Analyzing the need for orchestration of smart mobile devices, software and pedagogical design in the teaching learning process for secondary school students using IFCM method

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Abstract
In the recent trends in education, the need for employing emerging technologies rises to high for effective, authentic teaching learning in the secondary schools. In this century E-learning, Learning Management Systems (LMS), M-learning, and U-learning (Ubiquitous) play a vital role in education. It serves as an attractive tool for the present students who are digital natives. In this paper a study is made on the need for an automated arrangement of smart mobile devices, software and pedagogical design together, which is the urgency in schools today to increase the learning capacity and create skills of critical thinking, communication, creativity etc. This task is achieved through the application of Induced Fuzzy Cognitive Map to find the factor which is most important in this process of coordinating the devices, software and pedagogical designing in the teaching learning process.

Keywords
E-Learning, M-Learning, Induced Fuzzy Cognitive Map, Fuzzy Cognitive Map.

AMS Subject Classification
97C70.

1. Introduction
Every student has a different learning style. Learning is a two phase process of reception and process of information. The conscious effort to promote others to acquire knowledge, skills and character is education. The advent of technologies in communication and the use of internet brought newness in teaching and learning which gave birth for e-learning too. It is the extensive use of internet, electronic devices and network to gain knowledge. Different e-tools are provided in the market with multiple functionalities. The learners set up their own phase of learning in e-learning. The later developments in
the web technologies paved platform for computing with web applications, with attributes like continuous updated software, making network as platform consuming and remixing data from various sources.

In the recent past, many studies have proven that the integration of smart devices like laptops, tablet personal computer, cell phones and e-book readers in teaching and learning increased the effectiveness and learning achievement. Students are the majority, exposed to online activities like chatting, blogging, tweeting and through social networks with peers as well as teachers. Youth find it easy to communicate with computers than face to face (Boyle and O’Sullivan 2016) [1]. Since they are portable and environmentally friendly, they provide convenience, multi sources and multitask for comprehensive learning experiences. The present generation is digital literate and digital natives (Wang ET al.2009, Evans 2009) [1].

In traditional class room and outside it is an effective learning tool. Traditional style is supported but innovative teaching methods are promoted through informative gathering, Co-operative learning, exploratory learning and game based learning. These, leads not only to subject content learning but facilitate the development of communication, problem-solving, creativity and other high level skills (Warschauer, 2007) [14]. Thus the need for orchestration of smart mobile devices, software and pedagogical design in the teaching learning process arises.

1.1 Need for Orchestration

The features of mobile devices are like real time access to information, content sensitivity, quick communication and feedback. The study of scholars proved that the effect of information technology needs the connection among the components like hardware and software, between teaching and learning processes and between students and teachers. The orchestration of these components is necessary in order to enable compatible, efficient and effective technology-enhanced teaching and learning environment. The wireless communication and the features of individuality are used for self directed learning.

For effective positive learning the instructional strategies are inevitable for mobile enhanced instruction. To achieve orchestration, learning oriented software has to be expanded with educational activities. Secondly, the teachers’ development programs on how to modify the already existing mobile integrated education programs and customize them as their own personalized program, to modify the diverse functions and the many different learning oriented software programs with little pedagogy like reciprocal teaching, inquiry learning and formative assessment need to be trained [14].

This paper analyzes the need for orchestration of smart mobile devices, software and pedagogical design in the teaching learning process for secondary school students using IFCM method. This paper includes six sections. Introductory part is given in section one with the subdivision, the need for orchestration. Section two gives literature review. Section three contains basic definitions. Section four defines the algorithm of IFCM. Section five gives the mathematical approach of IFCM. Section six draws conclusions based on our study.

1.2 Literature Review

There are several studies which review the integration of laptops and other mobile devices with teaching and learning. In the field of education, students at all levels use mobile technology such as Tablet and smart phones in the classrooms. (Dhir, Gahwaji & Nyman, 2013 Kinash, Brand & Matthew, 2012)[2]. The current students are digitally literate and are called digital natives whereas the teachers are digital immigrants (Wang ET al. 2009)[1]. Fleischer (2012) [14] found that laptops are used for motivation in learning and in student-centered learning activities [14]. Penuel (2006) [14] found mostly smart mobile devices are used to complete homework assignments and taking notes. Mobile technology provides new ways of learning, access to information and increased engagement in learning (Zhang, Wang et.al. 2015) [2]. Children have more opportunities to learn from different perspectives (Morphy 2011) [2]. Mobile devices extend, enhance and enrich the learning in numerous ways (Traxler & Wishart 2011) [5]. Adaptability cost, scalability are the main motivation for using mobile technology (Ozadamlı, 2012)[5]. Teachers’ willingness for transition from traditional to nontraditional classroom brings successful teaching learning outcomes of teachers and students alike such that their interactions will enable them to share the task, analyzing and recreating knowledge (Hilbert et-al 2015)[1].

Technology media used in learning is influential (Sakat, et.al 2012) [15]. Bebell and O’Dwyer (2010) [14] discussed that schools using one-to-one programs with the devices had significant increase in grade point averages or standardized tests of student achievement comparing to control group. They enhance high level collaborative learning and assist in teachers’ ongoing feedback and cumulative assessment data (Goodwin,2012)[5]. The mobile devices are easy to be carried, it provides anytime, anywhere learning [5]. Tablets are used to implement personalized learning environments and tracking learning processes in a unique manner (Huang et.al 2012)[5]. The digital technology has positive impact on education and training of teachers and for the development of students’ skills (Prawiradilaga, 2012). It is the basic requirement that teaching materials are delivered faster with more affordability[15]. Fleischer (2012) [15] says teachers are challenged to change their beliefs on teaching methods and to cope up the conflict between students’ desire for independent study with greater autonomy and teacher’s guidance. It is the basic requirement that teachers be able to develop technological skills (Amirullah, 2017) [15]. Professional development is inevitable that the teachers be fully equipped with the technological skills to change the content according to their subjects, to develop activities for the students, to provide tasks, to prepare project, to give feedback, to evaluate, to
assess the learning achievement and so on. This paper insists that the effectiveness of teaching learning process depends not only in using the smart mobile devices but teachers’ skill in coordinating the necessary software and pedagogical designing also. Besides teachers’ effectiveness, more research on how they reconcile mobile hardware and software, teaching methods, content and educational goals.

2. Fuzzy Cognitive Map and Induced Fuzzy Cognitive Map

FCM is a technique used for prediction and decision making especially where fuzziness and uncertainty exists. In 1965, Lofti and A.Zadeh introduced the motion of fuzziness. Politician scientist Axelord (1976) later used this fuzzy model Cognitive Map (CM) to study decision making in social and political systems. Bart Kosko(1986) proposed some models to extend the idea of cognitive map using the concepts of neural networks and fuzzy logical approach by representing the concept linguistically with an associated fuzzy set. This well suited models support the decision making process and experts’ opinion [4]. This paper describes the method of analyzing the most contributing factors of m-learning using Induced Fuzzy Cognitive Maps (IFCMs). It analyzes the data by directed graphs and matrices. This method is simple and effective. It is a fuzzy graph modeling approach based on experts’ opinion. This is a non-statistical approach to study the problems with imprecise information.

2.1 Adjacency matrix and Cycle

The matrix $M$ is defined by $M = (e_{ij})$ where $e_{ij}$ is the weight of the directed edge $P_iP_j$. $M$ is called the adjacency matrix of the FCM, also known as connection matrix. The directed edge $e_{ij}$ from the causal concept $P_i$ to concept $P_j$ measures how much $P_i$ causes $P_j$. The edge $e_{ij}$ takes values in the real interval $[-1,1]$, $e_{ij} = 0$ indicates no causality. $e_{ij} > 0$ indicates causal increase / positive causality $e_{ij} < 0$ indicates causal decrease / negative causality. Simple FCMs provide quick first-hand information to an expert’s stated causal knowledge. Let $P_1, P_2, P_3,..., P_n$ be the nodes of FCM. Let $A = (a_1, a_2,..., a_n)$ be called a state vector where either $a_i = 0$ or 1. If $a_i = 0$, the concept $a_i$ is in the OFF state and if $a_i = 1$, the concept $a_i$ is in the ON state, for $i = 1, 2,..., n$. Let $P_1P_2, P_2P_3,..., P_{n-1}P_n$ be the edges of the FCM ($i \neq j$). Then the edges form a directed cycle.

2.2 Hidden Pattern and Fixed Point

An FCM is said to be cyclic if it possesses a directed cycle. An FCM with cycles is said to have a feedback, when there is a feedback in an FCM, i.e., when the causal relations flow through a cycle in a revolutionary way, then FCM is called a dynamical system. The equilibrium state for the dynamical system is called the hidden pattern. If the equilibrium state of a dynamical state is a unique state vector, it is called a fixed point or limit cycle. If FCMs settles down with a state vector repeating in the form $A_1 \rightarrow A_2 \rightarrow ...A_i \rightarrow A_1$ then this equilibrium is called a limit cycle. Inference from the hidden pattern summarizes the joint effects of all interacting fuzzy knowledge.

Finite number of FCMs can be combined together to prove the joined effect of all FCMs. If $E_1, E_2,...E_p$ be the adjacency matrices of all FCMs with nodes i.e. combined FCM denotes the relational matrix by $E = E_1 + E_2 + ... + E_p$. Suppose $A = (a_1, a_2,...a_n)$ is a vector which is passed in to a dynamical system $E$, then $AE = (a_1', a_2',...a_n')$ after thresholding and updating the vector suppose we get $(b_1, b_2,...b_n)$. We denote that by $(a_1',...a_n')(b_1, b_2,...b_n)$. Thus the symbol means the resultant vector has been threshold and updated.

3. Algorithmic Approach in Induced Fuzzy Cognitive Maps (IFCM)

Now we have to discuss another type of fuzzy model which is modified version of FCM called Induced Fuzzy Cognitive Maps (IFCMs). IFCMs focused on algorithmic approaches of FCMs which works on unsupervised data to derive an optimistic solution. The following are the steps of IFCM:

Step 1: For the given problem collect the nodes which is unsupervised data that is in determined factors.

Step 2: Draw the directed graph (FCMs) for the model, according to the expert opinion.

Step 3: To obtain the connection matrix M from FCMs. Here the number of rows in the given matrix = number of steps to be performed.

Step 4: Consider the state vector $C_1$ by setting the first component of this vector $C_1$ in ON position which is denoted by 1 and the rest of the components as 0 which are in OFF position.

Step 5: Find $C_1 \times M$. At each stage the state vector is updated and threshold. The symbol $\wedge$ represents the threshold value for the product of the result. The threshold value is calculated by assigning 1 for the values $x_i > 0$ and assigning 0 when $x_i = 0$.

Step 6: Now each component in the $C_1$ vector is taken separately and product of the given matrix is calculated. Find out the vector $y_1$ which has maximum number of one’s. The vector with maximum number of one’s which occurs first.

Step 7: Considered as fixed point when the same threshold value occurs twice and the iteration gets terminated.

Step 8: Set the state vector $C_2$ in ON state which is assigning the second component of the vector to be 1 and the rest of the components as 0. Precede the calculations discussed in steps 4 to 7.

Step 9: Continue the above process for the all the remaining state vector $Cn$ and find out the hidden pattern.
4. Adaptation of IFCM to analyze the need for orchestration of smart mobile devices, software and pedagogical design in the teaching learning process for secondary school students.

At the first stage we have taken the following twelve concepts: \( C_1, C_2, ..., C_{12} \). To analyze the factors that influence the effective use of smart mobile devices, we have interviewed and discussed with 100 students in different ages from 12 - 16 years in different schools and nearly 50 teachers aging from 30 - 50 years of Trichy district, Tamilnadu and with the experts opinion we have taken the following attributes.

The important concepts that contribute to why we need to use the Smart Mobile Devices in coordinating software and pedagogy for the students who are born with technical gadgets:

- \( C_1 \) = Smart Mobile Devices(SMD) along with software programmed, provide portability, convenience and autonomy in learning.
- \( C_2 \) = The orchestration supports discourse in knowledge building communities beyond the traditional classroom patterns.
- \( C_3 \) = It establishes for teachers and students, successful teaching and learning outcome as their interactivity share the task, analyzing and recreating knowledge.
- \( C_4 \) = Integrates teaching material with various interactions and interesting exercises to facilitate optimal m-learning process.
- \( C_5 \) = Inculcates strong thinking and investigative skills, communication skills and problem solving skills.
- \( C_6 \) = Promotes personalized, inquiry based learning thus creating open ended learning environment.
- \( C_7 \) = Simulates real world situations, allowing for greater degree of enquiry repeating the tasks as many times as possible like Laboratory experiments etc.
- \( C_8 \) = Accelerates Ubiquitous learning of students.
- \( C_9 \) = Encourages students to be active leaders in the design of curriculum and instruction.
- \( C_{10} \) = Promotes innovative teaching methods namely cooperative learning, exploratory learning, project based and game based learning.
- \( C_{11} \) = Students learning is redefined and modified through transformative pedagogical models paving way for more creative pursuits in order to explore new pedagogical approaches.
- \( C_{12} \) = Modification in software allow teachers to arrange their own teaching and learning flexibly in the classroom.

4.1 Directed Graph

The directed diagram is drawn based on the experts’ opinion with the vectors whose values are \( e_{ij} = 1 \) according the corresponding matrix is given.

4.2 Implementation of IFCM’s Model to the study

Based on the experts’ opinion from the field of Information Communication Technology and Education, based on this the directed diagram was drawn and the corresponding connection matrix is given as follows:

\[
M = \begin{pmatrix}
0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 \\
1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\
1 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \\
0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\
0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\
0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 \\
1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \\
\end{pmatrix}
\]

Now using the matrix \( M \) the factors are determined. Let the concept \( C_1 \) (i.e) Smart Mobile Devices(SMD) along with software programmed, provide portability, convenience and autonomy in learning is taken as the ON state and all the other nodes are in OFF state.

**Step1:**

In step 1, by setting the attribute \( C_1 \) to ON state (i.e) the first component of the vector is set to be 1 and the rest are assigned 0.

Let \( C_1 = (100000000000) \).
\[
C_1 \times M = (0111011111001) \cap (1111011111001) = C_1^1
\]

Threshold value is calculated by assigning 1 for the values > 1 and 0 for the values < 0. The symbol \( \cap \) represents the threshold value for the product of the result.

As mentioned in the algorithm of IFCM methodology, each component in the \( C_1^1 \) vector is taken separately and the product of the given matrix is calculated. The vector which has the maximum number of one’s which occurs first is considered as \( C_2 \).

The symbol \( \cap \) denotes the calculation performed with the respective vector, here \( C_1^1 \)

\[
\begin{align*}
C_1^1 \times M &= (100000000000)M = (0111011111001) \\
C_1^1 \times M &= (010000000000)M = (101101111111) \\
C_1^1 \times M &= (001000000000)M = (010001100111) \\
C_1^1 \times M &= (000100000000)M = (110010011101) \\
C_1^1 \times M &= (000010000000)M = (100010111111) \\
C_1^1 \times M &= (000001000000)M = (010010001110) \\
C_1^1 \times M &= (000000100000)M = (110011011110) \\
C_1^1 \times M &= (000000010000)M = (010100010110) \\
C_1^1 \times M &= (000000001000)M = (100000110110) \\
C_1^1 \times M &= (000000000100)M = (111100101111) \\
C_1^1 \times M &= (000000000010)M = (010100001110) \\
C_1^1 \times M &= (000000000001)M = (110101111111)
\end{align*}
\]

The vector has maximum number of one’s which occurs first is denoted as \( C_2 \) Therefore

\[
C_2 = (101101111111)
\]

Now product of \( C_2 \) and \( M \) is calculated.

\[
C_2 \times M = (101101111111) \times M = (572354568756)
\]

Thresholding

\[ \cap (111111111111) = C_2^1 \]

Now product of \( C_2^1 \) and \( M \) is calculated.

Threshold value is calculated by assigning 1 for the values > 1 and assigning 0 for the values < 1

\[
C_2^1 \times M = (100000000000)M = (0111011111001)
\]

\[
\begin{align*}
C_2^1 \times M &= (010000000000)M = (101101111111) \\
C_2^1 \times M &= (001000000000)M = (110010111111) \\
C_2^1 \times M &= (000100000000)M = (011100011111) \\
C_2^1 \times M &= (000010000000)M = (100010011110) \\
C_2^1 \times M &= (000001000000)M = (110010111101) \\
C_2^1 \times M &= (000000100000)M = (010100001100) \\
C_2^1 \times M &= (000000010000)M = (100000011100) \\
C_2^1 \times M &= (000000001000)M = (111000011110)
\end{align*}
\]

Similar to the above computation, the vector which has the maximum number of one’s is found and let it be \( C_3 \).

Therefore

\[
C_3 = (101101111111) = C_2
\]

When the same threshold value occurs twice, the value is considered as fixed point. The iteration gets terminated and the calculation gets terminated. Likewise any state vector can be taken and its effect can be analyzed.

Therefore the fixed point is

\[
C_3 = (101101111111)
\]

and the triggering pattern is \( C_1 \rightarrow C_2 \rightarrow C_2 \) when the first attribute is kept ON state. When the same threshold value occurs twice, the value is considered as the fixed point. The iteration gets terminated and the calculation gets terminated and the calculation for step 2 is performed. Similar to the step 1, consider \( C_1 \) by setting \( C_2 \) in ON state, i.e., assigning the second component of the vector to be 1 and the rest of the components as 0.

**Step: 2**

Let \( C_1 \) be

\[
\begin{align*}
C_1 &= (010000000000) \\
C_1 \times M &= (101101111111) \\
\cap (100000000000) &= C_1^1
\end{align*}
\]
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Now the vector with maximum number of one’s be \( C_2 \)

Therefore

\[
C_2 = (101101111111)
\]

\[
C_2 \times M = (101101111111) \times M
\]

\[
= (57235468756)
\]

\[
\therefore (111111111111) = C'_2
\]

\[
C'_2 \times M = (100000000000)XM = (011101111101)
\]

\[
C'_2 \times M = (010000000000)M = (101101111111)
\]

\[
C'_2 \times M = (001000000000)M = (010011001101)
\]

\[
C'_2 \times M = (000010000000)M = (000010011101)
\]

\[
C'_2 \times M = (000001000000)M = (100100111111)
\]

\[
C'_2 \times M = (000000100000)M = (010011100000)
\]

\[
C'_2 \times M = (000000010000)M = (001000111111)
\]

\[
C'_2 \times M = (000000001000)M = (100011100000)
\]

\[
C'_2 \times M = (000000000100)M = (010000111111)
\]

\[
C'_2 \times M = (000000000010)M = (100000011111)
\]

Similar to the above computation, the vector which has the maximum number of one’s is found and let it be \( C_3 \).

Therefore

\[
C_3 = (101101111111) = C_2
\]

In the above manner, the other steps to be performed. By keeping each vector in ON position, the various fixed points are found.

Table I: Induced Patterns for the adjacency matrix \( M \) by IFCMs
5. Discussion and Conclusion

In this section, the discussion about the factors that influence the need for the orchestration of smart mobile devices with software and pedagogical designing, using IFCM is carried on. Result of Step 1 suggests, by keeping $C_1$ in ON state, we obtain the hidden pattern. That is, all the 1’s in $C_2$ are the possible factors revealed from the first factor. More precisely, the factors viz: Smart Mobile Devices (SMD) along with software programmed, provide portability, convenience and autonomy in learning, establishes for teachers and students, successful teaching and learning outcome as their interactivity share the task, analyzing and recreating knowledge. Integrates teaching material with various interactions and interesting exercises to facilitate optimal m-learning process. Promotes personalized, inquiry based learning thus creating open ended learning environment. Simulates real world situations, allowing for greater degree of enquiry repeating the tasks as many times as possible like Laboratory experiments etc, Accelerates Ubiquitous learning of students. Encourages students to be active leaders in the design of curriculum and instruction, Promotes innovative teaching methods namely cooperative learning, exploratory learning, project based and game based learning. Students learning is redefined and modified through transformative pedagogical models paving way for more creative pursuits in order to explore new pedagogical approaches. Modification in software allow teachers to arrange their own teaching and learning flexibly in the class room are the casual implications. The above discussed algorithm focused on the criteria $C_2(101101111111)$ i.e “The orchestration of Smart Mobile devices with software and pedagogical designing support discourse in knowledge building communities beyond the traditional classroom patterns” plays the role of fixed point. The above criteria proves that the orchestration supports building up knowledge among students than traditional class room.

In a similar manner, the results of step 2 are analyzed. On the whole, the factors 1, 3, 4, 6, 7, 8, 9, 10, 11 & 12 are the main implicated factors so for any common factor as we have taken as attributes 1 to 12, the above are the casualties. In today’s context everybody is affordable to have mobile devices especially among students, adolescents and adults too hence it is inevitable to use technologies in education. It is challenging to use mobile devices in the teaching and learning process because the teachers may lack training. Shortage of technical support and lack of relevant training may be the cause for not using them in the classroom (Oliviera, 2014).[5] Teachers need to be taught how to use technology in their subject (Tayfun & Arzu, 2012, Kochlere Mishra, 2008).

6. Suggestions

It is notable to mention here that Tamilnadu government has already taken efforts to provide laptops for the higher education nearly for the past five years and also planning to introduce Tablet for the secondary school students.

(i) The government may also give relevant training for the secondary school teachers on how to prepare teaching learning activities according to their subjects.

(ii) Internet facility can be made available for the schools in the remote areas.

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