Multi Criteria Decision Making Modeling for Assessment of a School Performance Using Best Worst Method and Expert System Technology

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Abstract: This paper presents an integrated approach to develop a model for Multi Criteria Decision Making (MCDM) usingan Expert System,Best Worst Method and Artificial Neural Networks for performance assessment of Government Schools using test casesof district Tank, Khyber Pakhtunkhwa Pakistan. There is a dire need to integrate and assessallthe provided facilities to a school (i.e., Teaching Staff, School Building, Equipment, Control Mechanism, Furniture & Furnishing, Co-Curricular Activities, Costs and Course Curriculum etc.) through a model and to test by an Expert System. This work is composed of various stages i.e., 1) to acquire the tacit knowledge of the problem domain, 2) to analyze andpoint out the best and worst factors of the assessment model 3) to integrate the Best Worst Method and Artificial Neural Networks for development of an assessmentmodel, Tree Diagram, analysis of Best & Worst Criteria, Best & Worst Solver Spreadsheet, Artificial Neural Network Model and Decision Table etc. 4) to test and evaluate the assessment model by domain experts for few schools through a Ruled-Based Expert System. Anassessment report was achieved through a prototype ExpertSystem pointing out the key areas of the school management system for decision makingwith capability to give answers to questions, like, "EXPLAIN" and "WHY". The performance and efficiency of the proposed Knowledge Based System was tested through the domain experts of education sector. These experts awarded it 84.8% efficiency rate, which means that the proposed Expert System is highly adoptable for evaluation of the performance management of Government Schools in the mentioned area. The proposed research model as well as the proposed Expert System was tested before deployment for various schools for the above-mentioned schools. Which can be expanded to all types of schools and colleges that will be useful both for government and researchers as well.

Keywords: Schools' Performance; Expert System; Symbolic Model; Decision Table; Multi Criteria Decision Making Method

I. Introduction

The main issue with government schools is to critically analyze, evaluate, monitor and supervise the provided facilities through a specialized knowledge-based system for assessment of performance management. Although, the education ministry should consider the various important factors extracted from the knowledge and expertise of domain experts, that affect the performance of these educational institutions in terms of; Building, Equipment, Furniture & Fixture, Teaching Staff, Course Curriculum, Control Mechanism etc. All these important facilities need to be integrated through a model and tested through a specialized software system like Knowledge Based System being integrated with Multi Criteria Decision Making Methods and Artificial Neural Networks (ANN).

The analysis and modeling process is based upon the decision making for selection of suitable criteria for performance management of schools using- analysis of Best & Worst Criteria, Best & Worst Solver Spreadsheet, Tree Diagram, Decision Table, development of ANN model and the symbolic model.
The proposed research study is tested to the Government Schools of district Tank, Khyber Pakhtunkhwa. The priority weights are assigned by the selected domain experts to the sub factors of schools' performance management. The proposed knowledge-based system is a prototype system in nature but can be extended towards other educational institutions through minor changes in the knowledge base.
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1.1 Aims and Objectives

The aim of this research work is to develop a model for assessment of Schools performance and test through Knowledge Based System integrated with Multi Criteria Decision Making and Artificial Neural Networks etc.To achieve the requisite goal, we have to achieve the following research objectives:

- To acquire the tacit knowledge about the problem domain.
- To integrate Multi Criteria Decision Making techniques & Artificial Neural Networks and present the problem domain through various models, like; a conceptual model, Symbolic model, tree diagrams etc.
- To develop the proposed prototype Expert System using an Expert System Shell.
- To test and validate the proposed Knowledge Expert System through Domain Experts and System users.

2.0 Literature Review

Developed countries of the world have transformed their education system from the odd methods towards the new modern ICT and AI technologies. The Ministry of education, Pakistan may consider the AI areas to efficiently combat the flaws in the educational system. (Chassignol et. al., 2018)

This research is about quantitative, qualitative and review methods which aims as to identify a set of 10 effective factors referred to as the 10 Ms: management, manpower, machine, material, method, money, minutes, measurement, market and ministry (Anwari et. al., 2011).

The article throws light on the top eight Components of Educational Management i.e., Educational Planning, Educational Administration, Education Organizational, Educational Direction, Educational Co-ordination, Educational Supervision, Educational Control and Educational Evaluation (Diksha Kashyuap, 2022).

Performance management is the important part of every organization, it may be formally as process in organization or informally as form of dialogue. It was pointed out that performance management is an essential organizational driven process of organization (Brown et. al., 2018).

Analysis conducted between standard performance management model and performance management system applying local organization development. The researchers suggested that performance management is not one time activity but continuous process in a successful organization. (Shahjehan et. al., 2010).

Knowledge based system incorporates the expert knowledge that has been coded into facts, rules, heuristics and procedures. The power of expert system resides in the specific, high-quality knowledge about task domain (Sampada, R.V. Kulkarni, 2009).

Expert Systems are the technology of knowledge management of the 21stCentury with basic functions entirely under the supervision of human expert, because it combines the expertise of domain experts i.e., Computer Programmers, Engineers, Doctors, Scientists etc., for decision making. Author stated that Robotics, Geographic Information System, Image Analysis, recognition are the main applications of Expert Systems (Leondes et. al, 2001).

Role of Expert Systems and Artificial Intelligence for taking online exam in the current situation is remarkable. It is great time to take advantage from the applications of Expert System in conducting online exams. According to author, the Expert Systems have same expertise as knowledge experts (Simsek et. al, 2019).

The study work suggested the IF-THEN ruled based expert system for the automatic questions arrangement in mathematics adaptive evaluation on Indonesian Elementary Schools environment (Yuhana et. al., 2019).

Expert System for Text Animation (ESTA) was used to demonstrate a rule-based system for the diagnosis of vaginal discharge disease. The knowledge representation of the research was based on production rules (IF-THEN). Study work proposed that ESTA is much convenient as development tool and no proper training is required, even a layman user can easily consult with it and may extract the relevant information from the knowledge-based system. (Kamel Boulos, 2012).

Data mining attributes integrated with ANN has great importance in predicting students' performance in education institutions. The research study is based on feed forward mechanism and Apriori Algorithm of artificial neural network. For the study work a sample of 60 students of computer science was selected from Pimri College Pune. Attributes of student performance were applied to determine, that which attribute has major influence in performance, the results shows that student's attendance is found as major affecting attribute (Borkar et. al., 2014).

For further analysis of best and worst criteria, we have adopted the Microsoft Excel based Best Worst Solver Spreadsheet, it is a method a popular method of Multi Criteria Decision Making, which uses comparison of Best Criteria (most important, most desirable) and Worst Criteria (least important, least desirable) with other Criteria (Jaffar Rezaei, 2015).

3.0 Material &Methods

The whole research work is the combination of various methods, tools and techniques being used to solve the existing problem. Following are the various step of this research work:

- **Knowledge Acquisition:** This phase includes knowing the existing details about resources of the school management system (see the Figure 1). In this step knowledge about various resources or facilities to be provided in Schools being extracted from the domain experts of the problem area as well through physical observation.

- **Knowledge Extraction & Elicitation:** In second step important techniques and tools for assessment of schools' performance management were identified through literature studies and domain experts, like; Education Planning, Education Administration, Education Organization, Education Monitoring &Evaluation, Education Supervision, Education Controlling, Education Co-Ordination and Education Direction. These techniques and tools were applied to the resources or facilities to extract the hidden knowledge for assessment purposes.

- **Knowledge Modeling:** In the third step the knowledge acquired and extracted in the previous phase were depicted through various diagrams and tables, models like; Tree Diagram, Decision Table, Multi Decision Making Method (i.e., Best Worst Method), Neural Network Analysis Model and Symbolic Model etc., which can be seen in the following paragraphs.

- **Expert System Development:** In this step a prototype Expert System was developed using ESTA (Expert System Shall for Text Animation) as a development platform integrating with Best Worst Method and Artificial Neural Network to test and evaluate the research model that will be used for decision making to assess the school performance factors.

- **Expert System Testing &Validation:** The final step is about the testing & validation of proposed Expert System through diverse type of users. Education Management Officers, School Principals and Expert System users were requested to evaluate the proposed research model and Expert System. Analysis shows that they found the proposed system is highly efficient and adoptable for the performance management of Schools. The complete research process of the proposed research work is represented through the Figure 1 as below.

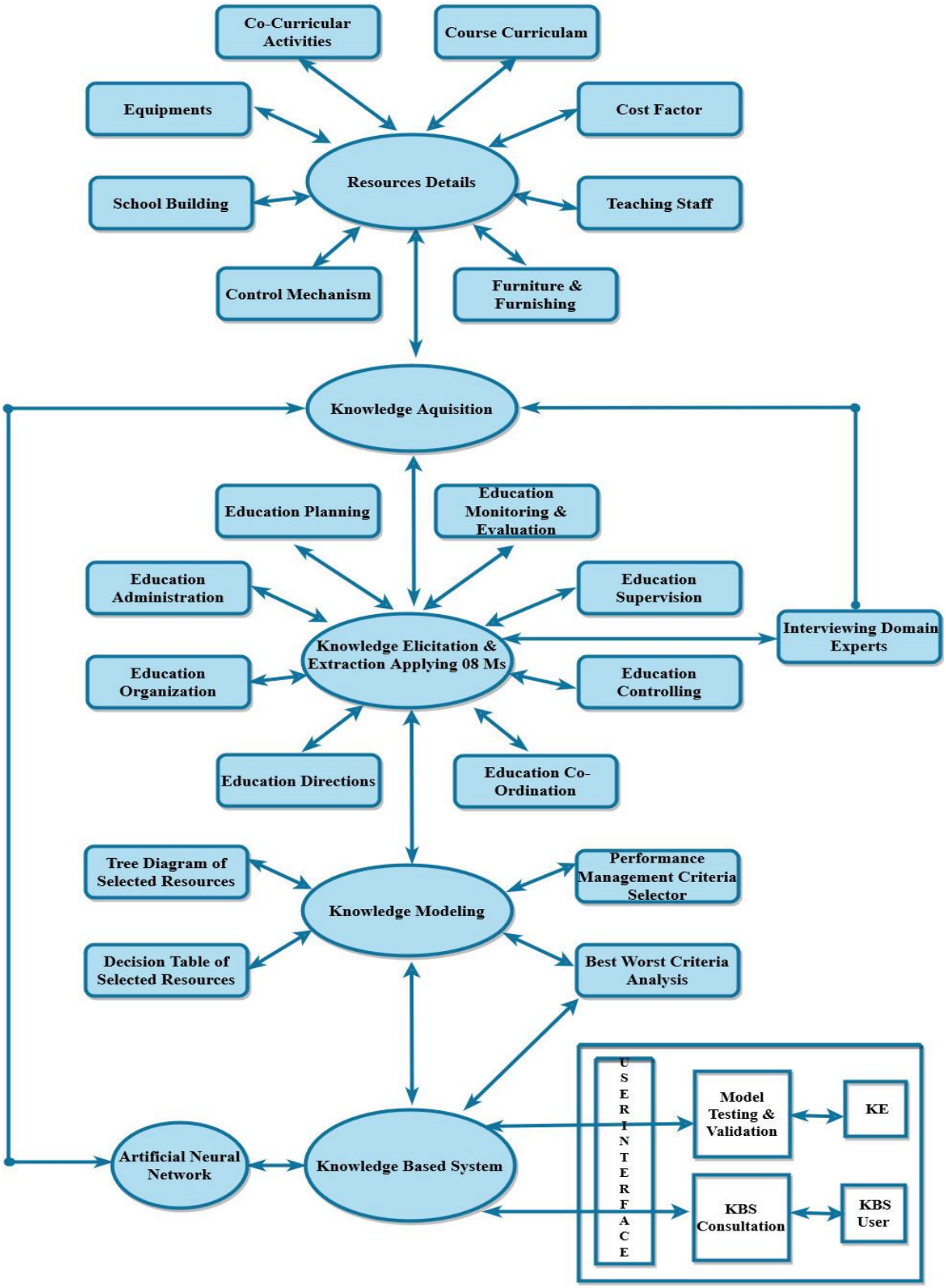

Fig1: Conceptual Model of Schools Performance Assessment

3.1 Tree Diagram for Resources in Govt. Schools

Tree diagram shows the facility in Figure 2 to break down the problem domain into smaller parts for understanding and fast decision-making process.

Fig2: Tree Diagram Showing Resources in Govt. Schools

3.2 Suitable Criteria for Performance Management of Schools

The mean of the main factors using SPSS tool was found to determine the weightage criteria of factors to find out the best (most desirable) and worst (least desirable) criteria as shown in Table 1.

Table 1: Mean of Criteria of School's Performance Management

	N	Minimum	Maximum	Mean	Std. Deviation
Teaching Staff	92	3	5	4.3629	0.35025
Equipment's	92	2.8	5	4.1891	0.41549
School Building	92	2.8	4.5	4.0022	0.31202
Control Mechanism	92	3	5	3.9859	0.41737
Furniture Furnishing	92	2.88	4.88	3.9321	0.32754
Co-Curricular Activities	92	2.73	5	3.9081	0.48189
Cost Factor	92	2.43	4.86	3.9053	0.46268
Course Curriculum	92	1.67	4.33	3.1993	0.46896
Valid N (list wise)	92				

The calculated mean of the factors as shown in the Table 1represents the assigned priorities to main factors by the domain experts i.e., Teaching Staff is on top, Equipment 2nd, School Building 3rd, Control Mechanism 4th, Furniture & Furnishing 5th, Co-Curricular Activities 6th, Cost Factor 7th and Course Curriculum is at 8thposition. In other words, we determined from the acquired data, that the Teaching Staff is the Best Criteria (most desirable) and Course Curriculum is worst one (least desirable) as shown in Figure 3 below.

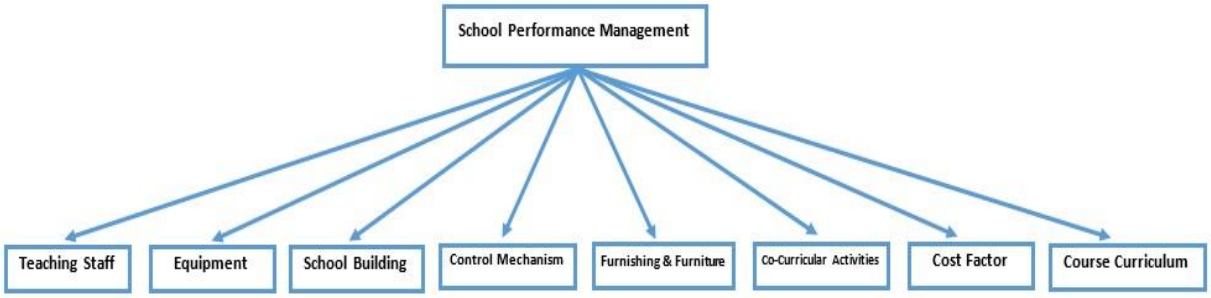

Fig 3: Criteria Selection for Schools' Performance Management

3.3 Analysis of Best & Worst Criteria

As stated earlier that Teaching Staff is Best Criteria (most desirable or most important) and Course Curriculum is Worst Criteria (least desirable or less important), we compared the Best and Worst Criteria with other Criteria of the school's performance management, that enabled us to determine the weightage of Best and Worst Criteria over other criteria of performance management. The objective is to reach a logical conclusion, that to which degree Best & Worst criteria are better than the rest ones.

3.4 Analysis of Best Worst Criteria through BMW Solver

For further analysis of best and worst criteria, we have adopted the Microsoft Excel based Best Worst Solver Spread sheet. This is a popular method of Multi Criteria Decision Making (MCDM), which uses comparison of Best Criteria (most important, most desirable) and Worst Criteria (least important, least desirable) with other Criteria (Jaffar Rezaei, 2015).

The advantage of this method over the other methods of MCDM is to minimize execution time and maximize efficiency of Expert System. It provides pair wise linear solution of two or more criteria. This method is considering as, one of the most feasible MCDM, because it only considers Best& Worst Criteria, while comparing the rest ones, without un-necessary utilization of process time. It is one of the easily applicable methods and can support single and multiple decision makers. BWM can provide fast consensus and solution in natural way that supports both qualitative and quantitative analysis. It is also compatible with other MCDM methods and provides comparison of Best Worst Criteria both in equation form and BWM Spreadsheet solver. Fig 4 shows, that we have selected the Best and Worst Criterion (BWC) and assigned weights by the domain experts on their preferences. The BWM evaluated best criterion by comparing with rest criterion, then the Worst criteria is compared with other criteria to determine the actual contributing weights. The results of weights show, their actual contribution in performance management model. KSI shows the consistency of the process, BWM suggests that the KSI value closed to zero is considered as reliable one. The following results shows that the consistency in most acceptable and reliable one in the research study that can be carried out.

Criteria Number =	Criterion 1	Criterion 2	Criterion 3	Criterion 4	Criterion 5	Criterion 6	Criterion 7	Criterion 8
Names of Criteria	Teaching Staff	Equipments	School Building	Control Mechanism	Furniture & Furnishing	Co-Curricular Activities	Cost Factor	Course Curriculam

Select the Best	Teaching Staff

Select the Worst	Course Curriculam

Best to Others	Teaching Staff	Equipments	School Building	Control Mechanism	Furniture & Furnishing	Co-Curricular	Cost Factor	Course Curriculam
Teaching Staff	1	2	3	4	5	6	7	8

Others to the	Course Curriculam
Teaching Staff	8
Equipments	7
School Building	6
Control	5
Furniture &	4
Co-Curricular	3
Cost Factor	2
Course Curriculam	1

Weights	Teaching Staff	Equipments	School Building	Control Mechanism	Furniture & Furnishing	Co-Curricular	Cost Factor	Course Curriculam
	0.332068643	0.199241186	0.132827457	0.099620593	0.079696474	0.066413729	0.056926053	0.033206864

Ksi*	0.066413729

Fig 4: Weights of Criteria Selected for School Performance Assessment

Figure 5 represents the graph of the weights assigned to the criterion of school performance management in Best Worst Method, the Teaching Staff shows the top most criteria in the performance management. Domain experts have stressed upon the capacity building of teaching staff in school to maximize its performance.

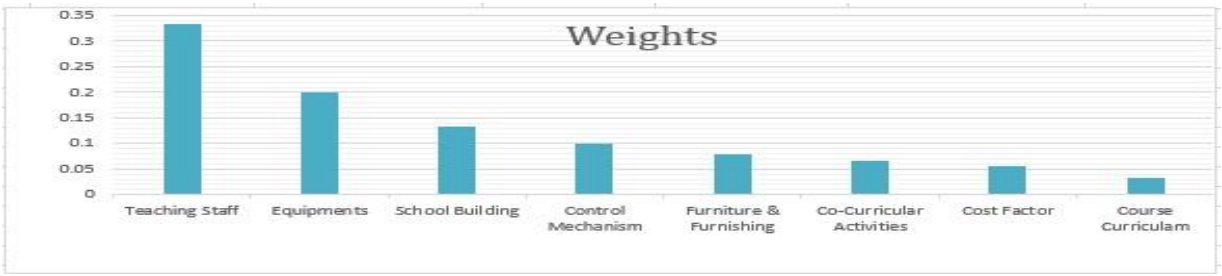

Fig 5: Graph of Criterion Weights of School Performance Management

Table 3 shows the ranked wise priority of the criteria assigned by the domain experts of the education department of district Tank, we determined the Best &Worst Criteria of the school's performance management for further analysis.

Table 3: Ranking Criteria of Schools' Performance Management

S.No.	Criteria	Rank
1	Teaching Staff	1st
2	Equipment	2nd
3	School Building	3rd
4	Control Mechanism	4th
5	Furniture & furnishing	5th
6	Co-Curricular Activities	6th
7	Cost Factor	7th
8	Course Curriculum	8th

Table 4, represents the SPSS generated network information of case processing summary of ANN, which depicts those total responses are 92, wherein the neural networks has reserved 64 responses i.e., (69.6%) for training and 28 responses i.e., (30.4%) for model testing respectively. It has the ability to train and test its model during processing.

Table 4: Case Processing
Summary of Artificial Neural Network

Case Processing Summary

		N	Percent
Sample	Training	64	69.6%
	Testing	28	30.4%
Valid		92	100.0%
Excluded		0	
Total		92	

Table 5, represents the basic information of ANN and denotes that the ANN has 07 inputs or covariates, standardized rescaling, one hidden layer with two nodes, hyperbolic tangent activation function, teaching staff as dependent variable or output, one output layer, bias unit is added additionally for error function.

Table 5: Artificial Neural Network Information

Network Information

Input Layer	Covariates	1	Equipment
		2	School Building
		3	Control Mechanism
		4	Furniture Furnishing
		5	Co-Curricular Activities
		6	Cost Factor
		7	Course Curriculum
	Number of Units		7
	Rescaling Method for Covariates		Standardized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		2
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	Teaching Staff
	Number of Units		1
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
	Error Function		Sum of Squares

a. Excluding the bias unit

3.5 Weight Assignment to Decision Making Factors

The Best Worst Method Analysis shows the priorities of the factors affecting the assessment of a school performance (see Figure 4) which was represented in Table 6 as given below.

S.NO.	Assessment Factors	Allocated Weights
1	Teaching Staff	0.332
2	Equipment	0.199
3	School Building	0.133
4	Control Mechanism	0.100
5	Furniture & Furnishing	0.080
6	Co-Curricular Activities	0.070
7	Cost Factor	0.057
8	Course Curriculum	0.033
Aggregate Weight		1.004

Table 6: Weights of Assessment
Factors for Schools Performance Assessment

Note: The Aggregate weight must be 1.000, while .004 is the rounding-up error

The following symbolic model was extracted from the above factors of assessment so as to finally decide to which level a specific school fulfils the prescribed criteria of assessment.

$$W = \sum_{i=1}^{8} Xi = T + E + B + M + FF + CA + C + CC \quad (1)$$

Where, W represents total weight of the factors, T = Teaching Staff, E= Equipment, B = Building, M = control Mechanism, FF = Furniture &Furnishing, CA = Co-Curricular Activities, C= Cost and CC = Course Curriculum.

This model will be tested through the proposed prototype Expert System for few schools of the above-mentioned area.

3.6 Decision Table for Schools Performance Management

In a decision table, conditions are tested and actions are taken consequently which has shown in Table 7 that the Decision Maker will judge the School System and fill this tool for final decision. The given weight as shown in Table 6 is allocated to the specified factor if the prescribed condition is fulfilled, otherwise zero weight is assigned. The weights of these parameters are summed up and tested in the Expert System for the specified criteria, i.e., 40%. If the total weight is ≥40 than the minimum efficiency level has been achieved by the system, otherwise it must be pointed out that the education system in the specific school is below the prescribed standard.

Table 7: Decision Table for School Performance Management

In this way few schools of District Tank, Pakistan, were tested through this model and evaluated through the Proposed Prototype System as shown in Figure6 and 7.

S.NO.	IF (CONDITIONS)	THEN (ACTION)
1	Teaching Staff have value, >= 40%	allocate 0.332 weight
2	Equipment Facilities >= 40%	allocate 0.199 weight
3	School Building status >= 40%	allocate 0.199 weight
4	Control Mechanism >= 40%	allocate 0.100 weight
5	Furniture & Furnishing >= 40%	allocate 0.80 weight
6	Co-Curricular Activities >= 40%	allocate 0.70 weight
7	Cost Factor >= 40%	allocate 0.057 weight
8	Course Curricular >= 40%	allocate 0.33 weight

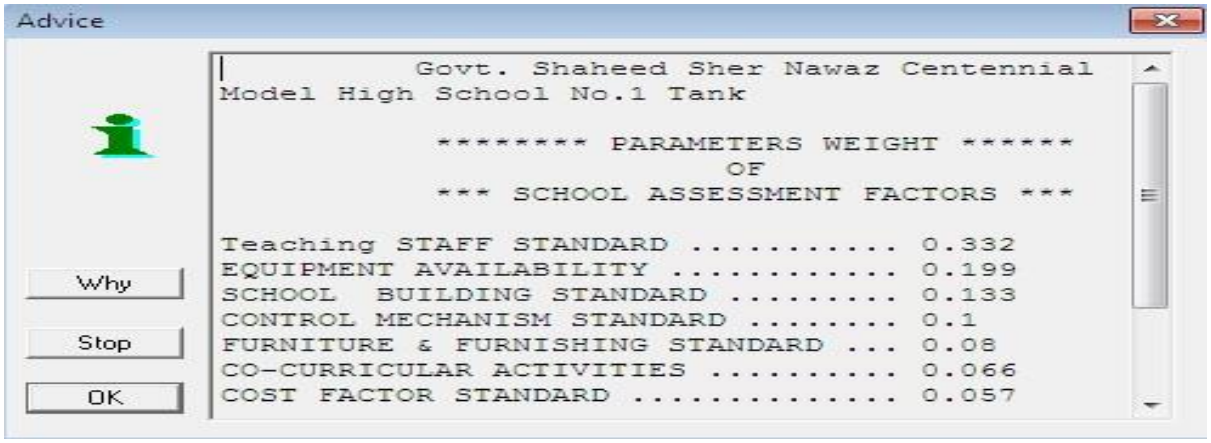

Fig 6: Parameters of Weight's Assessment Factors

Figure 6 represents the final results of the proposed Expert System that evaluated the weights assigned by the domain experts to various factors for the performance monitoring of Govt. Shaheed Sher Nawaz Centennial Model High School No.1 Tank, Pakistan. The system replies with advice in Figure 7 that the concerned School satisfied the prescribed standard and fulfils the requirements of performance management.

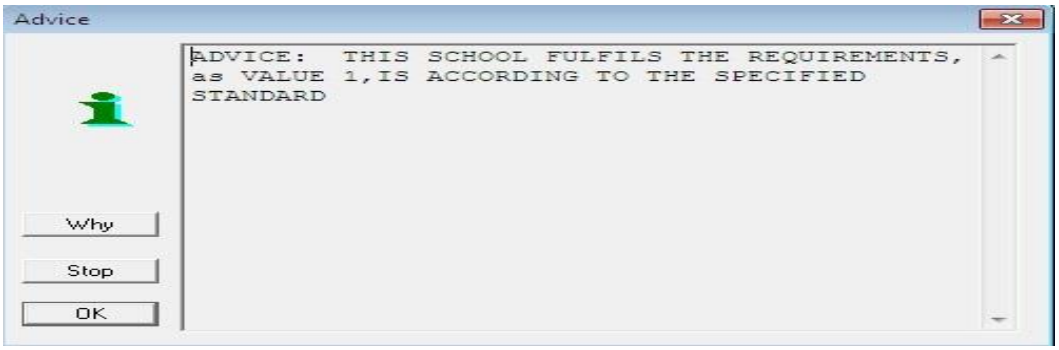

Fig 7: Final Advice of the Knowledge Based System

4.0 Conclusion and Recommendation

In the presented research work, we have achieved to most extent all of our research objectives as discussed in the paper. This work is original and novel to be deployed in about all the school systems for their assessment and improvement. This work will be useful for govt., researchers and students as a pedagogical instrument.

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