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Study of Imaginative Play in Children using Neutrosophic Cognitive Maps Model

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Abstract: This paper studies the imaginative play in young children using a model based on neutrosophic logic, viz, Neutrosophic Cognitive Maps (NCMs). NCMs are constructed with the help of expert opinion to establish relationships between the several concepts related with the imaginative play in children in the age group 1-10 years belonging to socially, economically and educationally backward groups. The NCMs are important in overcoming the hindrance posed by complicated and often imprecise nature of psychological or social data. Data was collected by video recording of children playing and the interpretations given by experts. Fifteen attributes / concepts related with children playing with the same toy were observed and according to experts several concepts were related and for some the relations between concepts were indeterminate, so it was appropriate to use NCMs. These NCMs were built using five expert's opinion and the hidden patterns of them happened to be a fixed point.

Keywords: Neutrosophic Cognitive Maps (NCMs) model; Dynamical system; Hidden patterns; Fixed point; Limit cycle; Child psychology; Imaginative play

1. Introduction

Imaginative play is role-play in which children are using their imagination to express something they have experienced or display what they like. It is an integral part for the development of social, cognitive and emotional well-being and language and thinking skills of children in the age group 1-10 years. It serves as a determinant of the imaginative capability and psychological development of the child. In this paper, we study the importance of imaginative play in children in the age group of 1 to 10 years using mathematical and computational models. This will help to qualitatively and quantitatively analyse the influence of imaginative play in the psychological development of a child.

In order to objectively study the influence of imaginative play in child development, we make use of Neutrosophic Cognitive Maps (NCMs) [1] model, a generalization of the Fuzzy Cognitive Maps (FCMs) models. The benefit of these tools lies in their ability to handle incomplete and/or conflicting information that gives the result as the hidden pattern which may be a fixed point or a limit cycle. They are also one of the most efficient and strongest AI technologies that can be used when the data in hand in not large. They work as combination of neural networks and neutrosophic logic.

Given the imprecise and subjective nature of our study, artificial intelligence is best suited for it. FCMs and NCMs are important tools in AI when the data is small [1-4] and with the help of these tools we propose a model for assessing the influence of imaginative play in a child's psychological development. The study begins with collecting data from various sources which is processed and transformed to NCMs models with the help of expert's opinion. Using these directed neutrosophic graphs [5] of the NCMs, a dynamical system is formed which acts as the mathematical model to determine the influence of imaginative play in child development.

2. Related Works

Fuzzy Cognitive Maps (FCMs) and Neutrosophic Cognitive Maps (NCMs) have found applications in several fields in their classical forms and have also been extended to suit other applications [1-2, 6-12]. The most fundamental application of FCMs and NCMs is to establish relationships between seemingly unrelated concepts. A cause-effect relationship has been established in the parameters determining interrelated dynamics in socio-political and psychological backgrounds. The FCMs and NCMs models have been used in social issues like untouchability, school dropouts, social aspects of migrant labourers living with HIV/AIDS [7, 11, 13] and so on. Hence using FCMs and NCMs in study of finding the cognitive and mental abilities of children in the age group of 1-10 will certainly yield a better result by relating the seemingly unrelated factors associated with child development. For this study we collected data by video recording of children playing with the toy phone and the interpretations were obtained from the experts. Using these experts NCMs models were constructed. Another important application of predictive capability of FCMs is to diagnose autism spectrum disorder [9]. However, they have not considered the indeterminacy concept involved in this study.

Diagnosis of language impairment in children using FCMs is another application of FCMs in the field of artificial intelligence [3]. The determinants of the disorder are assigned fuzzy weights and a qualitative and quantitative computer model is developed which gives accurate diagnosis. FCMs have played a significant role in development of IQ tests for AI-based systems [4]. This helps in establishing a relationship between IQ characteristics for AI system and analyze them objectively. FCMs have been used for opinion mining in [10].

NCMs have been used in the study of socio-economic model [8], problems of school dropouts [7], social stigma faced by people suffering with AIDS [6], psychological problems suffered by women with AIDS [11] and in medical diagnosis [12]. Neutrosophy has been used for studying several decision-making problems [14-17]

However, FCMs cannot asses when the problem under investigation is clouded under indeterminacy and incompleteness, under these situations NCMs is a better tool which can tackle them and yield a better solution. So, in this paper we use the NCMs model to study the imaginative play in children.

This paper is organized into six sections. Section one is introductory in nature. A literature survey and related works are mentioned in section two. Section three gives the necessary basic concepts to make the paper a self-contained one. Section four describes the problem in general and the concepts / attributes involved. Section five gives the NCMs model using five experts' opinion and the final section gives the conclusions based on our study.

3. Basic Concepts

This section describes the FCMs and NCMs to make the paper a self-contained one.

3.1. FCMs

The notion of Fuzzy Cognitive Maps (FCMs) which are fuzzy signed directed graphs with feedback are discussed and described [2]. The directed edge e_{ij} from causal concept C_i to concept C_j measures how much C_i causes C_j. The time varying concept function $C_i(t)$ measures the non negative occurrence of some fuzzy event, perhaps the strength of a political sentiment, historical trend or opinion about some topics like child labor or school dropouts etc. FCMs model the world as a collection of classes and causal relations between them. The edge e_{ij} takes values in the fuzzy causal interval $[-1,1]$ ($e_{ij} = 0$ indicates no causality, $e_{ij} > 0$ indicates causal increase; that C_j

increases as C_i increases and C_j decreases as C_i decreases and $e_{ij} < 0$ indicates causal decrease or negative causality C_j decreases as C_i increases or C_j, increases as C_i decreases. Simple FCMs have edge value in $\{-1,0,1\}$. Thus if causality occurs it occurs to maximal positive or negative degree. It is important to note that e_{ij} measures only absence or presence of influence of the node C_i on C_j but till now any researcher has not contemplated the indeterminacy of any relation between two nodes C_i and C_j. When we deal with unsupervised data, there are situations when no relation can be determined between some two nodes. So in this section we try to introduce the indeterminacy in FCMs, and we choose to call this generalized structure as Neutrosophic Cognitive Maps (NCMs). In our view this will certainly give a more appropriate result and also caution to the user about the risk of indeterminacy.

3.2. NCMs

Now we proceed on to define the concepts about NCMs [1]. For the notion of neutrosophic graphs refer [5].

Definition 3.1 *A Neutrosophic Cognitive Maps (NCMs) is a neutrosophic directed graph with concepts like policies, events etc. as nodes and causalities or indeterminates as edges. It represents the causal relationship between concepts. Let $C_1, C_2, \dots, C_n$ denote n nodes, further we assume each node is a neutrosophic vector from the neutrosophic vector space V. So a node C_i will be represented by$(x_1, \dots x_n)$ where x_k's are zero or one or I (I is the indeterminate) and $x_k = 1$ means that the node C_k is in the on state and $x_k = 0$ means the node is in the off state and $x_k = I$ means the nodes state is an indeterminate one at that time or in that situation. Let C_i and C_j denote the two nodes of the NCM. The directed edge from C_i to C_j denotes the causality of C_i on C_j called connections or relations. Every edge in the NCM is weighted with a number in the set $\{-1,0,1,I\}$. Let e_{ij} be the weight of the directed edge C_iC_j, $e_{ij} \in \{-1,0,1,I\}$. e_{ij} = 0 if C_i does not have any effect on C_j, $e_{ij} = 1$ if increase (or decrease) in C_i causes increase (or decreases) in C_j, $e_{ij} = -1$ if increase (or decrease) in C_i causes decrease (or increase) in C_j . $e_{ij} = I$ if the relation or effect of C_i on C_j is an indeterminate.*

NCMs with edge weight from $\{-1,0,1,I\}$ are called simple NCMs.

Let the neutrosophic matrix $N(E)$ be defined as $N(E)$ = (e_{ij}) where e_{ij} is the weight of the directed edge C_i C_j, where $e_{ij} \in \{0,1,-1,I\}$. N(E) is called the neutrosophic adjacency matrix of the NCMs.

Let $A = (a_1, a_2, \dots, a_n)$ where $a_i \in \{0,1,I\}$. A is called the instantaneous state neutrosophic vector and it denotes the on-off-indeterminate state position of the node at an instant; $a_i = 0$ if a_i is off (no effect) $a_i = 1$ if a_i is on (has effect) $a_i = I$ if a_i is indeterminate(effect cannot be determined) for $i = 1,2, \dots n$.

Let $\overline{C_1C_2}$, $\overline{C_2C_3}$, $\overline{C_3C_4}, \dots, \overline{C_iC_j}$, be the edges of the NCMs. Then the edges form a directed cycle. A NCM is said to be cyclic if it possesses a directed cycle. A NCM is said to be acyclic if it does not possess any directed cycle. A NCM with cycles is said to have a feedback. When there is a feedback in the NCMs i.e. when the causal relations flow through a cycle in a revolutionary manner the NCMs is called a dynamical system.

Let $\overline{C_1C_2}$, $\overline{C_2C_3}$, $\overline{C_3C_4}, \dots, \overline{C_{n-1}C_n}$ be a cycle, when C_i is switched on and if the causality flow through the edges of a cycle and if it again causes C_i, we say that the dynamical system goes round and round. This is true for any node C_i, for $i = 1,2, \dots n$. The equilibrium state for this dynamical system is called the hidden pattern.

If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point.

Consider the NCMs with C_1, $C_2, \dots, C_n$ as nodes. For example let us start the dynamical system by switching on C_1. Let us assume that the NCMs settles down with C_1 and C_n on, i.e. the state vector remains as (1, 0,…, 0, 1) this neutrosophic state vector (1,0, …, 0, 1) is called the fixed point.

If the NCM settles with a neutrosophic state vector repeating in the form

$$A_1 \to A_2 \to \ldots \to A_t \to A_{t+1} \to \ldots \to A_n \to A_t$$

Where A_i is the vector which is passed into a dynamical system *N(E)* repeatedly; $1 \le i \le n$ then this equilibrium is called a limit cycle of the NCM [1].

4. Description of the Problem

Here for the theme of imaginative play in children in the age group 1-10 years, the data is collected from nearby schools and an orphanage in Vellore, India. The play material supplied to them was just a play with a toy mobile phone that is to conduct imaginary talks which was video recorded. We recorded by video on phone separately we also recorded the comments made from observations of the expert. This data was analysed by a group of five experts and they gave the 15 concepts or attributes associated with the data, which formed the parameter or the concepts /attributes of our observation and is described the Table 1. The experts agreed on the point that the play material cannot be used as an attribute so the other 14 concepts can be used as attributes. However, the experts were given the liberty to use any number of concepts from the table and some of them used 8 of the concepts and some only 6 and others all the 14 of the concepts. They gave their directed neutrosophic graphs which gave the dynamical system and they worked with the attributes of their own choice which are described in the following section.

Based on expert's opinion and on the previous works [9, 3], the following have been considered as important parameters in assessing imaginative play capabilities in children. Each of these components will be used as attributes/nodes of the NCMs based on experts' opinion, the influence of these parameters is then mathematically determined by performing necessary operations and obtaining hidden pattern of the dynamical system.

Table 1. Concepts / Attributes of the NCMs

Concept	Concept Description
C_1	Imaginative Theme
C_2	Physical Movements
C_3	Gestures
C_4	Facial Expressions
C_5	Nature and Length of Social Interaction
C_6	Play Materials Used
C_7	Way Play Materials were Used
C_8	Verbalisation
C_9	Tone of Voice
C_{10}	Role Identification
C_{11}	Engagement Level
C_{12}	Eye Reaction
C_{13}	Cognitive Response
C_{14}	Grammar and Linguistics
C_{15}	Coherence

All the fifteen attributes or concepts happens to be self explanatory. Using these five experts work the NCMs models were construcuted.

5. NCMs in the analysis of the imaginative play in young children

We have described in the earlier section the method of data collection and the assignments of the fifteen concepts and their list is provided in the Table 1. Now we have five experts working with this problem taking some or all the attributes mentioned in the Table 1. The five experts are child psychologists, Montessori trained teachers and specialist in child psychology. However they wanted to remain anonymous.

The first expert wished to work with the concepts $C_2, C_3, C_4, C_8, C_9, C_{10}, C_{11},$ and C_{12}. Figure 1 represents the directed neutrosophic graph G_1 given by the first expert.

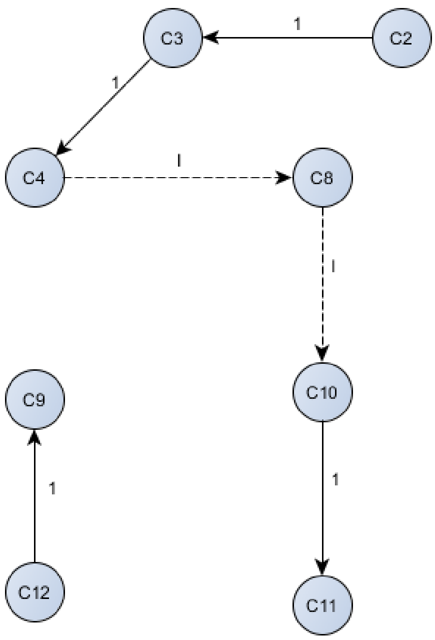

Figure 1. Directed Neutrosophic Graph *G₁*

Let M_1 be the connection matrix associated with the directed graph G_1.

$$M_1 = \begin{array}{c} \\ \end{array} \begin{array}{cccccccc} C_2 & C_3 & C_4 & C_8 & C_9 & C_{10} & C_{11} & C_{12} \end{array}$$

$$M_1 = \left[\begin{array}{cccccccc} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & I & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & I & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{array}\right] \begin{array}{c} C_2 \\ C_3 \\ C_4 \\ C_8 \\ C_9 \\ C_{10} \\ C_{11} \\ C_{12} \end{array}$$

M_1 will serve as the dynamical system to find the effect of any state vector x on M_1. The state vectors $x \in \{(C_2, C_3, C_4, C_8, C_9, C_{10}, C_{11}, C_{12}); C_i \in \{0,1,\text{I}\}; i = 2,3,4,8,9,10,11,12\}$. By default of notation we denote it by C_i's as we wish to record that the C_i's correspond to the attributes / concepts from the table and their on or off or indeterminate state. Let $x = (0,0,1,0,0,0,0,0)$ where only the concept C_4 that is facial expressions alone is in the on state and all other nodes are in the off state. The effect of x on the dynamical system M_1 is given by

$$x \circ M_1 = (0,0,0,I,0,0,0,0) \hookrightarrow (0,0,1,I,0,0,0,0) = x_1(say)$$

($\hookrightarrow$ symbol is used to denote the resultant vector that is thresholded and updated).

Now

$$x_1 \circ M_1 \hookrightarrow (0,0,1,I,0,I,0,0) = x_2(say)$$
$$x_2 \circ M_1 \hookrightarrow (0,0,1,I,0,I,I,0) = x_3(say)$$
$$x_3 \circ M_1 \hookrightarrow (0,0,1,I,0,I,I,0) = x_4(= x_3)$$

Thus the hidden pattern of the state vector x is a fixed point given by $x_4 = (0,0,1,I,0,I,I,0)$. Facial expression results in the indeterminate state of C_8, C_{10} and C_{11}; that is, role identification and engagement level respectively. That is according to this expert facial expression and its relation to verbalization, role identification and engagement level can not be determined as one can not find out exactly what the child imagines when he uses the phone. It can be an imitation of parents or others whom they have seen using it.

Next we find the effect of the on state of the two nodes C_{10} and C_{11} that is role identification and engagement level on the dynamical system M_1. Let $t = (0,0,0,0,0,1,1,0)$ be the state vector in which only the nodes C_{10} and C_{11} are in the on state. The effect of t on the dynamical system M_1 is given by

$$t \circ M_1 \hookrightarrow (0,0,0,0,0,1,1,0) = t_1(say)$$

This also results in a fixed point with no effect on the other concepts or attributes. So role identification and engagement level has no effect on the other nodes chosen by this expert for the study. Clearly when the child identifies the role it plays the engagement level is high and both the concepts are interdependent. We have just given these two state vectors but have worked with several such state vectors.

The second expert was interested to work with the attributes $C_1, C_4, C_5, C_7, C_{10}$ and C_{15} from Table 1. The neutrosophic directed graph G_2 given by him is as follows:

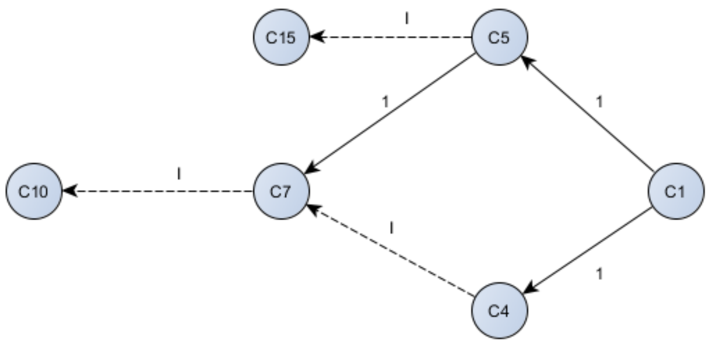

Figure 2. Directed Neutrosophic Graph G_2

Let M_2 be the connection matrix related with the graph G_2 which serves as the dynamical system.

$$M_2 = \begin{array}{c} \\ \end{array} \begin{array}{c} C_1 \quad C_4 \quad C_5 \quad C_7 \quad C_{10} \quad C_{15} \\ \begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & I & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & I \\ 0 & 0 & 0 & 0 & I & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array} \begin{array}{c} \\ C_1 \\ C_4 \\ C_5 \\ C_7 \\ C_{10} \\ C_{15} \end{array}$$

Now the expert wishes to work with a state vector in which only the node C_4 is in the on state and all other nodes are in the off state.

Let $x = (0,1,0,0,0,0)$, the effect of x on the dynamical system M_2.

$$x \circ M_2 = (0,0,0,I,0,0) \hookrightarrow (0,1,0,I,0,0) = x_1(say)$$

$$x_1 \circ M_2 \hookrightarrow (0,1,0,I,I,0) = x_2(say)$$

$$x_2 \circ M_2 \hookrightarrow (0,1,0,I,I,0) = x_3(= x_2).$$

Thus the hidden pattern is a fixed point given by $x_2 = (0,1,0,I,I,0)$ that is the on state of facial expressions has indeterminate effect on C_7 and C_{10} that is the way play materials are used and role identification respectively. It is interesting to keep on record both the experts agree and arrive at the same conclusions.

If C_{15} alone is in on state we see the effect on the dynamical system M_2 has no influence for if $s = (0,0,0,0,0,1)$ then

$$s \circ M_2 \hookrightarrow (0,0,0,0,0,1) = s.$$

That is coherence has no influence on imaginative theme, facial expressions, nature and length of social interaction, way play materials are used and role identification. Evident from the fixed point resulting in s.

For usually a normal child with average IQ can not relate them however we found that majority of these children on whom we made the sample study belong to a poor and first generation learners background so in the task of using a phone, coherence can not play a role.

Next the 3^{rd} expert works with the nodes $C_2, C_3, C_4, C_8, C_9, C_{12}, C_{14}, C_{15}$. G_3 is the directed graph given by the expert.

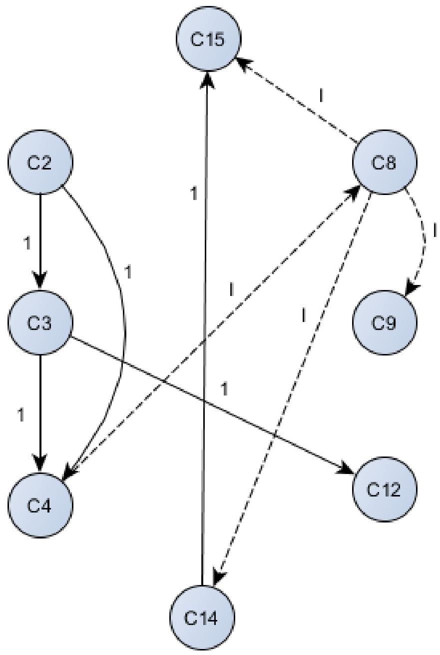

Figure 2. Directed Neutrosophic Graph G_3

Let M_3 be the connection matrix associated with the neutrosophic graph G_3.

$$M_3 = \begin{array}{c} \\ \end{array}\begin{array}{cccccccc} C_2 & C_3 & C_4 & C_8 & C_9 & C_{12} & C_{14} & C_{15} \end{array}$$
$$M_3 = \begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & I & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & I & 0 & I & I \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{array}{c} C_2 \\ C_3 \\ C_4 \\ C_8 \\ C_9 \\ C_{12} \\ C_{14} \\ C_{15} \end{array}$$

Let $m = (0,0,1,0,0,0,0,0)$ be the state vector where only the node C_4 is in the on state and all other nodes are in the off state.

The effect of m on the dynamical system M_3 is given in the following

$$m \circ M_3 = (0,0,1,I,0,0,0,0) = m_1(say)$$
$$m_1 \circ M_3 \hookrightarrow (0,0,1,I,I,0,I,I) = m_2(say)$$
$$m_2 \circ M_3 \hookrightarrow (0,0,1,I,I,0,I,I) = m_3(= m_2).$$

Thus the hidden pattern is a fixed point given by

$$m_2 = m_3 = (0,0,1, I, I, 0, I, I).$$

Clearly the on state of C_4 node that is facial expression has indeterminate effect on verbalization - C_8, tone of voice - C_9, grammar, linguistics - C_{14} and coherence - C_{15}. Clearly the 3rd expert alone can not relate coherence he finds it is an indeterminate.

Let $n = (0,0,0,0,0,0,1,0)$ be the given state vector, to find the effect of n on M_3; Next we consider the only on state of the node C_{14} alone that is the child has grammar and linguistics in the on state and all other nodes are in the off state.

$$n \circ M_3 \hookrightarrow (0,0,0,0,0,0,1,1) = n_1(say)$$

$$n_1 \circ M_3 \hookrightarrow (0,0,0,0,,0,1,1) = n_2(= n_1).$$

The hidden pattern is a fixed point given by n_2. Clearly if the child has developed grammar and linguistics naturally the child would have developed coherence and vice versa.

The fourth expert wishes to work with 9 nodes, $C_2, C_3, C_4, C_5, C_7, C_8, C_9, C_{14}$ and C_{15} be the directed graph given by him.

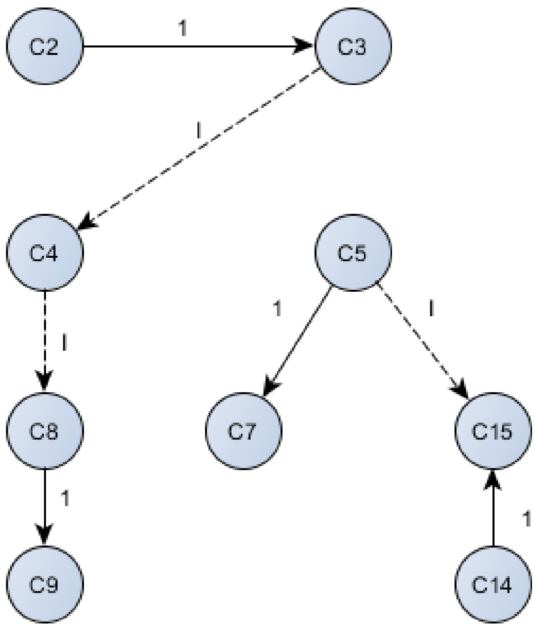

Figure 4. Directed Neutrosophic Graph G_4

Let M_4 be the connection matrix associated with the directed graph G_4 which will serve as the dynamical system for the neutrosophic directed graph G_4.

$$M_4 = \begin{array}{c} \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_7 \\ C_8 \\ C_9 \\ C_{14} \\ C_{15} \end{array}\begin{array}{c} \begin{matrix} C_2 & C_3 & C_4 & C_5 & C_7 & C_8 & C_9 & C_{14} & C_{15} \end{matrix} \\ \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & I & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & I & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & I \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

The effect of the state vector $v = (0,0,1,0,0,0,0,0,0)$ where only the node C_4 is in the on state and all other nodes are in the off state. The effect of r on the dynamical system M_4 is given by

$$r \circ M_4 \hookrightarrow (0,0,1,0,0, I, 0,0,0) = r_1(say)$$

$$r_1 \circ M_4 \hookrightarrow (0,0,1,0,0,I,I,0,0) = r_2(say)$$
$$r_2 \circ M_4 \hookrightarrow (0,0,1,0,0,I,I,0,0) = r_3(= r_2).$$

Thus the hidden pattern is a fixed point given by $r_2 = (0,0,1,0,0,I,I,0,0)$. The on state of facial expression makes on state C_8 and C_9 but both verbalization C_8 and tone of voice C_9 are in the indeterminate state only. That is facial expressions makes verbalization and tone of voice only to indeterminate state, rest of the states remain off. Next we study the effect of the state vector $z = (0,0,0,1,0,0,,0,0,0)$ on the dynamical system M_4. That is only the node C_5 nature and length of the social interaction is in the on state. All other nodes are in the off state. Effect of z on M_4 is as follows:

$$z \circ M_4 \hookrightarrow (0,0,0,1,1,0,0,0,I) = z_1(say)$$
$$z_1 \circ M_4 \hookrightarrow (0,0,0,1,1,0,0,0,I) = z_2(= z_1)$$

So the hidden pattern is the fixed point. On state of the concept nature and length of the social interaction makes on the node C_7 the way play materials are used but the coherence is in the indeterminate state, all other nodes remain unaffected.

Next expert wishes to work with all the 14 concepts barring the play materials used for study.

G_5 is the directed graph given by this expert. Let M_5 be the connections matrix which will serve as the dynamical system of the graph G_5.

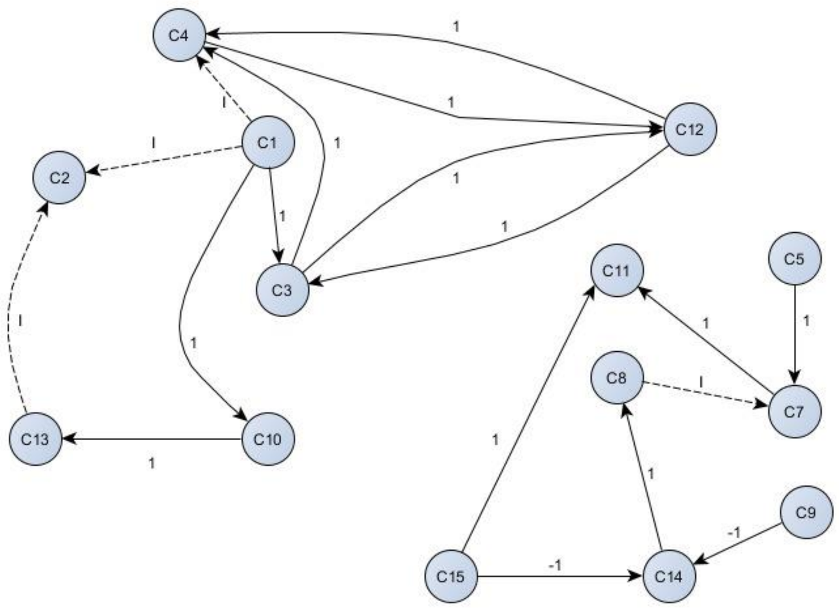

Figure 5. Directed Neutrosophic Graph G_5

$M_5 =$

	C_1	C_2	C_3	C_4	C_5	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	0	I	1	I	0	0	0	0	1	0	0	0	0	0
C_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C_3	0	0	0	1	0	0	0	0	0	0	1	0	0	0
C_4	0	0	0	0	0	0	0	0	0	0	1	0	0	0
C_5	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C_7	0	0	0	0	0	0	0	0	0	1	0	0	0	0
C_8	0	0	0	0	0	I	0	0	0	0	0	0	0	0
C_9	0	0	0	0	0	0	0	0	0	0	0	0	−1	0
C_{10}	0	0	0	0	0	0	0	0	0	0	0	1	0	0
C_{11}	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C_{12}	0	0	1	1	0	0	0	0	0	0	0	0	0	0
C_{13}	0	I	0	0	0	0	0	0	0	0	0	0	0	0
C_{14}	0	0	0	0	0	0	1	0	0	0	0	0	0	0
C_{15}	0	0	0	0	0	0	0	0	0	1	0	0	−1	0

Let $p = (0,0,0,1,0,0,0,0,0,0,0,0,0,0)$ be the initial state vector in which only the node C_4 is in the on state all other nodes are in the off state. Effect of p on M_5 is given by

$$p \circ M_5 \hookrightarrow (0,0,0,1,0,0,0,0,0,0,1,0,0,0) = p_1(say)$$
$$p_1 \circ M_5 \hookrightarrow (0,0,0,1,0,0,0,0,0,0,1,0,0,0) = p_2(say)$$
$$p_2 \circ M_5 \hookrightarrow (0,0,1,1,0,0,0,0,0,0,1,0,0,0) = p_3(say)$$
$$p_3 \circ M_5 \hookrightarrow (0,0,1,1,0,0,0,0,0,0,1,0,0,0) = p_4(= p_3).$$

Thus the hidden pattern is a fixed point. This expert has taken all the 14 concepts, the on state of concept C_4 alone that is facial expressions makes on the states C_3 and C_{12} namely gestures and eye reaction respectively.

Next we study the effect of $w = (1,0,0,1,0,0,1,0,0,1,0,0,0,1)$ where C_1, C_4, C_8, C_{11} and C_{14}.

$$w \circ M_5 \hookrightarrow (1, I, 1,1,0,0,1,1,1,1,1,0,0,1) = w_1(say)$$
$$w_1 \circ M_5 \hookrightarrow (1, I, 1,1,0,1,1,1,1,1,1,0,1,1) = w_2(say)$$
$$w_2 \circ M_5 \hookrightarrow (1, I, 1,1,0,1,1,1,1,1,1,0,1,1) = w_3(= w_2)$$

Thus the hidden pattern of w is a fixed point and on state of the concepts C_1, C_4, C_8, C_{11} and C_{15} makes on all the states except C_5 nature and length of social interaction and C_{14}- grammar and linguistics and makes C_2 an indeterminate.

6. Conclusions

In this paper the authors have studied the imaginative play of children in the age group 1 to 10 years. We have taken these children from educationally, socially and economically backward classes. Study shows that the concepts C_1 to C_{15} are interrelated in a very special way. Further we saw that most children did not relate the facial expression with their verbal communication, in fact we could not determine it. For several, the coherence and the verbal communications or otherwise cannot be determined. For an 8-year old child started to talk to his elderly relative and ended up talking with a friend in less than 2 minutes of conversation. In fact, our study has authentically revealed that several concepts/relations cannot be determined. Further we felt for these children generally their overall ability was below average. Conclusions of each model for the state vectors under investigation are given along with the models. So, our future research would be to use the same toy phone and study the children of the same age group but from better socio-economic background and compare it with these children so that one can determine the ways to develop the first-generation learners.

Further for future research, we plan to adopt different Neutrosophic concepts [18-26] like Single Valued Neutrosophic Sets (SVNS), Double Valued Neutrosophic Sets (DVNS) and Triple Refined Indeterminate Neutrosophic sets (TRINS), Neutrosophic triplets and duplets in Cognitive models and study this problem.

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