

A STUDY ON THE CAUSES FOR FAILURES IN MATHEMATICS BY ENGINEERING STUDENTS USING COMBINED FUZZY COGNITIVE MAPS (CFCMS)

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Abstract: In all Engineering degree courses a level of mathematical ability is required as Mathematics plays a vital role in seeking solution to problems posed by areas in Engineering. But students in general find difficulty in understanding this subject than any other subjects. In this paper, we analyze the causes for failures in mathematics among the engineering students of Tamil Nadu by interviewing and collecting the data from the students, teachers, parents and members of the management. We found each category of people blaming the other. This paper analyses the causes for this problem using Combined Fuzzy Cognitive Mapping (CFCM) Model. This gives the result in an effective way by combining the opinion of two or more experts. This paper consists of four sections. Section one deals with the causes for failure in mathematics, which is introductory in nature. Section two gives the description of Combined Fuzzy Cognitive Map model. Section three deals with the attributes involved that states the causes for such a problem and uses CFCM to analyze the problem. Section four gives the conclusion and suggestions based on the study.

Keywords: CFCMs, Hidden pattern, fixed point, failure, mathematical ability.

Introduction: Engineering is the field which requires the application of mathematical tools, to effectively solve the problems it poses. But a majority of engineering students experience difficulties in understanding the concepts in Maths and show aversion to the subject compared to any other subjects. Though they know the value of this subject, students find it difficult to cope up with it. Due to the lack of basic knowledge, critical thinking and application skill students are not able to show interest and involvement in this subject. To know the real cause of such failure the students, teachers, parents and the members of management were interviewed. The students and parents were telling that it is the responsibility of teachers to motivate the students, to develop the interest in Mathematics. On the other hand, the teachers were of the view that home is the first society where parents should identify the strength and weakness of their children and should be a motivating factor for them. Teacher – student relationship is more enhanced when the institution provides a good atmosphere in their progress by providing not only the necessary infrastructure for conducive learning but also provide motivation and continuous training to teachers teaching the subject.

2. Combined Fuzzy Cognitive Map (CFCM):

2.1 Preliminaries: Fuzzy cognitive maps (FCMs) are more applicable when the data in the first place is an unsupervised one. The FCMs work on the opinion of experts. FCMs model the worlds as a collection of classes and causal relation between classes. It is a very convenient, simple and powerful tool, which is used in numerous fields such as social, economical and medical etc. illustrated by W.B.Vasantha Kandasamy in her book, “ Special Fuzzy Matrices for Social

Sciences”.

Definition 2.1.1: An FCM is a directed graph with concepts like policies, events etc as nodes and causalities as edges. It represents causal relationship between concepts.

Definition 2.1.2: When the nodes of the FCM are fuzzy sets then they are called as fuzzy nodes.

Definition 2.1.3: FCMs with edge weights or causalities from the set $\{-1, 0, 1\}$ are simple FCMs.

Definition 2.1.4: The edges e_{ij} take values in the fuzzy causal interval $[-1, 1]$. $e_{ij} = 0$ indicates no causality, $e_{ij} > 0$ indicates causal increase C_j increases as C_i increases (Or C_j Decreases as C_i Decreases). $e_{ij} < 0$ indicates causal decrease or negative causality. C_j decreases as C_i increases (and or C_j increases as C_i decreases). Simple FCMs have edge values in $\{-1, 0, 1\}$. Then if causality occurs, it occurs to a maximal positive or negative degree. Simple FCMs provide a quick first approximation to an expert's stand or printed causal knowledge. If increase (Or decrease) in one concept leads to increase (or decrease) in another, then we give the value 1. If there exist no relation between the two concepts, the value 0 is given. If increase (or decrease) in one concept decreases (or increases) another, then we give the value -1. Thus, FCMs are described in this way. Consider the nodes or concepts C_1, \dots, C_n of the FCM. Suppose the directed graph is drawn using edge weight $e_{ij} \in \{0, 1, -1\}$. The matrix E be defined by $E = (e_{ij})$, where the e_{ij} is the weight of the directed edge $C_i C_j$. E is called the adjacency matrix of the FCM, also known as the connection matrix of the FCM. It is important to note that all matrices associated with an FCM are always square matrices with diagonal entries as zero.

Definition 2.1.5: Let C_1, C_2, \dots, C_n be the nodes of an the instantaneous state vector and it denoted the on off position of the node at an instant $a_i=0$ if a_i is off and $a_i=1$ if a_i is on, where $i = 1, 2, \dots, n$.



Definition 2.1.6: Let C_1, C_2, \dots, C_n be the nodes of an FCM. Let $C_1 C_2, C_2 C_3, \dots, C_i C_j$, be the edges of the FCM ($i \neq j$). Then, the edges form a directed cycle. An FCM is said to be cyclic if it possesses a directed cycle. An FCM is said to be acyclic if it does not possess any directed cycle.

Definition 2.1.7: An FCM with cycles is said to have a feedback.

Definition 2.1.8: Where there is a feedback in an FCM, i.e., when the causal relations flow through a cycle in a revolutionary way, the FCM is called a dynamical system. $\rightarrow \rightarrow \rightarrow$

Definition 2.1.9: Let $C_1 C_2, C_2 C_3, \dots, C_i C_j$, be a cycle when C_i is switched on and if the causality flows 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.

Definition 2.1.10: If the equilibrium state of a dynamical system is a unique state vector, then it is called a fixed point. Consider a FCM 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 FCM settles down with C_1 and C_n on, i.e. the state vector remains as $(1, 0, 0, \dots, 0, 1)$ this state vector $(1, 0, 0, \dots, 0, 1)$ is called the fixed point.

Definition 2.1.11: If the FCM settles down with a state vector repeating in the form $A_1 \rightarrow A_2 \rightarrow \dots A_1 \rightarrow A_1$. Then this equilibrium is called limit cycle.

Definition 2.1.12: Finite number of FCMs can be combined together to produce the joint effect of all the FCMs. Let E_1, E_2, \dots, E_p be adjacency matrices of the FCMs with nodes C_1, C_2, \dots, C_n , then the combined FCM [5,6,7] is got by adding all the adjacency matrices E_1, \dots, E_p . We denote the combined FCM adjacency matrix by $E = E_1 + E_2 + \dots + E_p$

2.1.13: METHOD OF DETERMINING HIDDEN PATTERN: Let C_1, C_2, \dots, C_n be the nodes of an FCM, with feedback. Let E be the associated adjacency matrix. Let us find the hidden pattern when C_6 is switched on. When an input is given as the vector $A_1 = (1, 0, 0, \dots, 0)$, the data should pass through the relation matrix E . this is done by multiplying A_1 by the matrix E . Let $A_1 E = (a_1, \dots, a_n)$ with the threshold operation that is by replacing a_i by 1 if $a_i > k$ and a_i by 0 if $a_i < k$ (k is a suitable positive integer). We update the resulting concept. The concept C_6 is included in the updated vector by making the sixth coordinate as

FCM. Let $A = (a_1, a_2, \dots, a_n)$, where $a_i \in \{0,1\}$. A is called 1 in the resulting vector. Suppose $A_1 E \rightarrow A_2$ then consider $A_2 E$ and repeat the same procedure. This procedure is repeated till we get a limit cycle or a fixed point.

3. A STUDY ON THE CAUSES FOR FAILURES IN MATHEMATICS BY ENGINEERING STUDENTS USING CFCM MODEL: By administering linguistic questionnaire among students, teachers, parents and members of management, we arrived at the experts opinion based on which we have taken the following eleven nodes $\{C_1, C_2, \dots, C_{10}, C_{11}\}$

3.1 The problems faced by the engineering students in Tamil Nadu:

C_1 -Higher Secondary Schools fail to provide thorough knowledge of XI std syllabus which forms the basis for XII std syllabus.

C_2 -Teachers are not dedicated to their profession

C_3 -Teachers lack the basic knowledge in teaching methodology

C_4 -Teachers fail to be kind and understanding to the students

C_5 -Parents fail to identify the interest and admit their children in courses of their choice by compulsion

C_6 -Students don't show interest and involvement in mathematics

C_7 - Students are not regular to classes

C_8 - Lack of logical reasoning and application skill

C_9 - Lack of confidence among the students

C_{10} - Aversion to Mathematics from Childhood due to varied reasons

C_{11} - The Institution fails to provide good atmosphere for teacher - student relationship

C_1 -Higher Secondary Schools lack in providing thorough knowledge of XI std syllabus which form the basis for XII std syllabus: There are Higher Secondary Schools which do not take XI std syllabus and directly teach XII syllabus with the only motive of getting high pass percentage of result for their institutions. They fail to concentrate on all topics of XI std syllabus. Most of the schools follow only the blueprint and do not work out all the problems given in the book. Failures to teach the basics of calculus in std XI and teach only the important problems that are often repeated in the board examination and make them to memorize only help them to score high, without making them understand the basic concepts.

C_2 -Teachers are not dedicated to their profession: Teaching profession is said to be a noble profession. This profession is kept next only to God in order, 'Matha, Pitha, Guru, Theivam'. But we don't find such dedicated teachers these days. Many a teachers consider it only as a part time job. There are instances where the teachers teach more effectively in

‘Tuition centres’ than in the regular classes.

C₃-Lack the basic knowledge in teaching methodology: To become a school teacher at any level gone training in methods of teaching, child psychology, philosophical foundation of education and there are also teachers who involve in other business such as Real estate, finance, agriculture, petti-shop etc...But in Engineering colleges those who completed degree straight away become lecturer without undergoing such training. So, they lack sufficient knowledge and skill in methods of teaching the subject. Though they may be well versed with the subject, they lack the psychological basics to handle the adolescents with their behavior. Hence their teaching becomes content-centered rather than student-centered.

C₄-Teachers fail to be kind and understanding to the students: Teachers are the second mother to the students. They are the role model for them. Each and every word from their mouth affects the mentality of the students. Apart from the subject teaching, teachers need to be kind, considerate and interested in the welfare of the students. But the College teachers don't undergo any course in child psychology or on the psychology of the adolescents, before becoming a lecturer. Naturally, most of the mathematics teacher seems to be strict and harsh towards the students which make them to have fear for the subject. I remember my Maths teacher introducing the topic ‘Algebra’ stating ‘Algebra is a Cobra’.

C₅-Parents fail to identify the interest and admit their children in courses of their own choice by compulsion: Parents should identify the course by knowing the interest and aptitude of their children. But in most of the families we find that the parents impose the course of their liking on the children. For instance, a parent who fails to become a Doctor compels his/her child to join Medical College. The aptitude of the child may be to become an Engineer. Naturally the children fail to live up to the expectation of parents.

C₆-Students don't show interest and involvement in mathematics: Most of the engineering students who keep arrear in mathematics found not to be interested in this subject due to fear for this subject from childhood, lack of knowledge in basics of Mathematics, memory loss, lack of application skill etc. Hence they find it difficult to learn this subject with interest.

C₇- Students are not regular to classes: Students not interested in mathematics find some means to bunk the classes. Teacher's harsh approach to the students by being strict, scolding using bad words,

giving punishment in front of opposite gender affects the students in the very beginning of the academic year. So, throughout the year, students either bunk classes, or pay least attention in classes.

C₈- Lack of logical reasoning and application skill: Though the students memorize all the formulae, regular to the class, attentive in the class they are not able to think critically and apply the knowledge in the new situations. Teachers fail to develop such ability among the students. They just provide their notes and important problems to concentrate which were prepared ‘Examination point of view’ without making them to think critically and logically.

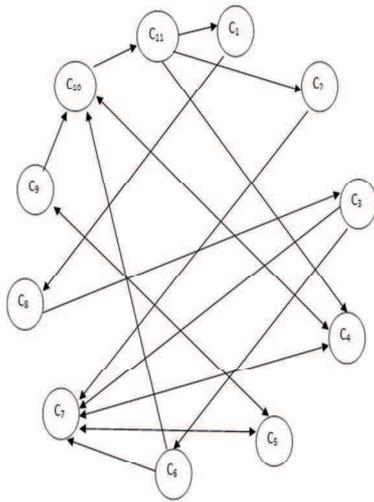
C₉- Lack of confidence among the students: Students are in need of extra confidence to learn, practice and appear for maths exam compared to other subjects. Due to fear, students lack confidence in learning, in understanding and applying Mathematics in new situations.

C₁₀- Aversion to Mathematics from Childhood due to varied reasons: Low level achievement in this subject at school level, teachers harsh behavior in dealing with students, giving corporal punishment, scolding, frightening them by asking formula without teaching the concepts, pressure from parents to get centum in maths leads to aversion to learn Mathematics. The content based examination oriented teaching, make both the students and teachers to develop an aversion to learning / teaching Mathematics.

C₁₁- The Institution fails to provide good atmosphere for teacher – student relationship
Most of the private Educational Institutions run only for profit motive. They lack the basic knowledge on the importance of holistic human capital development. As a result they don't provide sufficient infra structural facilities conducive to learning. They don't pay the teachers sufficiently. They don't promote teacher-student relationship. Frequent in-service teacher training such as FDP, Refresher course on the recent developments in the subject etc...

3.2 ANALYSIS OF THE PROBLEM: Now we proceed on to analyze the problems listed by taking the above eleven attributes using CFCM. Let us consider the eleven concepts {C₁, C₂, ..., C₁₀, C₁₁}. The Problems listed above were collected from the engineering students and teachers, parents, engineering institutions of Chennai through survey and personal interview .

3.2.1 Analysis of the First Expert's view: The first expert's opinion arrived through the responses from teaching communities is given as graph and the relational connection matrix is given below



	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	0	0	0	0	0	0	0	1	0	0	0
C2	0	0	0	0	0	0	1	0	0	0	0
C3	0	0	0	0	0	1	1	0	0	0	0
C4	0	0	0	0	0	0	1	0	0	1	0
C5	0	0	0	0	0	0	1	0	1	0	0
C6	0	0	0	0	0	0	1	0	0	1	0
C7	0	0	0	1	1	0	0	0	0	0	0
C8	0	0	1	0	0	1	0	0	0	0	0
C9	0	0	0	0	1	0	0	0	0	1	0
C10	0	0	0	1	0	0	0	0	0	0	1
C11	1	1	0	1	0	0	0	0	0	0	0

Let the initial input vector be

$$X_0 = \{000000100000\}.$$

$$X_0 A = \{000000010010\} \rightarrow \{000000110010\} = X_1$$

$$X_1 A = \{00021010011\} \rightarrow \{00011110011\} = X_2$$

$$X_2 A = \{11021030121\} \rightarrow \{11011110111\} = X_3$$

$$X_3 A = \{11022041131\} \rightarrow \{11011111111\} = X_4$$

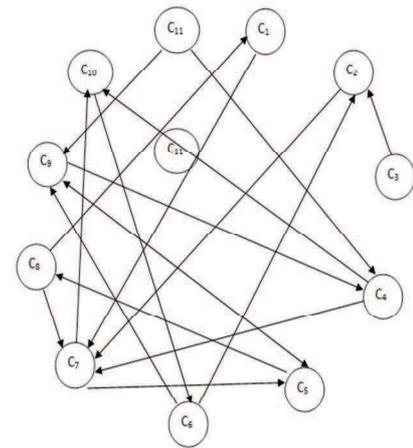
$$X_4 A = \{11132141131\} \rightarrow \{11111111111\} = X_5$$

$$X_5 A = \{11132251131\} \rightarrow \{11111111111\} = X_5$$

X_5 is the hidden pattern which is the fixed point. According to this expert's opinion when the node C_6 i.e "Students don't show nterest and involvement in mathematics" is in on state, we have all the states to be on.

3.2.2. Analysis Of the Second Expert's view

The second expert's opinion arrived through responses from students is given as graph and the relational connection matrix is given below



	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	0	0	0	0	0	0	1	0	0	0	0
C2	0	0	0	0	0	0	1	0	0	0	0
C3	0	1	0	0	0	0	0	0	0	0	0
C4	0	0	0	0	0	0	1	0	0	1	0
C5	0	0	0	0	0	0	0	1	1	0	0
C6	0	1	0	0	0	0	0	0	1	0	0
C7	0	0	0	1	0	0	0	0	0	1	0
C8	1	0	0	0	0	0	1	0	0	0	0
C9	0	0	0	1	1	0	0	0	0	0	0
C10	0	0	0	0	0	1	0	0	0	0	0
C11	0	0	0	1	0	0	0	0	1	0	0

Let the initial input vector be

$$X_0 = \{000000100000\}.$$

$$X_0 A = \{010000000100\} \rightarrow \{010000100100\} = X_1$$

$$X_1 A = \{01011010100\} \rightarrow \{01011110100\} = X_2$$

$$X_2 A = \{00021021120\} \rightarrow \{00011111110\} = X_3$$

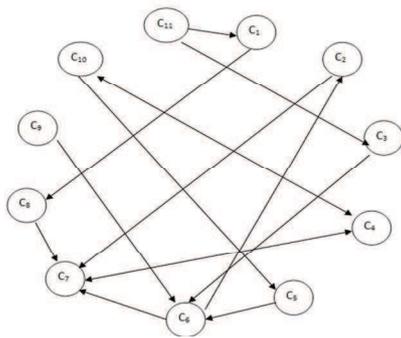
$$X_3 A = \{11021121220\} \rightarrow \{11011111110\} = X_4$$

$$X_4 A = \{11021141220\} \rightarrow \{11011111110\} = X_4$$

X_4 is the hidden pattern which is the fixed point.

According to this expert's opinion when the node C_6 i.e "Students don't show interest and involvement in mathematics" is in on state, we have all the states to be on except C_3 and C_{11} i.e. Lack in teaching methodology and The Institution fails to provide good atmosphere to teacher - student relationship

3.2.3 Analysis Of the Third Expert's view: The third expert's opinion arrived through responses from parents is given as graph and related fuzzy relational matrix is given below



	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	0	0	0	0	0	0	0	1	0	0	0
C2	0	0	0	0	0	0	1	0	0	0	0
C3	0	0	0	0	0	1	0	0	0	0	0
C4	0	0	0	0	0	0	1	0	0	1	0
C5	0	0	0	0	0	1	0	0	0	0	0
C6	0	1	0	0	0	0	1	0	0	0	0
C7	0	0	0	1	0	0	0	0	0	0	0
C8	0	0	0	0	0	0	1	0	0	0	0
C9	0	0	0	0	0	1	0	0	0	0	0
C10	0	0	0	1	1	0	0	0	0	0	0
C11	1	0	1	0	0	0	0	0	0	0	0

C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	0	0	0	0	0	0	1	2	0	0	0
C2	0	0	0	0	0	0	3	0	0	0	0
C3	0	1	0	0	0	2	1	0	0	0	0
C4	0	0	0	0	0	0	3	0	0	2	0
C5	0	0	0	0	0	1	1	1	2	0	0
C6	0	2	0	0	0	0	2	0	1	1	0
C7	0	0	0	3	1	0	0	0	0	1	0
C8	1	0	1	0	0	1	2	0	0	0	0
C9	0	0	0	1	2	1	0	0	0	1	0
C10	0	0	0	2	1	1	0	0	0	0	1
C11	2	1	1	2	0	0	0	0	1	0	0

Let the initial input vector be

$$X_0 = \{0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\}$$

$$X_0 A = \{0\ 2\ 0\ 0\ 0\ 0\ 2\ 0\ 1\ 1\ 0\} \rightarrow \{0\ 1\ 0\ 0\ 0\ 0\ 1\ 0\ 1\ 1\ 0\} = X_1$$

$$X_1 A = \{0\ 0\ 0\ 6\ 4\ 2\ 0\ 0\ 0\ 2\ 1\} \rightarrow \{0\ 0\ 0\ 1\ 1\ 1\ 0\ 0\ 0\ 1\ 1\} = X_2$$

$$X_2 A = \{2\ 3\ 1\ 4\ 1\ 2\ 6\ 1\ 4\ 3\ 1\} \rightarrow \{1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\} = X_3$$

$$X_3 A = \{3\ 4\ 2\ 8\ 4\ 6\ 13\ 3\ 4\ 5\ 1\} \rightarrow \{1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\} = X_3$$

X_3 is the hidden pattern which is the fixed point.

Where \rightarrow Denotes the resultant vector after thresholding and updating. X_3 is the hidden pattern which is the fixed point.[8]

3.3 Future Work: Analyzing the problem faced by the engineering students and teachers in Tamil Nadu in learning/teaching Mathematics in an effective way using different mathematical Fuzzy Models.

3.4 Acknowledgment: The authors wish to thank the management of Hindustan University and Prof. Dhanapalan College of Arts & Science for the constant source of encouragement and support.

4. Conclusion And Suggestions: While analyzing CFCM, when the concept C_6 “Students don’t show interest and involvement in mathematics” is kept in the on state, all other concepts are also in the on state. These ten attributes are inter-related to each other for the causes of failure in mathematics by engineering students. This implies that one should exercise self-discipline and concentrate in learning the subject Maths. The Teacher must come well prepared to the class and facilitates the learning process by adopting innovative methods. The Institution should provide the necessary infra-structural facilities like the “Smart Classroom”, “In-service course to the teacher”, well equipped library and laboratory and room. Also the teachers need to be given sufficient financial incentive so that they concentrate fully on their teaching mission. The Govt can bring in policy decision to make the teacher training compulsory to become eligible to teach in colleges. Above all the parents must provide a congenial atmosphere in the house and keep in motivating their children’s in their studies.

Let the initial input vector be

$$X_0 = \{0\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\}$$

$$X_0 A = \{0\ 1\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 0\} \rightarrow \{0\ 1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 0\ 0\} = X_1$$

$$X_1 A = \{0\ 1\ 0\ 1\ 0\ 0\ 2\ 0\ 0\ 0\ 0\} \rightarrow \{0\ 1\ 0\ 1\ 0\ 1\ 1\ 0\ 0\ 0\ 0\} = X_2$$

$$X_2 A = \{0\ 1\ 0\ 1\ 0\ 0\ 3\ 0\ 0\ 1\ 0\} \rightarrow \{0\ 1\ 0\ 1\ 0\ 1\ 1\ 0\ 0\ 1\ 0\} = X_3$$

$$X_3 A = \{0\ 1\ 0\ 2\ 1\ 0\ 3\ 0\ 0\ 1\ 0\} \rightarrow \{0\ 1\ 0\ 1\ 1\ 1\ 1\ 0\ 0\ 1\ 0\} = X_4$$

$$X_4 A = \{0\ 1\ 0\ 2\ 1\ 1\ 3\ 0\ 0\ 1\ 0\} \rightarrow \{0\ 1\ 0\ 1\ 1\ 1\ 1\ 0\ 0\ 1\ 0\} = X_4$$

X_4 is the hidden pattern which is the fixed point.

According to this expert’s opinion when the node C_6 i.e “Students don’t show interest and involvement in mathematics” is in on state, we have $C_1, C_3, C_8, C_9, C_{11}$ in off state. i.e Higher Secondary Schools lack in providing thorough knowledge of XI and XII std syllabus, Lack in teaching methodology, Lack of logical reasoning and application skill, Lack of confidence among the students, The Institution fails to provide good atmosphere to teacher – student relationship are in off state.

3.2.4 Analysis of the problem combining all the three experts’ views: Now we formulate the combined fuzzy cognitive maps using the opinion of three experts. Let S denote the combined connection matrix by $S=A+B+C$

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