APPLICATION OF AUGMENTED FUZZY COGNITIVE MAP IN EDUCATION

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Abstract

In any academic setting, mutual respect among teachers, students and administrators is essential in order to maintain a positive learning environment. It is well established that the quality of children's relationships with their teachers in the early grades has important implications for children's concurrent and future academic and behavioral adjustment. Improving students' relationships with teachers has important, positive and long-lasting implications for students' academic and social development. Teachers who foster positive relationships with their students create classroom environments more conductive to learning and meet students' developmental, emotional and academic needs. But due to certain inter personal and environmental factors, students hesitate to move closer to the teachers and these factors affect completely the quality of the relationship between teachers and students. Several studies have reported specific links between teacher – student relationship quality and student engagement. This study aims to analyze and prioritize various empirical, environmental and inter-intra personal factors that affects the quality of teacher- student relationship in the present educational era. For this analysis, an efficient tool which has the capability of solving an unsupervised data namely augmented fuzzy cognitive map has been used. A fuzzy cognitive map (FCM) can be understood as a graphical representation of the knowledge about or the perception of a given system. FCM is a combination of fuzzy logic and cognitive mapping.

Key Words : Teacher-student relationship, FCM, Augmented FCM

1.Introduction

Parents and educators quickly accept that students need to be taught from an effective curriculum in order to be successful in school. However, although most parents would say that they would want their children to have positive relationships with their teachers, they may view a close teacher-student relationship as less than necessary. Research suggests that this variable has
a significant influence on student achievement. In order for students to learn what is offered from an effective curriculum, they must be able to access support from their teachers (Klem & Connell, 2004).

1.1. Literature Review on Teacher-Student relationship

Adults often assume that children like school due to the opportunities it offers for peer interaction. Although previous studies support that notion, research also indicates that certain teacher traits serve as strong indicators of students' like or dislike for school (Montalvo, Mansfield, & Miller, 2007). Hallinan (2008) states that when students' needs to be valued and respected are met, their attachment to school increases. Research by Montalvo et al. (2007) has shown that students will put forth greater effort and demonstrate a higher degree of persistence if they like their teachers. In addition, findings indicate that students attain better grades in classes taught by teachers they like (Montalvo et al., 2007). The evidence linking student-teacher relationships with student achievement has been consistent across grade levels. Given these findings, it is important for all students to have equal access to establishing positive relationships with their teachers. It would seem that is not the case for all students. According to Jerome, Hamre, and Pianta (2009), some subgroups of kindergarten children, including those who were Black, male, lower in ability level, and higher in exhibiting externalizing behaviors experienced teacher relationships with more conflict than their peers. Conversely, it was found that children who were female, came from higher socio-economic backgrounds, and were higher in ability level enjoyed closer teacher relationships (Jerome et al., 2009). Teacher-student relationships also appear to be impacted by how smooth the transition is to a child's first school experiences. In a study made in a kindergarten setting, Mantzicopoulos (2005) found that kindergarten teachers reported lower teacher-student conflict when schools coordinated activities designed to ease the transition between preschool and kindergarten, such
as communicating kindergarten expectations to parents, arranging kindergarten preview experiences, and encouraging parent involvement. Perhaps these strategies resulted in closer relationships because teachers were given the opportunity to better understand their students' skills and appreciate their

families' backgrounds (Mantzicopoulos, 2005). But, Multiple factors contribute to the quality of student–teacher and parent–teacher relationships. Jan Hughes,2007 tested a theoretical model positing that (a) the quality of teachers' relationships with students and their parents mediates the associations between children's background characteristics

and teacher-rated classroom engagement and that (b) child classroom engagement, in turn, mediates the associations between student–teacher and parent–teacher relatedness and child achievement the following year. The current study considered the factors that influence the quality of teacher- student relationship according to Jan Hughes, 2007 and using augmented FCM it aims to analyze the factors and to prioritize the factors as per their influencing level with other factors.

This paper is structured into six sections. Section 2 describes the foundations of FCM and introduces augmented FCM. Section 3 gives the factors for the problem and implementation of the augmented FCM is done in section 4. Section 5 concludes this proposed study.

2. Theoritical Background

2.1. FCM Foundations

A Fuzzy Cognitive Map (FCM) is a graphical depiction consisting of nodes indicating the most relevant factors of a decisional environment, and links between these nodes representing the relationships between those factors. A FCM describes the behavior of the system in terms of concepts ; each concept representing an entity, a state, a variable or a characteristic of the systems .

The concept of Cognitive Maps (CMs) is the origin of FCM. CM is first proposed and applied by a political scientist Axelrod, 1976 to represent the causal relationships among factors in order to critical a decision-making process. Then Bart Kosko,1985, 1986 enhanced the power of cognitive maps considering fuzzy values for the concepts of the cognitive map and fuzzy degrees of interrelationships between concepts. After this pioneering work, Fuzzy Cognitive Maps attracted the attention of scientists in many fields and have been used in a variety of different scientific problems.

In a graphical illustration, FCM seems to be a signed directed graph with feedback consisting of nodes and weighted arcs. It must be renowned that all the values in the graph are fuzzy, so the weights of the arcs lie in the interval [-1, 1]. Observing this graphical representation, it becomes clear which

concept influences other concepts directly or reversely. Between concepts, there are three types of causal relationships, that articulate the type of influence from one concept to other.

(i) The weights of the arcs between concepts C_i and C_j (W_{ij}) could be positive if there is an increase in the value of C_i leads to an increase in the value of C_j and a decrease in the value of C_i leads to the decrease of the value of C_j.

(ii) $W_{ij} < 0$ which means that an increase in the value of C_i leads to the decrease of the value of C_j and vice versa.

(iii) $W_{ij} = 0$ if there is no relation between C_i & C_j.

Fuzzy Cognitive Maps have been used for planning and making decision in the field of international relations and political developments(Taber,R., 1991) and for analyzing graph theoretic behavior (Zhang,W.R.,1988) been proposed on a generic system for decision analysis(Zhang,W.R.,et al.,1989) and for distributed co-operative agents(Zhang,W.R.,et al.,1992). FCMs also have been used to scrutinize electrical circuits (Styblinski,M.A.,1991) to structure virtual worlds (Dickerson,J.A.,1994). In the control related themes, FCMs are used to model and support plan to control(Goloh,K., et al.,1989) to represent Failure Models and Effects Analysis for a system model (Pelaez,C.E.,1994,1995,1996;) and to model the superior of control systems(Stylios,C.D.,1997). It is obvious that there is high interest in the use of FCM in a wide range of different fields.

2.2. Augmented FCM

An Augmented Fuzzy Cognitive Map was built for modeling Critical Success Factors in Learning Management Systems.(Jose L. Salmeron, 2009). Various methodologies could be used in order to reach a consensus among the experts(Bryson,N.,et al., 1997). Finally the Augmented FCM approach has been adopted, because it doesn't need that experts change slightly their judgment for consensus as Delphi methodologies (Bueno,S.,2008). The Augmented adjacency matrix is built adding the adjacency matrix of each expert (Kosko,B.,1996).

Let two FCMs with no common nodes. FCM_A with C_i^A as nodes $FCM_A=\{ C_i^A \}$ and FCM_B with C_j^B as nodes $FCM_B = \{ C_j^B \}$. The adjacency matrix of FCM_A is $A_A = (W_{ij}^A)$; and the adjacency matrix of FCM_B is $A_B =\{W_{ij}^B\}$,

The Augmented adjacency matrix is

$$A = \begin{pmatrix} W_{ij}^{A} & 0 \\ 0 & W_{ij}^{B} \end{pmatrix}$$

If there are common nodes, then the element W_{ij}^{Aug} in the augmented matrix is

$$W_{ij}^{Aug} = \frac{\sum_{k=1}^{n} W_{ij}^{k}}{n}$$

n being the number of FCMs added, one by expert, k the identifier of each expert and i and j the identifier of the relationships (fig.2).

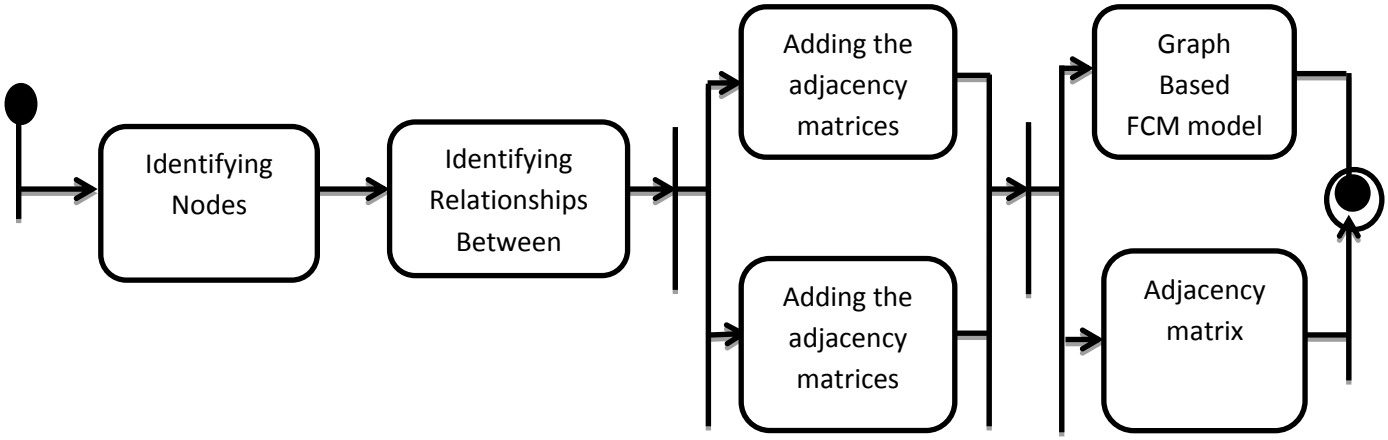

Fig.1. Basic stages for building a Fuzzy Cognitive Map

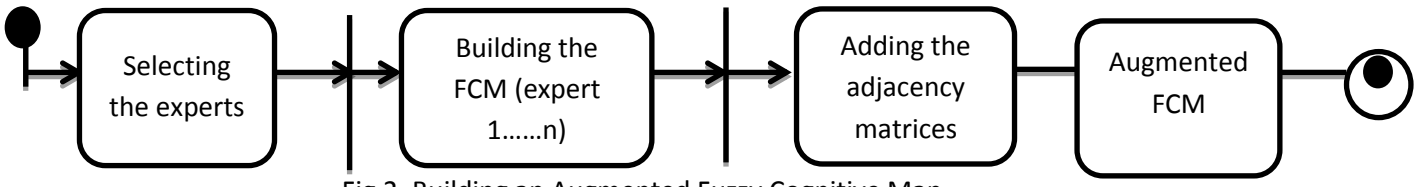

Fig.2. Building an Augmented Fuzzy Cognitive Map

Example for Augmented Matrix :

Let two FCMs with common nodes. Starting from each adjacency matrix

$A^{Exper-1}$ =

	A	B	C
A	0	0.5	-0.2
B	0	0	0.1
C	0	0	0

$A^{Expert-2}$ =

	A	B	C
A	0	0.4	0
C	0	0	0
D	0.7	0.1	0

The augmented adjacency matrix will be built as follows

A^{Aug} =

	A	B	C	D
A	0	0.25	0.1	0
B	0	0	0.05	0
C	0	0	0	0
D	0.35	0	0.05	0

3. Factors influencing Teacher- Student relationship

P1 - Students sense of social relatedness

P2 - Students sense of belonging at school

P3 - Socio economic status of children

P4 - Gender and racial disparity

P5 - Student motivation and engagement

P6 - Students who exhibit under controlled or aggressive behavior lower levels of support

P7 - The ethnic imbalance between teachers and students

P8 - Racial difference in behavior orientation and academic task engagement of teachers

P9 - Teachers less support and more criticism with students

P1 – Students Sense of Social Relatedness

Student's sense of social relatedness at school is a key construct in contemporary theories of academic motivation and engagement (Connell & Wellborn, 1991; Eccles, Wigfield, & Schiefele, 1998; Stipek, 2002). When students experiences a sense of belonging at school and supportive relationships with teachers and classmates, they are motivated to participate actively and appropriately in the life of the classroom (Anderman & Anderman, 1999; Birch & Ladd, 1997; Skinner & Belmont,1993).

Student sense of belonging at school has been linked both to engaged versus disaffected school identities and to learning outcomes(Battistich, Solomon, Watson, & Schaps, 1997; Skinner, Zimmer-Gembeck, & Connell, 1998). Although the vast majority of the extant research on social relatedness and engagement has been conducted with students in Grade 3 and higher(Furrer & Skinner, 2003, and Stipek, 2002), recent research suggests that children's social relatedness in the primary grades may establish patterns of school engagement and motivation that have long-term consequences for their academic motivation and achievement(Hamre & Pianta, 2001; Ladd, Birch, & Buhs, 1999).

P2 – Students sense of belonging at school

The term school belonging refers to students' subjective perception of being accepted and respected in their particular school setting. Some researchers have also examined the parallel perception in relation to specific classes; typically using the term class belonging . Bausmeister and leary (1995) have proposed that all people have an innate need to belong to social groups and to form positive interpersonal relationships with others. Given the amount of time children and adolescents spend in educational settings and the societal importance attached to school-related activities, students' sense of belonging in those settings is particularly important for their healthy development.

Carol Goodenow(1993) defined student's sense of belonging as the sense of "psychological membership in the school or classroom, that is , the extent to which students feel personality accepted, respected, included, and supported by others in the school environment".

P3 – Socio economic status of children

Positive relations with teachers in the classroom and between home and school appear to be less common for low-income and racial minority children than for higher income, White students (Entwisle & Alexander, 1998; Hamre & Pianta, 2001; Hill et al., 2004; Kohl, Weissberg, Reynolds, &Kasprow, 1994; Ladd et al., 1999). Furthermore, several researchers have suggested that these early racial and income differences in relatedness may contribute to disparities in achievement (Pianta, Rimm-Kauffman, & Cox, 1999; Pianta & Walsh, 1996) .

Socio economic status (SES) is an economic and sociological combined total measure of a person's work experience and of an individual's or family's economic and social position in relation to others, based in income, education and occupation. When analyzing a family's SES, the household income, earner's education and occupation are examined, as well as combined income, versus with an individual, when their own attributes are assessed.

Socioeconomic status is typically broken into three categories, high SES, middle SES, low SES to describe the three areas a family or an individual may fall into. When placing a family or individual into one of these categories any or all of the three variables (income, education, and occupation can be assessed.

Education in higher socioeconomic families is typically stresses as a more important in topic in the household and local community. In poorer areas where food and safety are priority education can take a backseat.

P4 – Gender and Racial disparity

Recent investigation suggests many finding such as minority, especially African American, children and children of low socioeconomic status (SES) are less likely than Caucasian or higher SES children to enjoy supportive relationships with teachers (Entwisle & Alexander, 1998; Hamre & Pianta, 2001; Ladd et al., 1999; Wehlage & Rutter, 1986).

Although the reasons for these differences are not known, the fact that the teacher workforce in the united states is predominantly Caucasian and middle class may contribute to racial and income differences in teacher-student relationship quality.

P5 – Student motivation and engagement

Several studies have reported specific links between teacher-student relationship quality and student engagement (Furrer & Skinner, 2003). Engagement has been defined in different ways by different investigators, but it most often refers to behavioral engagement as indexed by cooperative participation, conformity to classroom rules and routines, self-directedness persistence and effort (Fredricks, Blumenfeld, & Paris, 2004).

Students who enjoy a close and supportive relationship with a teacher are more engaged in that they work harder in the classroom, persevere in the face of difficulties, accept teacher direction and criticism, cope better with stress, and attend more to the teacher (M. Little & Kobak, 2003; Midgley, Feldlauffer, & Eccles, 1989; Ridley, McWilliam, & Oates, 2000, 2000; Skinner & Belmont, 1993; Wentzel, 1999).

P6 - Students who exhibit under controlled or aggressive behavior lower levels of support

Multiple factors contribute to the quality of student-teacher relationships. Not surprising, students who exhibit under-controlled or aggressive behaviors establish relationships with teachers characterized by lower levels of support and acceptance and higher levels of conflict (Birch & Ladd, 1998; Silver, Measelle, Armstrong, & Essex, 2005).

Compared with girls, boys' relationships with teachers are characterized by less closeness and more conflict (Birch & Ladd, 1997, 1998; Saft & Pianta, 2001; Silver et al., 2005), perhaps because boys are less conforming and self regulated than girls.

P7 – The ethnic imbalance between teachers and students

In 2003-2004, 84% of elementary teachers in the united states were Caucasian (National Center for Education Statistics, 2005a). Conversely, 42% of elementary children in 2003 were part of an ethnic minority (National Center for Education Statistics, 2005b). The ethnic imbalance between teachers and students gains in significance in light of several studies reporting that teacher-child ethnicity match is associated with more positive teacher ratings of closeness (Saft & Pianta, 2001; Zimmerman, Khoury, Vega, Gill, & Warheit, 1995).

P8 – Racial difference in behavior orientation and academic task arrangement of teachers

It is well established that the quality of children's relationships with their teachers in the early grades has important implications for children's concurrent and future academic and behavioral

adjustment (Howes, Hamilton, & Matheson, 1994; Hughes, Cavell, & Jackson, 1999; Meehan, Hughes, & Cavell, 2003; Pianta, Steinberg, &Rollins, 1995).

The association between teacher- student relationship quality and children's subsequent adjustments holds when previous levels of adjustment are statistically controlled (Hughes, Cavell, & Jackson, 1999; Ladd et al., 1999; Meehan et al., 2003).

P9 – Teachers less support and more criticism with students

American children experience less supportive relationships with teachers may also be explained by racial differences in behavioral orientation and academic task engagement. Because African American children are less conforming and more active than are Caucasian children at school entrance(Hudley, 1993; Rock & Stenner,2005), teachers' interactions with African American students may be characterized by more criticism and less support.

4. Adaption of Augmented FCM to the problem

Using the questionnaire and the expert's opinion the following nine attributes are considered. It is not a hard and fast rule we need to consider only these nine attributes but one can increase or decrease the number of attributes according to needs the following attributes are taken as the main nodes for study.

The Matrix M_1 is given by the first expert who is a educational expert

	1	2	3	4	5	6	7	8	9
1	0.8	0	0.76	0.9	-0.9	-0.8	-0.7	-0.8	1
2	0.95	0	-0.7	-0.9	1	-0.8	-0.7	-0.8	-1
3	-0.8	-0.75	0	-0.7	-0.85	0.85	-0.75	-0.7	-0.9
4	-0.6	-0.9	-0.8	0	-0.6	0.9	0.8	0.9	0.85
5	-0.7	0.8	-0.6	0.75	0	-0.7	0.3	-0.4	-0.7
6	0.9	0.8	-0.75	0.8	-0.75	0	0.8	-0.75	0.8
7	-0.85	-0.75	0.7	0.8	-0.85	0.82	0	0.5	0.7
8	-0.75	-0.85	0.5	-0.75	-0.75	0.9	0.8	0	0.85
9	0.75	-0.9	-0.25	0	0.5	0.4	0.5	-0.6	0

The Matrix M_2 is given by the second expert who is a educational expert

	1	2	3	4	5	6	7	8	9
1	0	0.9	0	-0.8	0.7	-0.9	-0.7	0.9	-0.8
2	1	0	0	-0.9	0.8	0.8	-0.4	-0.6	0.6
3	1	0.9	0	0.9	-0.3	0.9	0.8	0.4	0.7
4	1	0.9	0	0	-0.4	0.9	0.8	0.7	0.85
5	0.9	0.8	0.2	0.3	0	0.7	-0.7	-0.8	-0.7
6	0.8	-0.5	0.8	-0.4	0.3	0	0.8	0.75	0.9
7	0	-0.7	0	0.3	-0.4	0.8	0	0.8	-0.7
8	0.7	0.6	0	0.3	0.8	0.4	-0.9	0	-0.9
9	-0.6	-0.9	0	-0.4	0.9	0.8	0.6	-0.7	0

The Augmented matrix is

$$W_{ij}^{Aug} = \frac{\sum_{k=1}^{n} W_{ij}^{k}}{n},$$

Using this formula we get the augmented adjacency matrix will be built as follows

	1	2	3	4	5	6	7	8	9
1	0	0.85	0	-0.02	0.8	-0.9	-0.75	0.1	-0.8
2	0.975	0	-0.35	-0.9	0.9	0	-0.55	-0.7	-0.2
3	0.1	0.075	0	0.1	0.575	0.875	0.025	-0.15	-0.1
4	0.2	0	-0.4	0	-0.5	0.9	0.8	0.8	0.85
5	0.1	0.8	-0.2	0.525	0	0	-0.2	-0.6	-0.7
6	0.85	0.15	0.025	0.2	-0.225	0	0.8	0	0.85
7	-0.425	0.725	0.35	0.55	0.625	0.81	0	0.65	0
8	-0.025	-0.125	0.25	-0.225	0.025	0.65	-0.05	0	-0.025
9	0.075	-0.9	-0.125	-0.2	0.7	0.6	0.55	-0.65	0

5.Conclusion:

From the Augmented matrix drawn above, we can discuss the influence level of various factors to the model defined. In the matrix we can observe that many positive and negative signs present which

denotes that, the quality of teacher- student relationship is affected by both intrapersonal and social factors which inhibits one another. Among the list of factors, second factor is considered to be the most impactful factor as the second row consists maximum membership grades 0.9, 0.975 . So, "students' sense of belongingness at school" should be moulded positively from the infancy period of the students by parents. And the sixth factor namely, "Students who exhibit under controlled or aggressive behavior lower levels of support" is the second more impactful factor. This is also should be studied and observed by the parents. Hence our findings suggest that parents' involvement and motivation to enhance positive relationship between teacher and student play a vital role to improve the quality of Student-teacher relationship.

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