Fuzzy Cognitive Map Based Approach for Teachers' Performance Evaluation.

X.Y. Djam, Ph.D.* and A.K. Mishra, Ph.D.

Department of Mathematics, Gombe State University, PMB 127, Gombe State, Nigeria.

E-mail: dxaveria@yahoo.com*
Telephone: +23480689993095

ABSTRACT

Teachers' performance evaluation is the best way to keep teachers on track in higher institutions. Managing people is a difficult task for most organizations and maintaining a regular assessment is vital for the growth of any organization. Owing to the fact human behavior are mostly based on quantitative facts which are uncertain, an expert system to manage this uncertainty is desired.

This paper presents the implementation of teachers' performance evaluation based on fuzzy cognitive map approach to provide a decision-support tool to executive management in higher institutions to manage academic uncertainties. Fuzzy cognitive map as a soft computing tool is a powerful tool to render precise what is imprecise in human behavior. Microsoft Visual Basic.Net 2010 and Structured Query Language (SQL) were used to design the system. Fifty (50) teachers were used to test the system and success rate of 98% was achieved. The results showed that fuzzy cognitive maps can be used effectively for teachers' performance evaluation.

(Keywords: fuzzy sets, fuzzy database, linguistics variables, expert system, performance evaluation, fuzzy cognitive map)

INTRODUCTION

Teachers' performance evaluation is the best way to keep teachers on track in higher institutions. Managing people is a difficult task for most organizations and maintaining a regular assessment is vital for the growth of any organization. A highly reliable and effective performance evaluation system is essential in decision making environments. In academics, evaluation procedures involve a lot of uncertainty and subjectivity. The application of fuzzy set theory in the assessment process can manage academic uncertainty effectively. Generally, a decision-making procedure is a complex process that has to take under consideration a variety of interrelated factors. Owing to the fact human behavior are mostly based on quantitative facts which are uncertain, an expert system to manage this uncertainty is desired. Fuzzy cognitive map (FCM) as a soft computing tool is a powerful tool to render precise what is imprecise in human behavior. FCM, a branch of fuzzy logic [6] was introduced by [7] as an extension of cognitive maps is powerful tools for modeling dynamic systems.

The traditional method of teacher performance evaluation involves a lot of uncertainty due to inability to actually quantify the behavior of teachers in a transparent and interpretable format. Reasoning with certainty is more acceptable to humans than the recommendations given by black box systems, because such is comprehensive, provides explanations and can be validated adequately by human inspection.

There are several methods proposed for developing expert systems (Bayesian Networks, Artificial Neural Networks, Case Base Reasoning, Genetic Algorithm, Analytical Hierarchy Process, and Fuzzy Cognitive Maps)[11]. Despite these existing techniques, there is still a painful lack of evidence-based expert systems for effective teachers' management. Although several studies have addressed the need for an expert system for teachers' assessment, until today the demand for a standardized tool to handle academic uncertainties remains an active research area.

Some research efforts have been made to computerized teachers' performance evaluation processes which are mainly based on statistical classifier [1-3]. Significant research efforts on teachers' assessment systems have been focused on the application of fuzzy concepts

mainly by means of membership functions and fuzzy rules [4, 5]. Although they reported accuracy on teacher performance evaluation, still the approaches have not gained wide acceptance among the executive management due to the deficiency of the existed methods to assist executives with transparent and interpretable results.

To put teachers on tract, it is paramount to evaluate their performance periodically. Adequate research should be done on regularly basis in order to improve on the standard of education so as to avoid recycling of notes. The dynamic nature of academic requires academicians to frequently update their knowledge for continuous relevance.

In order to improve the decision-making process of teachers' evaluation, there is the need for the application of artificial intelligence technique to handle academic uncertainty. In this paper, we developed an expert system based on fuzzy cognitive maps for teachers' performance evaluation in higher institutions. This soft computing approach does not only automate the decision-making process of teachers' performance evaluation but can effectively provide periodic confidential feedback mechanisms for decision makers in higher institutions.

FUZZY COGNITIVE MAP MODEL FOR TEACHERS PERFORMANCE EVALUATION

Methodology

The developed performance evaluation management system uses fuzzy cognitive map modeling approach. FCM is a soft computing tool that offers a number of advantages including the ability to identify meaningful patterns for proper decision making. Some academic experts were consulted to define the main characteristics/factors that play important role in teachers' performance evaluation. More specifically, ten (10) essential characteristics were used for the process. These characteristics selected by domain experts are the causative factors/concepts for the performance evaluation system.

The FCM teachers' performance evaluation model was developed consisting of the following nine (9) concepts/factors as shown in Table 1 (Construction of fuzzy sets) based on domain experts' knowledge.

Each input parameters take linguistic variables of the form: None, Very Low, Low, Moderate, High and Very High as shown in Table 1 while each output parameter takes linguistic variables of the form: Poor, Average, Good, Excellent and Outstanding as shown in Table 2.

The fuzzy rule for each interconnection was evaluated using fuzzy reasoning and the inferred weight was normalized using sigmoid function in the interval [0,1]. The rule base for this study (Table 3) are "IF-THEN" linguistics rules and was designed with the help of academic experts. Sample rules are presented in Table 3.

The performance evaluator tool based on FCM for decision-making process is shown in Figure 1 and consists of nine (9) concepts and the resultant weight matrix in Table 4.

The following algorithm was used for teacher performance evaluation process:

Step 1: Compute an Initial Weight Matrix $M_{Initial}$ and an Overall Weight Matrix $M_{Overall}$

Step 2: Compute Teacher's Input T_{Input}

$$T_{Input} = \frac{L_{Option}}{T_{Option} - 1}$$

Step 3: Compute Final Decision Score

$$T_{Output} = f\left(T_{Input} * M_{Weight}\right)$$

Table 1: Input Factors for Teachers Performance Evaluation

Performance Evaluation Factors	Linguistic Variables/Degree of Membership
F1: Research Productivity and Publications	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
F2: Proficiency in Teaching	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
F3: Supervision and Creativity	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
F4: Students' Satisfaction and Performance	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
F5: Head of Department Satisfaction	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
F6: Punctuality and Responsibilities	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
F7: Academic Awards and Achievements	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
F8: Colleagues' Opinion	None(0), Very Low(0.2), Low(0.4), Moderate(0.6), High(0.8), Very High(1.0)
T_{Output}: Teacher Performance Output	Poor, Average, Good, excellent, outstanding

Table 2: Ranking of Output Variable for Teachers' Performance Evaluation $T_{Output.}$

Linguistic Variables	Fuzzy Values
Poor	$0.1 \leq x < 0.3$
Average	$0.3 \leq x < 0.5$
Good	$0.5 \leq x < 0.7$
Excellent	$0.7 \leq x < 0.9$
Outstanding	$0.9 \leq x \leq 1.0$

Table 3: Sample Fuzzy Rule Base.

No.	F1	F2	F3	F4	F5	F6	F7	F8	T_{output}
1	Moderate	Low	Very Low	Low	Low	Low	Low	Moderate	Poor
2	Moderate	Very Low	Low	Moderate	Low	Moderate	Moderate	Moderate	Average
3	Very High	Very High	High	Very High	Very High	High	High	High	Excellent
4	Moderate	Very Low	Very Low	Moderate	High	Very High	Very High	High	Excellent
5	Moderate	Very Low	Very Low	Moderate	High	High	High	Moderate	Good
6	Moderate	Low	High	Moderate	Moderate	Moderate	High	High	Average
7	Moderate	Very Low	Low	Moderate	Low	Moderate	Moderate	Moderate	Average
8	Very High	Very High	High	Very High	Very High	High	High	High	Excellent
9	Moderate	Very Low	Very Low	Moderate	High	Very High	Very High	High	Excellent
10	Moderate	Low	Low	Low	Low	Low	Low	Moderate	Poor
11	Very Low	Very Low	Very Low	Moderate	Very Low	Very Low	Very High	Low	Poor
12	Very High	Very High	Very High	Very High	Very High	High	Moderate	Very High	Excellent
13	Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate	Moderate	Good
14	Very High	Very High	High	Very High	Very High	High	High	Very High	Outstanding
15	Moderate	Very Low	Very Low	Moderate	High	Very High	Very High	High	Excellent
17	Moderate	Low	Low	Very Low	Low	Moderate	Moderate	High	Average
18	Moderate	Very Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Average
19	Very High	Very High	High	Very High	Very High	High	High	High	Excellent
20	Moderate	Very Low	Very Low	Moderate	High	Very High	Very High	High	Excellent

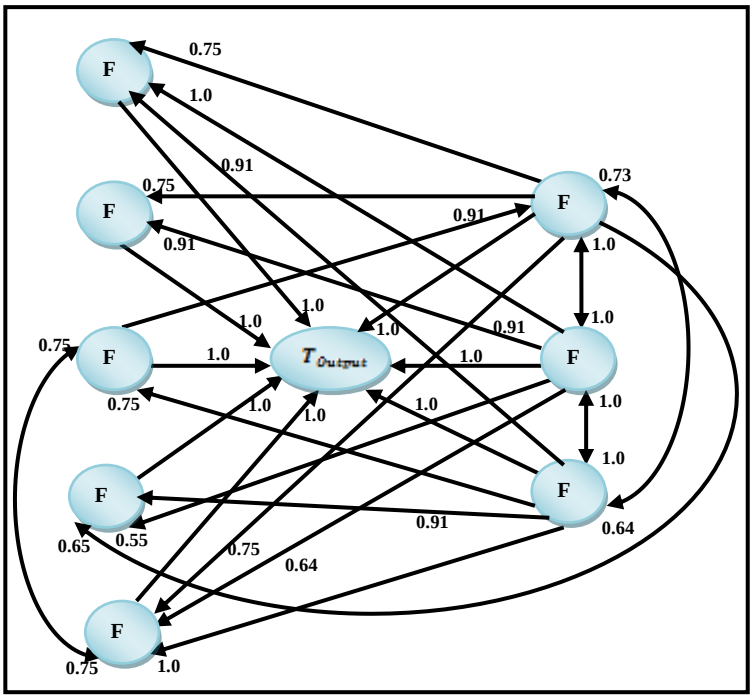

Figure 1: FCM Model for Teacher Performance Evaluation.

Table 4: Resultant Weight Matrix.

	F1	F2	F3	F4	F5	F6	F7	F8	T_{Output}
F1	0	1.0	1.0	0	0.55	0	0.91	0.64	1.0
F2	1.0	0	0.64	0.75	0.65	0.91	0.75	0.75	1.0
F3	1.0	0.73	0	0.91	0.91	0.75	0	1.0	1.0
F4	0	0	0	0	0	0	0	0	1.0
F5	0	0	0	0	0	0	0	0	1.0
F6	0	0.91	0	0	0	0	0	0.75	1.0
F7	0	0	0	0	0	0	0	0	1.0
F8	0	0	0	0	0	0.75	0	0	1.0
T_{Output}	0	0	0	0	0	0	0	0	1.0

RESULTS AND DISCUSSION

Experimental Results for Teacher Performance Evaluation

We considered two (2) different scenarios:

First Scenario: For this scenario, a teacher with personal identification number as 0463 performance evaluation status was evaluated as follows: Very High Research Productivity and Publications (F1=1.0), Very High Proficiency in Teaching (F2=1.0), Very High Supervision and Creativity (F3=1.0), High Student Satisfaction and Performance (F4=0.8), High Head of Department Satisfaction (F5=0.8), High Punctuality and Responsibility (F6=0.8), Very High Academic Awards and Achievement (F7=1.0), and Very High Colleagues' Opinion (F8=1.0). All these parameters were entered into the performance evaluator developed in VB.Net as shown in Figure 2.

Second Scenario: For this scenario, a teacher with personal identification number as 0466 performance evaluation status was evaluated as follows: High Research Productivity and Publications (F1=0.8), Very High Proficiency in Teaching (F2=1.0), High Supervision and Creativity (F3=0.8), High Student Satisfaction

and Performance (F4=0.8), High Head of Department Satisfaction (F5=0.8), High Punctuality and Responsibility (F6=0.8), Moderate Academic Awards and Achievement (F7=0.6), and High Colleagues' Opinion (F8=0.8). All these parameters were entered into the performance evaluator developed in VB.Net as shown in Figure 3.

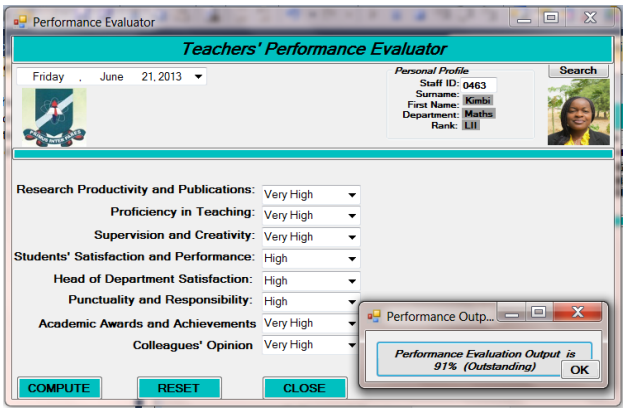

Figure 2: Scenario 1 - Parameters entered into Performance Evaluator System.

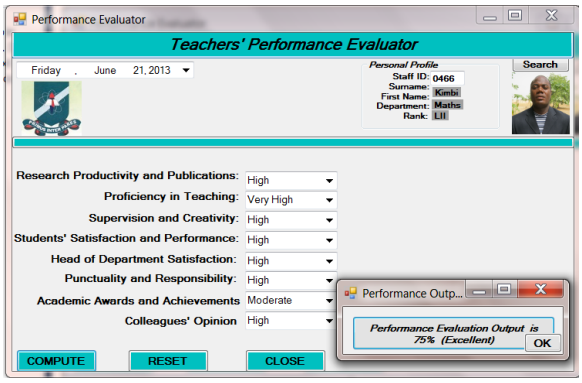

Figure 3: Scenario 2 - Parameters entered into Performance Evaluator System.

DISCUSSION

The developed FCM model for teachers' performance evaluation provides a framework within which decision makers can assess their teachers' with equity. All the eight (8) input factors are considered as factor concepts by the academic experts as listed in Table 1 to design the FCM model and each input concept represents six (6) fuzzy variables rate as: None (0), Very Low (0.2), Low (0.4), Moderate (0.6), High (0.8) and Very High (1.0). The output concept T_{Output} has five (5) Linguistic variables rate as Poor, Average, Good, Excellent and Outstanding as indicated in Table 2. Figure 2 and 3 respectively show the results derived from the performance evaluator system based on the input parameters; for the first scenario the performance evaluation based on the developed system was 91% (Outstanding) and for the second scenario 75% (Excellent). The results were in the desired limits based on domain experts' judgments. Similarly, the results for the other 48 teachers' were successful computed and success rate of 98% was achieved.

The results show that FCM can be effectively utilized for teachers' performance evaluation. One advantage of fuzzy performance evaluation is that it resembles human decision making with its ability to work from approximate reasoning and ultimately find a precise solution for effective decision-making.

CONCLUSION

The knowledge-based approach used in this study focuses on FCM as a soft computing tool to manage academic uncertainty and subjectivity. In the presented research, we have developed a FCM model to evaluate teachers' performance based on parameters that have validated by domain experts. The qualitative variables were translated into numeric results by developing an efficient and dynamic FCM Model as an artificial intelligence decision support tool with a view to help executive management to assess their teachers adequately for excellent academic standards. Our future work will be directed toward the integration of other knowledge schemes into this approach to improve the performance of the suggested tool.

REFERENCES

1. Clark, J.A. and F. Soliman. 1999. "A Graphical Method for Assessing Knowledge-based Systems Investments". *Logistics Information Management*. 12:63-77.

2. Day, A.J. and A.K. Suri. 1999. "A Knowledge-based System for Postgraduate Engineering Courses". *Journal of Computer Assisted Learning*.15:14-17.

3. Amin, H.U. and A.R. Khan. 2009. “Acquiring Knowledge for Evaluation of Teachers’ Performance in Higher Education – Using a Questionnaire”. *International Journal of Computer Science and Information Security*. 180-187.

4. Chiang, T.T. and C.M. Lin. 1994. “Application of Fuzzy Theory to Teaching Assessment”. In: *Proceedings of the 1994 Second National Conference on Fuzzy Theory and Applications*, Taipei, Taiwan, Republic of China. 92-97.

5. Khan, A.R., H.U. Amin, and Z.U. Rehman. 2011. “Application of Expert System with Fuzzy Logic in Teachers’ Performance Evaluation”. *International Journal of Advanced Computer Science and Applications*. 2(2):51-57.

6. Zadeh, L. 1965. “Fuzzy Sets”. *Information and Control*. 8(3):338-353.

7. Kosko, B. 1986. “Fuzzy Cognitive Maps”. *International Journal of Man-Machine Studies*. 24:65-75.

8. Stylios, C.D. and P.P. Groumpos. 2000. “Fuzzy Cognitive Maps in Modeling Supervisory Control Systems”. *Journal of Intelligent Fuzzy Systems*. 8:83-98.

9. Liu, Z. and R. Satur. 1999. “Contextual Fuzzy Cognitive Map for Decision Support in Geographic Information Systems”. *IEEE Transaction on Fuzzy Systems*. 5:495-507.

10. Stylios, C.D. and P.P. Groumpos. 2004. “Modeling Complex Systems Using Cognitive Maps”. *IEEE Transaction on Systems: Man and Cybernetics*. 34(1):155-162.

11. Djam, X.Y. and Y.H. Kimbi. 2011. “Fuzzy Expert System for the Management of Hypertension”. *Pacific Journal of Science and Technology*. 12(1): 390-402.

12. Djam, X.Y. and G.M. Wajiga. 2012. “A Novel Diagnostic Framework: The Application of Soft Computing Technology”. *Pacific Journal of Science and Technology*. 13(1):261-272.

13. Papageorgiou, E.I., C.D. Stylios, and P.P. Groumpos. 2003. “An Integrated Two-Level Hierarchical Decision Making System based on Fuzzy Cognitive Maps (FCMs)”. *IEEE Trans, Biomed Eng*., 50(12):1326-1339.

14. Papageorgiou, E.I., P.P. Spyridonos, C.D. Stylios, P. Ravazoula, P.P. Groumpos, and G.N. Nikiforidis. 2006. “Advanced Soft Computing Diagnosis Method for Tumour Grading”. *Artificial Intelligence in Medicine*. 36:59-70.

15. Papageorgiou, E.I., C.D. Stylios, and P.P. Groumpos. 2007. “Novel Architecture for Supporting Medical Decision Making of Different Data Types Based on Fuzzy Cognitive Map Framework”. *Proceedings of 29th IEEE EMBS Annual International Conference*, Conference in Medicine and Biology Society: Lyon, France. 21-23.

16. Papageorgiou, E.I., P.P. Spyridonos, D. Glotsos, C.D. Stylios, P. Ravazoula, G.N. Nikiforidis, and P.P. Groumpos. 2007b. “Brain Tumor Characterisation Using the Soft Computing Technique of Fuzzy Cogntive Maps”. *Applied Soft Computing*. 8:820-828.

17. Papageorgiou, E.I. 2009. “A New Methodology for Decisions in Medical Informatics Using Fuzzy Cognitive Maps Based on Fuzzy Rule Extraction Techniques”. *Applied Soft Computing*. 11:500-513.

18. Georgopoulos, V., G. Malandraki, and C. Stylios. 2002. “ A Fuzzy Cognitive Map Approach to Differential Diagnosis of Specific Language Impairment”. *Artif. Intell. Med*. 29(3):261-278.

SUGGESTED CITATION

Djam, X.Y. and A.K. Mishra. 2013. “Fuzzy Cognitive Map Based Approach for Teachers’ Performance Evaluation”. *Pacific Journal of Science and Technology*. 14(2):176-181.

Pacific Journal of Science and Technology