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FACTORS CONTRIBUTING TOWARDS CONSTRUCTIVIST LEARNING ENVIRONMENT - ANALYSIS USING FCM WITH INTERVAL VALUED LNCH APPROACH

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ABSTRACT. Teaching is the process of fulfilling the needs of the learners with the incorporation of innovative pedagogical tools. The classroom is becoming a battle field for the teachers as they combat against the channels of distraction of the learners and the diversity of the learner's sensory perception also adds to the intensity. The present educational system is devising suitable strategies to meet the didactic demands of Gen Z learners and learner centric approaches are gaining momentum. Exploration of ideas by working in groups in the presence of teacher performing the role of a moderator is the framework of constructivist learning environment and this learner centered approach will certainly facilitate the process of learning. Constructivist classrooms are highly meritorious as it stimulates the process of cognition development and skill acquisition.

It is the right time for the educationalist to formulate the mechanisms of creating constructivist learning environment, as an initial stage, the factors contributing towards such kind of learning environment have to be investigated in a systematic manner and this article is a step towards to it and assumes it as its aim. To reach the conclusions in a more objective manner, the notion of interval valued linguistic neutrosophic concentric fuzzy hypergraphs (LN$\mathcal{C}_{\mathcal{H}}$) are used in integration with Fuzzy Cognitive maps (FCM) to determine the core facilitating factors for constructivist learning environment with the assistance of expert's opinion.

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Key words and phrases. fuzzy cognitive maps, concentric fuzzy hypergraph, linguistic, neutrosophic, interval valued, constructivist classroom.

1. INTRODUCTION

The field of education is revolutionized to meet the demands of the digital natives by customizing towards learner centeredness. The younger techno generation craves for ingenious and collaborative learning environment for which the educationalists are exploring innovative teaching methods to bring changes in the existing educational scenario. The educational experts are designing new models of creative and interactive classrooms and one such kind is constructivist classroom which is embedded with new approaches of teaching and learning. Role modification is one of the significant characteristics of constructivist classroom, in which the conventional role set up of a teacher as instructor is transmuted to teacher as facilitator and the learners are moving from passive phase to active phase. Establishing constructivist classroom is chained by certain barriers of implementation and the absence of focus on the factors to be modified also adds to it. The set up of constructivist classroom is not subjected to modification of external appearance, rather it has to cater to the internal organization of the process of teaching and learning.

The need of such shift in the process of teaching and learning is under study by the researchers, who carry out their research on the impacts of innovative teaching and learning methods on the cognitive, conative and psychomotor domains of learning. But still, the blooming of constructivist classrooms in an educational set up is not much successful due to the experience of certain mishaps in the process of experimentation and it gets failed in its implementation. The factors contributing towards successful execution of constructivist classroom have to be determined to make a change in the conventional learning mode by overcoming the barriers.

Decision making is a massive task which encompasses multi stage processes and several experts' opinion to arrive at optimal decisions. The prime aim of this research is to investigate the factors contributing towards successful execution of constructivist classroom; determine the core factors and its interrelationship. To accomplish these tasks, fuzzy cognitive maps integrated with interval - valued linguistic neutrosophic concentric hypergraphs are used as a decision making tool.

The field of fuzzy hypergraphs is reconnoitered by the academicians and the theoretical developments of these aspects are transferred to practical applications. The fuzzy hypergraphs are getting extended to neutrosophic hypergraphs and complex neutrosophic hypergraphs which was discussed by Muhammad Akram et.al. [3]. This has motivated us to introduce neutrosophic concentric fuzzy hypergraphs with interval-valued linguistic representations. The notion of concentric fuzzy hypergraph was introduced by Nivetha and I. Pradeepa [5] and this kind of hypergraph was integrated with FCM with the intention of limiting the factors of the study and determining the interrelationship only between the core factors. FCM with linguistic concentric hypergraph was used as a decision making tool in evaluating the benefits of outcome based education by Nivetha et.al. The extension of neutrosophic concentric fuzzy hypergraphs with interval-valued linguistic representations will duly assist the decision makers to handle the prevailing uncertainties in making decisions.

The content of the paper is organized as follows, section 2 presents the methodology; section 3 comprises of the factors of study and computational results; section 4 discusses the results and the last section consolidates the research work.

2. METHODOLOGY

This section presents the sequence of steps of determining the optimal decision along with the preliminary requisite of related concepts. The definitions of the fundamental concepts required for this study is presented in accordance to the author's outlook based on the original concept construction.

2.1. **Preliminaries [4–6].**

Definition 2.1. Fuzzy set
Let X be a Universal set. A fuzzy set A is defined as $\{(x, A(x)), x \in X\}$, where $A(x) : X \to [0, 1]$.

Definition 2.2. Neutrosophic fuzzy set
A neutrosophic fuzzy set is represented by $\{(x, T(x), I(x), F(x)), x \in X\}$, where $T(x), I(x), A(x)$ are truth, indeterminacy and false membership functions and are all fuzzy sets.

Definition 2.3. Interval-valued neutrosophic fuzzy sets
An interval-valued neutrosophic fuzzy set is represented by $\{(x, T(x), I(x), F(x)), x \in X\}$*, where* $T(x), I(x), A(x)$ *are truth, indeterminacy and false membership interval-valued functions.*

Definition 2.4. Triangular Membership Function
A Triangular Fuzzy number A will be of the form (a_1, a_2, a_3) *and has the membership function of the form*

$$\mu_A(x) = \begin{cases} 0, x < a_1 \\ \frac{x-a_1}{a_2-a_1}, a_1 \leq x \leq a_2 \\ \frac{a_3-x}{a_3-a_2}, a_2 \leq x \leq a_3 \end{cases}$$

Definition 2.5. Concentric fuzzy hypergraph (Nivetha and Pradeepa)
A concentric fuzzy hypergraph $\mathcal{C}_{\mathcal{H}}$ *is defined as* $\mathcal{C}_{\mathcal{H}} = (X, \mathcal{E})$*, where* X *is finite set of vertex set.*

$\mathcal{E}$ *- concentric fuzzy hyper envelope - family of fuzzy sets of* X

$\mathcal{E}_{|} = \{(x_i, \mu_j(x_i))\,/\mu_j(x_i) > 0 \; and \; \forall x_i \in X\}$*,* $j = 1, 2, \ldots m$*.*

Definition 2.6. Linguistic variable
A variable to which linguistic terms are assigned is the linguistic variable.

Definition 2.7. Triangular quantification of linguistic variables

Very Low	*(0,0.1,0.2)*	*0.1*
Low	*(0.2,0.3,0.4)*	*0.3*
Medium	*(0.4,0.5,0.6)*	*0.5*
High	*(0.6,0.7,0.8)*	*0.7*
Very High	*(0.8,0.9,1)*	*0.9*

2.2. **Methodology.**

Step I: The initial expert's opinion of each factors are represented as interval-valued linguistic neutrosophic concentric hypergraphs.

Step II: The aggregate interval-valued neutrosophic representations of each factor is determined and its respective score value is obtained to find the core factors $S(C) = \frac{2+l+m-2n-2o-p-q}{4}$, where $C = ([l, m], [n, o], [p, q])$ [7].

Step III: The Fuzzy cognitive maps are used to find the interrelationship between the core factors by adopting the earlier procedure.

3. FACTORS CONTRIBUTING TOWARDS CONSTRUCTIVIST LEARNING ENVIRONMENT

The factors considered for the study are presented as follows [1, 2]:

(1) Efficacy of the instructor
(2) Feasible classroom environment
(3) Active participation of the students
(4) Acquisition of profound knowledge of constructive approach of teaching by the facilitator
(5) Instructor must act as moderator
(6) Democratic relationship between the facilitator and learners
(7) Formulation of need based curriculum fulfilling the requirements of the domains of learning
(8) Effective teaching and learning process
(9) Creating environment for the learners to organize the process of learning

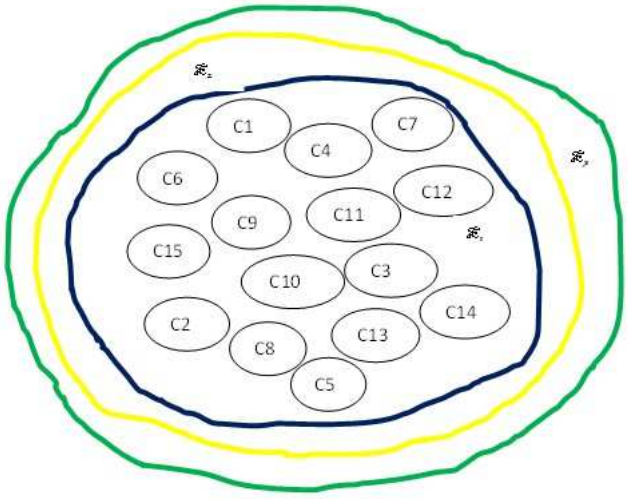

Fig.3.1 Concentric neutrosophic hypergraphs based on expert's opinion

(10) Establishing interface between student's experience and learning
(11) Organizing group activities to explore the diverse skills of the learners
(12) Planning activities to promote the creativity of the learners

(13) Enriching critical thinking and problem-solving skills by exposing the learners to different scenario
(14) Emphasizing student centric approach in all teaching and learning activities
(15) Generating opportunities for the learners to act independently

The neutrosophic concentric fuzzy hyper envelopes with interval-valued linguistic representations of the expert's opinion are presented below in Table 3.1.

	$\mathcal{X}_T$	$\mathcal{X}_I$	$\mathcal{X}_F$
C1	([M,H],[VL,L],[L,M])	([L,H],[VL,L],[M,H])	([M,VH],[VL,L],[M,H])
C2	([M,VH],[L,M],[VL,M])	([M,H],[M,H],[L,M])	([H,VH],[L,M],[L,M])
C3	([H,VH],[L,M],[L,M])	([M,VH],[L,M],[VL,M])	([M,VH],[VL,M],[L,M])
C4	([M,H],[VL,L],[L,M])	([L,H],[VL,L],[M,H])	([M,VH],[VL,L],[VL,M])
C5	([M,VH],[VL,L],[VL,M])	([M,H],[VL,L],[L,M])	([L,H],[VL,L],[M,H])
C6	([M,H],[VL,L],[L,M])	([M,VH],[L,M],[VL,M])	([L,H],[VL,L],[M,H])
C7	([M,VH],[L,M],[VL,M])	([L,H],[VL,L],[M,H])	([M,H],[VL,L],[L,M])
C8	([M,VH],[L,M],[VL,M])	([H,VH],[L,M],[L,M])	([L,H],[VL,L],[M,H])
C9	([VL,M],[L,M],[M,VH])	([L,M],[L,H],[H,VH])	([L,M],[VL,L],[M,H])
C10	([L,H],[VL,L],[M,H])	([M,VH],[L,M],[VL,M])	([M,H],[VL,L],[L,M])
C11	([M,H],[VL,L],[L,M])	([M,H],[VL,L],[L,M])	([L,H],[VL,L],[M,H])
C12	([M,VH],[VL,L],[VL,M])	([H,VH],[L,M],[L,M])	([M,VH],[L,M],[VL,M])
C13	([M,H],[VL,L],[L,M])	([M,VH],[VL,L],[VL,M])	([M,VH],[VL,L],[VL,M])
C14	([VL,M],[L,M],[M,VH])	([L,M],[L,H],[H,VH])	([L,M],[VL,L],[M,H])
C15	([L,M],[VL,L],[M,H])	([VL,M],[L,M],[M,VH])	([L,M],[L,H],[H,VH])

Table 3.1 Linguistic representations of expert's opinion

The quantification of the linguistic representation of the interval valued neutrosophic sets are presented in Table 3.2.

	$\mathcal{X}_T$	$\mathcal{X}_I$	$\mathcal{X}_F$
C1	([0.5,07],[0.1,0.3],[0.3,0.5])	([0.3,07],[0.1,0.3],[0.5,07])	([0.5,0.9],[0.1,0.3],[0.5,07])
C2	([0.5,0.9],[0.3,0.5],[0.1,0.5])	([0.5,07],[0.5,07],[0.3,0.5])	([07,0.9],[0.3,0.5],[0.3,0.5])
C3	([07,0.9],[0.3,0.5],[0.3,0.5])	([0.5,0.9],[0.3,0.5],[0.1,0.5])	([0.5,0.9],[0.1,0.5],[0.3,0.5])
C4	([0.5,07],[0.1,0.3],[0.3,0.5])	([0.3,07],[0.1,0.3],[0.5,07])	([0.5,0.9],[0.1,0.3],[0.1,0.5])
C5	([0.5,0.9],[0.1,0.3],[0.1,0.5])	([0.5,07],[0.1,0.3],[0.3,0.5])	([0.3,07],[0.1,0.3],[0.5,07])
C6	([0.5,07],[0.1,0.3],[0.3,0.5])	([0.5,0.9],[0.3,0.5],[0.1,0.5])	([0.3,07],[0.1,0.3],[0.5,07])
C7	([0.5,0.9],[0.3,0.5],[0.1,0.5])	([0.3,07],[0.1,0.3],[0.5,07])	([0.5,07],[0.1,0.3],[0.3,0.5])
C8	([0.5,0.9],[0.3,0.5],[0.1,0.5])	([07,0.9],[0.3,0.5],[0.3,0.5])	([0.3,07],[0.1,0.3],[0.5,07])
C9	([0.1,0.5],[0.3,0.5],[0.5,0.9])	([0.3,0.5],[0.3,07],[07,0.9])	([0.3,0.5],[0.1,0.3],[0.5,07])
C10	([0.3,07],[0.1,0.3],[0.5,07])	([0.5,0.9],[0.3,0.5],[0.1,0.5])	([0.5,07],[0.1,0.3],[0.3,0.5])
C11	([0.5,07],[0.1,0.3],[0.3,0.5])	([0.5,07],[0.1,0.3],[0.3,0.5])	([0.3,07],[0.1,0.3],[0.5,07])
C12	([0.5,0.9],[0.1,0.3],[0.1,0.5])	([07,0.9],[0.3,0.5],[0.3,0.5])	([0.5,0.9],[0.3,0.5],[0.1,0.5])
C13	([0.5,07],[0.1,0.3],[0.3,0.5])	([0.5,0.9],[0.1,0.3],[0.1,0.5])	([0.5,0.9],[0.1,0.3],[0.1,0.5])
C14	([0.1,0.5],[0.3,0.5],[0.5,0.9])	([0.3,0.5],[0.3,07],[07,0.9])	([0.3,0.5],[0.1,0.3],[0.5,07])
C15	([0.3,0.5],[0.1,0.3],[0.5,07])	([0.1,0.5],[0.3,0.5],[0.5,0.9])	([0.3,0.5],[0.3,07],[07,0.9])

Table 3.2 Quantified linguistic expert's opinion

The score values of the core factors are presented in Table 3.3 and it is represented graphically.

Factors	S (C)
C1	0.8825
C2	0.837
C3	0.8805
C4	0.8925
C5	0.8825
C6	0.8825
C7	0.8825
C8	0.8835
C9	0.479
C10	0.8825
C11	0.8805
C12	0.8805
C13	0.912
C14	0.616
C15	0.616

Table3.3 Score values of the Factors

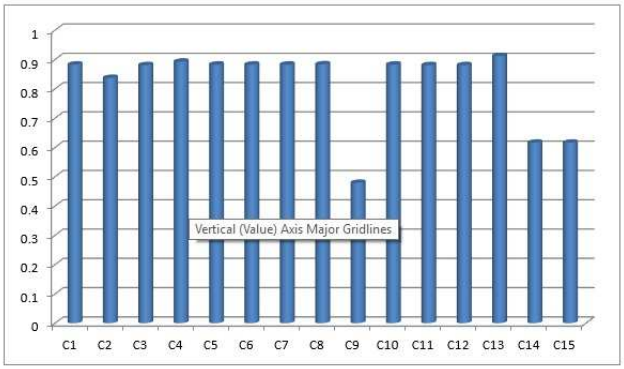

Fig.3.2 Graphical representation of the score values of the factors

The core factors are C1, C4, C5, C6, C7, C8, C10, C13 and are considered as G1, G2, G3, G4, G5, G6, G7, G8 respectively and the FCM representation is as follows

	G1	G2	G3	G4	G5	G6	G7	G8
G1	0	M	M	M	M	H	M	H
G2	L	0	M	M	VH	H	M	H
G3	M	L	0	H	M	M	H	M
G4	M	L	M	0	M	H	H	H
G5	L	M	M	M	0	M	L	M
G6	M	M	M	M	M	0	H	M
G7	M	H	M	M	M	M	0	M
G8	VH	M	M	M	M	H	H	0

Table 3.4 FCM representation

The interrelationship between the factors is determined by the similar application of FCM methodology and it is presented graphically in Figure 3.3.

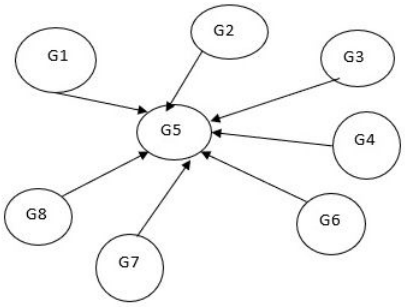

Figure 3.3 FCM representation of the interrelationships between factors

4. Discussions

Figure 3.3 vividly states that the factor G5, the formulation of need based curriculum fulfilling the requirements of the domains of learning, contributes to the successful constructivist classroom as all other factors are related to it. The factor G5 is a prime factor as it influences all other inter related factors. Inspite of teachers and students assuming new roles in constructivist classroom, the retention of the effectiveness and the positive impacts is constrained by the nature of the curriculum. Significant focus on the design of curriculum is indispensable. The representation of the expert's opinion in the form of interval-valued neutrosophic concentric fuzzy hypergraphs is a novel initiative as it reflects the expert's opinion in a more realistic manner.

5. Conclusion

The proposed decision making model with interval valued linguistic neutrosophic concentric fuzzy hypergraphs is a new endeavor by the authors to determine the core factor contributing towards constructivist classroom. The linguistic representation of the expert's opinion is more rational than representation

by the numerical values. This decision making model of concentric fuzzy hypergraphs can be extended by incorporating other kinds of fuzzy sets. This anticipated model will play a vital role in the scenario of optimal decision making process.

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