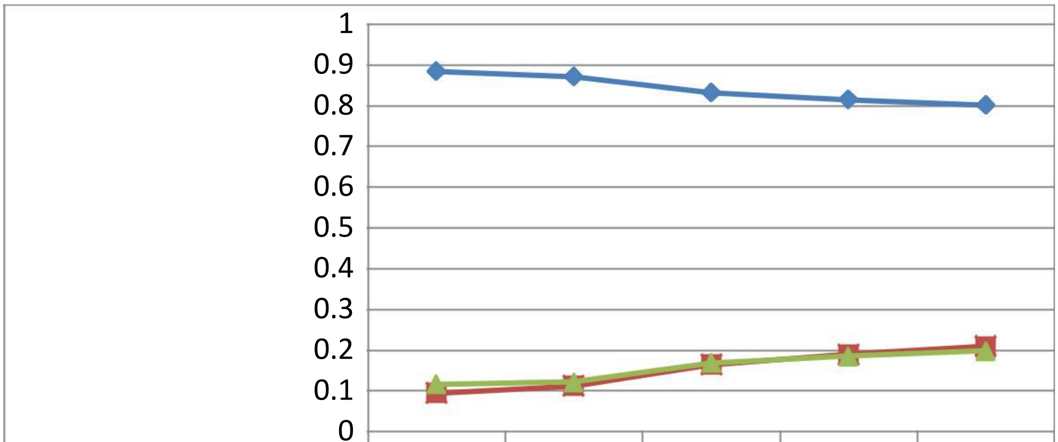


Figure 6.4 Weight Percentages presented in Deneutrosophied values

The use of the NAHP as a multi-criteria decision making method, for the selection of the most appropriate LMS, using given priorities and criteria, was presented. NAHP offers reliable results when collaboration takes place between decision makers and experts, and a good methodology is adopted. The inconsistency checking during the pairwise comparisons makes the NAHP reliable as a decision making method, even for people who are less experienced in taking decisions. The results of the study cannot be generalized, due to the face that the NAHP cannot evaluate products by itself.

In conclusion, according to given priorities shown in the criteria and sub criteria, Moodle is the most appropriate one that met the due to the determined criteria followed by Atutor and Dokeos which are accepted by experts as shown in Figure 6.5 and Figure 6.6. It is noted that the developed method can be used for different types of MCDM problems and these findings differ as a goal changes.



	Moodle	Atutor	Dokeos	Sakai	ILIAS
TRUE	0.8838	0.8709	0.8315	0.8147	0.802
INDETERMINANACY	0.0949	0.112	0.1655	0.1895	0.2096
FALSE	0.1162	0.1219	0.1685	0.1853	0.198

Figure 6.5 Weight Percentages of the Neutrosophic Scale Based the Alternatives

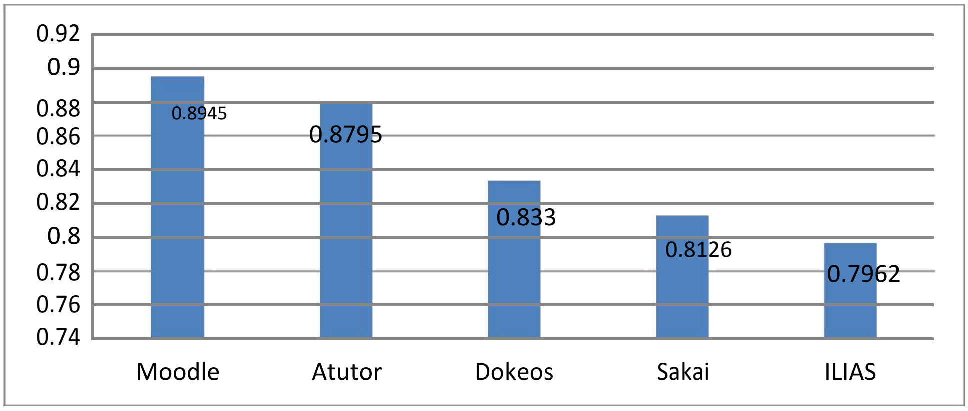


Figure 6.6 Weight Percentages of the Deneutrosophied values of Alternatives

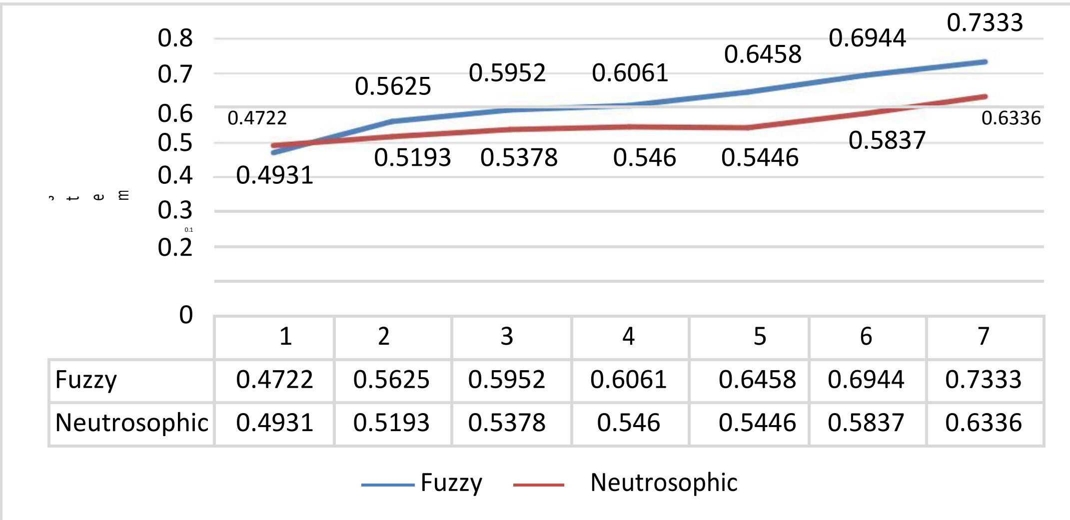
6.4 Learning Management Systems Quality Assessment

The third challenge presents neutrosophic logic to be applied in expert systems as it is a better solution to emulate human reasoning indeterminacy of information. The neutrosophic expert system presented for LMSs quality assessment considers three main attributes: usability, accessibility, and reliability. The information required for is collected by two questionnaires from eight experts; one for collecting the data needed to build the expert system, and the other is for validating the system rules and results after building it.

The final objective of this study was to present a neutrosophic expert system to evaluate LMSs quality. According to the experts' opinions, authors applied it for seven examples for LMSs evaluations, and the following results have been presented. The authors presented neutrosophic expert system for evaluating LMSs quality as illustrated in this paper, and fuzzy expert system which was not clarified as it was used to compare the final results. The results generated by neutrosophic expert system have three components of truth, indeterminacy, and false unlike in fuzzy expert system which represents the true membership value only and has no solution when experts have a to define membership. Fuzzy system handle vagueness; while neutrosophic system deals with vagueness when information is naturally graded, imprecision when the available information is not specified, ambiguity when information is unclear, and inconsistent when obtainable information is conflicted information existing in real world.

Neutrosophic expert system maps the true, indeterminacy and false inputs membership functions, knowledge base and output membership functions. Simulation of the neutrosophic expert system implemented by Fuzzytech 5.54 software it allows the implementing of true, indeterminacy, and false memberships freely without applying fuzzy membership restrictions which is not provided in other fuzzy logic software. The results illustrate that fuzzy expert system is limited as it represents the true membership value only and it cannot represent human paradoxes. Neutrosophic expert system deals with the different uncertainty types which are vagueness, imprecision, ambiguity, and inconsistent when obtainable information.

The findings resulted by neutrosophic expert system differs from fuzzy expert system which represents the true membership value only and has no solution when experts have a hesitancy to define membership. Figure 6.7 shows the comparison of the findings obtained by fuzzy expert system and the proposed neutrosophic expert system. The fuzzy system results are limited as it does not represent paradoxes as a feature of human thinking. Neutrosophic expert system gives obvious intuition of true, indeterminacy and false associate with inputs, rules and outputs.



	1	2	3	4	5	6	7
Fuzzy	0.4722	0.5625	0.5952	0.6061	0.6458	0.6944	0.7333
Neutrosophic	0.4931	0.5193	0.5378	0.546	0.5446	0.5837	0.6336

Figure 6.7 Results of the applied examples of Fuzzy and Neutrosophic Expert System

Chapter 7
Conclusion and Future Work

Chapter 7: Conclusion and Future Work

7.1 Conclusion

This Dissertation applied theoretical and practical aspects neutrosophic logic as in LMSs evaluation. It presented a comprehensive model to evaluate LMSs under uncertainty. Using neutrosophic sets gives obvious intuition than the fuzzy logic which is limited in representing paradoxes.

First, the dissertation reviewed various multivalued logic approaches that handle different types of uncertainties. The review showed that neutrosophic logic is as a better option to simulate human thinking as it handles vagueness, imprecision, ambiguity, and inconsistent uncertainties types, while fuzzy, type2 fuzzy and intuitionistic fuzzy can't handle information indeterminacy.

Second, a survey for LMSs success models was presented to investigate critical factors that affect LMSs success. From previous studies, the study develops an overall model for measuring the success of LMS from different perspectives. The presented model differs from previous models as it shows the relationships among the constructs of the model by concerning three dimensions of LMSs success which are system design; system usage; and system outcome. Neutrosophic values are endorsed in this study to represent the factors and weight importance rather than fuzzy values as it can represent and handle indeterminate information.

Third, a novel multi-criteria decision making method for LMs selection was developed. AHP is one of the most popular MCDM methods is. AHP is a reliable method that can deal with tangible and non-tangible attributes and compare alternatives with relative ease using hierarchical structure. The main limitation of AHP is its incapability of representing uncertain human's thoughts. Thus, the study extends the AHP method via the neutrosophic set. The developed method provides reliable results due to the fact that uncertain preferences can be expressed and inconsistency checking during the pairwise comparisons is applied. The most suitable LMSs in this case were Moodle according to defined criteria, after that comes Atutor, Dokeos, Sakai, Ilias orderly. The results cannot be generalized, due to the fact that the methods depend on defined preferences and it cannot evaluate products by itself. The developed method can be used for different types of MCDM problems.

Finally, a neutrosophic expert system for LMSs quality assessment based on usability, reliability, and accessibility criteria is presented. Prior studies for LMS quality assessment are performed under complete information, although uncertainty is a feature of true world. Information needed for developing and validating neutrosophic expert system was collected by surveys from eight experts. Simulation of the proposed system has been carried out by Fuzzytech 5.54 application by building three fuzzy inference systems representing the true, indeterminate and false value. By comparing the results of fuzzy expert system and neutrosophic expert system, it concluded that neutrosophic logic is capable of representing uncertainty in human thinking for assessing LMSs.

7.2 Future Work

As discussed in the dissertation, the continuous increasing number of LMSs usage in educational institutions leads to the need of achieving LMSs success, selection and assessment too. LMSs former researches performed under complete information, while the real environment has uncertainty aspects. The dissertation discusses the theoretical and practical aspects of applying neutrosophic logic in LMSs evaluation that can be applied in different domains.

Generating the content according to learner's intellect is a current challenge in e-learning systems. Most of the e-learning systems evaluate the learner’s intellect level according to tests crisp responses that are taken during the learning process. However, many factors lead to uncertainty about the evaluation process. Neutrosophic logic can add a value for personal learning environment by building an intelligent system for learner’s assessment and learning materials personalization according to learner’s level.

Further work will present a novel approach using neutrosophic logic to build an intelligent system that handles imprecision, vagueness, ambiguity and inconsistence information about the learners' assessment to personalize the learning material according to learners' level. Also, neutrosophic logic is worth in Future work to deal with talent eLearning system that recommends training courses suitable for learner's talent in which neutrosophic is needed to identify learner's needs and skills. The integration of talent management and eLearning system, improve the learner's task related skills.

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كلية الحاسبات و المعلومات
قسم نظم المعلومات
جامعة المنصورة

تقييم نظم ادارة التعلم

رسالة مقدمة للحصول على درجة الدكتوراه فى نظم المعلومات

الباحث
نوران محمد رضوان حسين

تحت اشراف

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أستاذ نظم المعلومات
أكاديمية السادات

٢٠١٨

كلية الحاسبات والمعلومات
قسم نظم المعلومات

لجنة الاشراف

عنوان الرسالة: تقييم نظم ادارة التعلم
اسم الباحث: نوران محمد رضوان حسين
الدرجة: الدكتوراه

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كلية الحاسبات والمعلومات
قسم نظم المعلومات

لجنة الحكم و المناقشة

عنوان الرسالة: تقييم نظم ادارة التعلم
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المـــلخـــص

تهتم الدراسات المتعلقة بعملية التقييم بجمع المعلومات التي تساعد في اتخاذ القرار لعمليات القياس، والاختيار، والتقدير بشأن حالة محددة. فمثلا في عملية القياس يتم تحديد التفضيلات التي تؤثر على الوضع لإنشاء قواعد القياسية، اما عملية الاختيار فتتعلق باختيار الخيار المناسب من خلال جمع المعرفة من صناع القرار، وأخيرا عملية التقييم التي تتضمن جمع المعلومات الضمنية والصريحة لضمان تحقيق الهدف المحدد.

وتستخدم نظم إدارة التعلم (انظمة إدارة التعلم) اليوم للمساعدة في تصميم، وتسليم، وإدارة مصادر التعلم للمتعلمين. ولذلك فان عملية تقييم انظمة إدارة التعلم أصبحت مطلب هام في المؤسسة التعليمية. وقد قامت العديد من الدراسات السابقة في تقييم انظمة إدارة التعلم بافتراض توافر المعلومات الكاملة، في حين صعوبة تحقيق ذلك في العالم الحقيقي الذي يشتمل على جوانب عديدة تتصف بعدم اليقين. حيث تم وصف هذه الأنظمة من قبل صناع القرار بعبارات غامضة، غير دقيقة، مبهمة، متعارضة مما يجعل استخدام الطرق التقليدية لتقييمها نظم غير فعال.

وفي هذه الرسالة تنقسم عملية تقييم نظم إدارة التعلم بثلاث تحديات: استكشاف وقياس العوامل التي تؤثر على نجاح تطبيق نظم إدارة التعلم، وتحديد البديل الأنسب من برامج نظم ادارة التعلم الذي يلبي متطلبات المؤسسة التعليمية، وتقدير جودة تلك النظم بعد التطبيق.

فبالنسبة الي التحدي الأول، فلا يمكن قياس نجاح تطبيق نظم ادارة التعلم بالاعتماد على عامل واحد مثل رضا المستخدمين أو عزم الاستخدام. ولقد قامت العديد من الدراسات السابقة بعرض العوامل المختلفة التي تؤثر على نجاح نظم المعلومات وأنظمة التعلم الإلكتروني ولكن لم يقدم احد نموذج شامل يجمع كل تلك العوامل و علاقتها. أما في هذا الجانب من الدراسة، فقد تم عرض استقصاء للعوامل الحرجة لنجاح انظمة إدارة التعلم من مختلف وجهات النظر وتطوير نموذج شامل لقياس نجاح تلك الأنظمة اعتمادا على الأبحاث السابقة والخبراء في مجال ممارسات التعلم الإلكتروني والتعليم العالي.
أما التحدي الثاني فيهتم بتطوير طريقة جديدة بدمج منطق النيوتروسوفيك مع عملية التسلسل الهرمي التحليلية لدعم مواجهة عدم اليقين في عملية صنع القرار للتعامل مع المعلومات الغامضة. ولتوضيح الطريقة المقترحة تم إجراء تجربة عددية لاختيار نظام إدارة التعلم المناسب، وأشارت النتائج إلى أن المنطق النيوتروسوفي يمكن أن يعبر عن المفاهيم الغامضة، والغير دقيقة، والمبهمة، والمتعارضة التي تستخدم من قبل المنطق البشري. وقد أظهرت النتائج أن "موودل" وهو احدى نظم إدارة التعلم هو الأنسب لتلبيته معايير محددة تم تحديدها من قبل متخذي القرار في هذه الحالة.

ويهتم التحدي الثالث بتقديم نظام خبير نيوتروسوفي لتقدير جودة نظم إدارة التعلم. حيث أن المنطق النيوتروسوفي هو النهج الأفضل لمحاكاة التفكير البشري من المنطق الضبابي لأن يمكنه التعامل مع المعلومات الغير دقيقة التي تعبر عن نسبة المعلمات المجهولة. ولقد تم جمع المعلومات لبناء والتحقق من صحة نظام الخبير النيوتروسوفي من خلال خمسة خبراء، وتم بناء النظام التحليلي من خلال البرنامج تحليل Fuzzytech 5.54d. وتشير النتائج إلى أن المنطق النيوتروسوفي قادر على تمثيل عدم اليقين الذي يتصف به العقل البشري لتقدير جودة نظم إدارة التعلم.

تتكون الرسالة من وهم كالآتي:

الفصل الأول: يحتوي هذا الفصل على مقدمة عامة للرسالة مستعرضا مشكلة وأهداف البحث وكذلك المنهجية المتبعة خلال مراحل البحث.
الفصل الثاني: يعرض هذا الفصل عدد من الموضوعات المتعلقة بنظم إدارة التعلم وتقييمها والتقنيات التي تتعامل مع المعلومات في حالة عدم اليقين. كما يتناول الفصل الدراسات الحديثة الحالية في مجال تقييم نظم إدارة التعلم محددة فيها عددا من التحديات وبالتالي المساهمة الجديدة التي يضيفها البحث.
الفصل الثالث: يقدم هذا الفصل نموذج شامل يجمع العوامل الحرجة وعلاقتها مع بعضها البعض لقياس نجاح نظم إدارة التعلم القرارباستخدام منطق النيتروسوفيك .
الفصل الرابع: تم عرض تطوير طريقة حديثة من خلال دمج منطق النيوتروسوفيك مع عملية التسلسل الهرمي التحليلية لدعم مواجهة عدم اليقين في عملية صنع القرار ولتوضيح الطريقة المقترحة تم إجراء تجربة عددية لاختيار نظام إدارة التعلم المناسب.
الفصل الخامس: يقوم هذا الفصل بتقديم نظام خبير نيوتروسوفي لتقدير جودة نظم إدارة التعلم وقد تم توضيح أن المنطق النيوتروسوفي هو المنهج الأفضل لمحاكاة التفكير البشري من المنطق الضبابي.
الفصل السادس: يقوم الفصل بتقديم التحديات البحث والحلول المقترحة ونتائج البحث.
الفصل السابع: يعرض الفصل استنتاجات الدراسة وعدد من التوصيات القابلة للتنفيذ وكذلك اتجاهات البحوث المستقبلية لذات المجال.