APPLICATION OF MULTI-CRITERIA DECISION MAKING (MCDM) APPROACHES ON TEACHERS' PERFORMANCE EVALUATION AND APPRAISAL

A project report submitted in partial fulfillment
of the requirements for the degree of

Bachelor of Technology

In

Mechanical Engineering

By

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<u>Certificate of recommendation</u>

This is to certify that the project report entitled "**APPLICATION OF MULTI-CRITERIA DECISION MAKING (MCDM) APPROACHES ON TEACHERS' PERFORMANCE EVALUATION AND APPRAISAL**" submitted by **Sri Avijit Mazumdar (Roll No. 10503020)** has been carried out under my supervision may be accepted in partial fulfillment of the requirements for the degree of ***Bachelor of Technology*** in ***Mechanical Engineering*** at National Institute of Technology (NIT), Rourkela and this work has not been submitted elsewhere before for any academic degree/diploma.

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ABSTRACT

Education quality is the ultimate result of significant contribution by each stake holder in an education system. However, it is believed that faculty quality has direct bearing on improving and sustaining quality in education. Teacher's performance evaluation is nothing but a Multi Criteria Decision Making Problem (MCDM). There are several quality attributes that influence the efficiency of a potential teacher while guiding his/her students towards a positive and value added academic outcome. However, the extent of significance of quality attributes may vary from individuals' viewpoint. In other words, different attributes may have different weightage according to their priority of significance while evaluating quality/performance level of a teacher. But there is no clear-cut methodology for assigning this priority weightage for the attributes. Therefore, expert opinion is indeed required to estimate those attribute weightage values. In the present reporting, a methodology adapted from Multi-Criteria-Decision Making (MCDM) has been proposed in order to evaluate performance of a teacher. Grey relational analysis has been explored in order to prioritize quality attributes that are expected to influence performance level of a teacher. Based on COPRAS-method, numerical values (interval scores) on different attributes assigned for a group of teachers (multiplied by individual weightage) have been accumulated to compute an overall quality estimate indicating performance level of individual teachers. Application feasibility as well as efficiency of this method and guidelines in solving such a multi-attribute decision making problem has been described illustratively in this paper.

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CHAPTER 1

INTRODUCTION

In the present study, an attempt has been made to apply strategic methodologies for performance evaluation and appraisal may be of different personnel from different background or it may be of various service sectors viz. education, health, public or private sectors as well. The aim is to evaluate the degree with which each item is performing its prescribed job responsibilities. Each item is assigned to perform some duties and the final outcome whether its output reaches to the satisfactory competent level, would be of great concern. In practical case, most of the factors that affect overall performance of an item are qualitative in nature. To address this issue, the common trend is to convert these qualitative indices into quantitative data by means of some scaling. Different weightage values are assigned to different factors in accordance with their relative importance. But assignment of individual response weights may cause misleading results which conflicts the actual happenings. Generally these weights depend on the decision maker and may vary from person to person. These is no specific guideline on assignment for prioritize those responses. Moreover, quality of a service sector depends on multiple attributes. The combinational effect of those attributes as a whole reflects overall quality index or performance measure. Literature review depicts that there are a number of statistical techniques to tackle this problem. The main objective of these techniques is to rank the performance factors according to their order to priority. Which factor is to given highest priority and which should be given less priority can be identified quantitatively. These are essentially required to estimate the extent of high performance of an item to the desired target level. In the proposed research the 'quality/ performance of an item' would be treated as a function of various factors. For example, the performance of a teacher depends on teaching preparation, teaching process, teaching strategy and teaching evaluation. The performance of an institute is influenced by quality of the teacher, quality of the students, infrastructure, administration and extent of training and placement. Performance evaluation is necessary not only for appraisal but it is also required to improve the overall quality of the item as well as the arena in which it belongs. In consideration of the above, the present study highlights service quality and performance as a multi-attribute estimate. Application of various statistics based multi-criteria decision making (MCDM) approaches is likely to be applied to determine overall quality index for various aspects of quality evaluation in relation to education sector and to select the best one (best alternative). Grey relation theory (traditional and modified) and utility concept have been adopted in the work in order to analyze data related to performance evaluation, quality estimation and benchmarking problems in educational sector.

Education requires well-organized curriculum and environment along with experienced teachers. Teachers' attitude, experience, and teaching methods play a vital role in teaching learning process. Satisfying and sharpening the inquisitive capacity of the students, positive attitude and participatory methodologies are required. Students' involvement in the teaching learning process becomes a source of intrinsic motivation; however, teachers have to play a vital role in harnessing the intellectual potentials of the students. They are the people who give direction and advice to the learners. Their behavior, communication skills, conceptual clarity and psychological equanimity have direct bearing on the character and personality of the students.

Learning is a process of psychosocial transaction between teachers and students in which the teachers have a dominant position. Students are not only imparted a particular skill, qualifications, and experience but an entire set of behavior. If the behavior of teacher is problematic, then the student is negatively affected, while competent and capable teachers inculcate positive habits in the students. Learning is a never-ending process and there is always room for improvement. Teachers being the builders of nations need continuous efforts to improve their own knowledge and transfer it to the new generation. There is need of well-qualified and trained teachers to deal positively with their students in teaching. Today faculty evaluation remains one of the most complex aspects of the academic world. Fiscal pressures on public and private colleges alike are facing them to find ways of determining effectiveness and efficiency, which means evaluation. Evaluation is an inherent element of any organized effort to achieve a goal. No one likes to be evaluated however, and it is a threatening procedure regardless of how it is approached. Most of us would prefer to rely upon our own instincts and experiences for going self-evaluation. Student evaluation is useful convenient, reliable, and valid means of self supervision and self improvement for the teacher.

Education means changes in behavior; hence, evaluation consisted of measuring the extent to which such changes had taken place, consistent with the previously defined objectives of the educational program being evaluated. This means that the goals and objectives of schooling are defined, instruction then seeks to bring about these changes in students; evaluation determines whether the desired changes have taken place. Therefore, teaching is a primary mission at most institutions of higher learning and a multidimensional activity. Teacher's performance is a particular concern for educators. Student feedback has motivated and empowered faculty to improve teaching performance. Student comments constitute important elements of evaluation to improve quality in education programs.

1.1 REVIEW OF PAST RESEARCH

I-Huei Ho et al. (2001) investigated the management and performance of engineering educational systems. The study established a performance evaluation model for engineering educational systems. The concept of balanced scorecard was explored to construct a performance evaluation model. The said conceptual methodology consists of collection of suitable performance evaluation configurations and indices by literature reviews and interviewing to department heads in engineering educational systems in Taiwan. According to the four components of the balanced scorecard, an efficient objective performance evaluation model was developed.

Ana Lúcia Miranda Lopes and Edgar Augusto Lanzer (2002) addressed the issue of performance evaluation-productivity and quality-of academic departments at an University. Data Envelopment Analysis (DEA) was applied to simulate a process of cross evaluation between the departments. The results of DEA in the dimensions of teaching, research, service and quality were modeled as fuzzy numbers and then aggregated through a weighted ordered aggregator. A single index of performance for each department was generated. The study proposed to identify the departments with low performance in one or more dimensions that should receive additional evaluation from an external auditing committee.

Emilio Martin (2003) applied DEA methodology for assessing the performance of Zaragoza University's departments (Spain). The indicators that were included in the study concerned both the teaching and the research activity of the departments. The results thereof revealed those departments that are more efficiently carrying out these activities. Finally, the author discussed about the existence of differences in the strengths and weakness between departments of different areas.

John Ruggiero (2004) highlighted that in DEA with non-discretionary inputs ignores the possibility of correlation among efficiency and the non-discretionary factors. It was shown that if the true technical efficiency is negatively correlated with the non-discretionary inputs, the existing DEA efficiency estimates will be biased upward. The work introduced a correlated model in order to tackle the problem effectively. The resulting model was capable to disentangle the two effects that the non-discretionary factor has on production.

Hahn-Ming Lee et al. (2005) reported a novel personalized recommendation system with online preference analysis in a distance learning environment called *Coursebot*. Users can both browse and search for course materials by using the interface of *Coursebot*. Moreover, the proposed system included appropriate course materials ranked according to a user's interests. In this work, an analysis measure was proposed to combine typical grey relational analysis and implicit rating. In this way a user's interests were estimated from the content of documents and the user's browsing behavior. This algorithm's low computational complexity and ease of adding knowledge supported online personalized analysis. In addition, the user profiles were dynamically revised to provide efficiency personalized information that reflects a user's interests after each page is visited.

Kosmas Kotivas et al. (2005) presented a self evaluation methodology on a specific post graduate engineering course in the critical technological area of advanced materials. The methodology developed was based on total quality management (TQM) procedures that were introduced in the higher education sector in Greece.

P. Kousalya et al. (2006) applied Analytical Hierarchy Process (AHP) to a decision making problem related to an educational arena. Through survey on the expert options, the criteria that cause student absenteeism were identified and the criteria hierarchy was developed. The relative importance of those criteria for Indian environment was obtained through the opinion survey. Alternatives that curb student absenteeism in engineering colleges like counseling, infrastructure, making lecture more attractive and many others were collected from different sources. Alternatives were evaluated based on the criteria and the preferential (priority) weights and ranks were obtained. The experts' opinions were validated by Saaty's inconsistency test method.

Cai Yonghong and Lin Chongde (2006) suggested that teacher performance evaluation should find its theoretical foundation in teacher performance constructs. After making literature review, critical case study, critical interview and qualitative research, the authors proposed a new conceptual construct of teacher performance and made necessary analysis for the construct of reliability and validity in empirical approaches.

Salah-Ud-Din Khan et al. (2006) developed a reliable instrument to evaluate the performance of Directors of Physical Education working in Government colleges of North West Frontier Province.

S. S. Mahapatra and M. S. Khan (2007) developed a quality measuring instrument called EduQUAL and proposed a Neural Network (NN) based integrated approach for evaluating service quality in education sector. The dimensionality of EduQUAL was validated by factor analysis followed by varimax rotation.

Mary Caroline N. Castano and Emilyn Cabanda (2007) evaluated the efficiency and productivity growth of state universities and colleges (SUCs) in the Philippines. The SUCs performance was determined on the changes in total factor productivity (TFP), technological and technical efficiency. Data Envelopment Analysis (DEA) has been adopted in estimating the relative performance of SUCs.

Wan Salmuni Wan Mustaffa and Hariri Kamis (2007) applied Analytic Hierarchy Process (AHP) technique to develop a staff performance appraisal system in the scenario of higher education system in Malaysia. A promotion appraisal based on the changing and globalization requirement needs a variety of criteria which should cover all their tasks, activities and contributions. The proposed technique assisted decision makers to identify and determine the priority of criteria for promoting academic staff by taking into consideration global requirements.

Nina Begičević, Blaženka Divjak and Tihomir Hunjak (2007) performed factor analysis on the survey data and constructed AHP based model for decision making on e-learning implementation. Organizational readiness, that includes university framework and faculty strategy for development, as well as financial readiness, was recognized as the most influential for e-learning implementation. It was found as a weakness of most Croatian universities and faculties, since the strategic planning of university and faculty development has been systematically neglecting.

Steven Pharr, John J. Lawrence, (2007) examined the efficacy of admission requirements as predictors of academic success in core business coursework, and as a rationing mechanism for limited course capacity, for both transfer and non-transfer students following integration of the core business curriculum. Regression analysis was used to test the efficacy of admission standards in explaining transfer and non-transfer student performance in the core business curriculum, before and after substantial curricular revision. Fisher's r-to-z transformation is used to test differences between student groups and core curriculum formats. Stepwise regression was used to identify an accurate predictor of transfer student performance for the integrated business core. It was concluded that efficacy of the admission standard decreased for transfer students following introduction of the new curriculum. While adequate for all students taking the traditional business core, it is a much less effective predictor of success for transfer students under the new curriculum. A modified admission standard for transfer students restored efficacy to previous levels. Re-examination of admission standards following curricular revision is necessary to ensure effective screening of transfer students. The root problem, however, may not be addressed in its entirety by a unique transfer student admission standard. Non-transfer students' benefit from acculturation as freshman and sophomores, as well as prerequisite courses specifically modified to prepare them for the integrated curriculum. This paper documents a potential problem for business schools that have, or are considering, significant curricular revisions.

Ching-Yaw Chen et al. (2007) studied the quality in higher education in Cambodia and explore the potential factors leading to quality in Cambodian higher education. Five main factors that were deemed relevant in providing quality in Cambodian higher education were proposed: academic curriculum and extra-curricular activities, teachers' qualification and methods, funding and tuition, school facilities, and interactive network. These five propositions were used to compare Shu-Te University, Taiwan with the top five universities in Cambodia. The data came in the forms of questionnaire and desk research. Descriptive analytical approach is then carried out to describe these five factors. It was found that only 6 per cent of lecturers hold PhD degree and about 85 per cent never published any papers; some private universities charge as low as USD200 per academic year, there is almost no donation from international organizations, and annual government funding on higher education sector nationwide in 2005 was only about USD3.67 million; even though there is a library at each university, books, study materials etc. are not up-to-date and inadequate; 90 per cent of the lecturers never have technical discussion or meeting and about 60 per cent of students felt that their teachers did not have time for them to consult with. A useful insight was gained into the perceived importance of quality in higher education that can stimulate debate and discussion on the role of government in building the standard quality in higher education. Also, the findings from this research can assist in the development of a framework of developing human resource.

R. Krishnaveni, J. Anitha, (2007) developed a comprehensive model of professional characteristics of an educator that will prepare them for high standards of professional achievements, as all professions demand standardization and formulation of guidelines in today's competitive environment. Literature on essentials of an educator was sourced to collect the various characteristics for diverse academic oriented goals. A set of ten vital characteristics was identified which were sorted under three spheres of the educators work life. These characteristics were then defined appropriately for the teaching discipline. A wide range of literature has resulted in ten characteristics and a comprehensive model was developed that would encompass the different characteristics that an educator ought to possess to develop his/her self, institution and with those he/she connects in professional life. The paper limits itself in identifying the characteristics of the educator. Further study is possible focusing at the impact of these characteristics on students, institution and the community as a whole. Adapting the model and practice of these characteristics will bring about standard and desired outputs that would help the teaching profession establish its high standards. It would also provide a deep impact on students who will be trained and dealt with using a more proficient approach. The model presents the various characteristics that were developed out of a number of attributes identified in the literature survey in a comprehensive and simple manner. It extends a wide scope for professional standards in teaching.

James S. Pounder, (2007) presented a framework to facilitate comprehension of research on the effectiveness of the teaching evaluation process. A comprehensive review of the literature that identifies common categories and factors that can be used to construct an analytical framework. The study identified student related, course related and teacher related aspects of research on teaching evaluations. Factors commonly addressed within these aspects are also identified. Use of the framework to analyze the literature on the student evaluation of teaching (SET) process leads to the view that the time is right to explore other methods of assessing classroom dynamics that could supplement the conventional teacher evaluation process. Educational literature is replete with studies of the SET system, yet due to the preponderance of these studies, it is difficult to take an overview on the effectiveness of this system. On the basis of a comprehensive survey of the literature, this paper identifies and discusses the central factors influencing SET scores. These factors are then presented in a comprehensible table that can be used as a reference point for researchers and practitioners wishing to examine the effectiveness of the SET system. The paper is one of the few to attempt to make sense of the myriad of studies on teacher evaluation and to develop a framework to facilitate analysis of the effectiveness of the SET system.

Katharina Michaelowa, (2007) provided an overview of the relationship among different levels of education by applying international cross-country comparisons, bi- and multivariate analyses, with many graphical illustrations. These methods are used to compare educational outcomes at the primary, secondary and tertiary level in terms of quantity (enrolment) and quality (measured in terms of student achievement, university rankings, patents and researchers), and to analyze the impact of heterogeneity between secondary schools on tertiary outcomes. The results suggested that certain minimum levels of enrolment at primary and secondary level represent a necessary condition for the development of functioning higher education. Another relevant result of our analysis is that strong differences between educational institutions at secondary level may be detrimental for tertiary education quality. This research only represents an initial explorative analysis. In order to improve tertiary education outcomes, education policy should not concentrate on tertiary education alone, but also consider insufficiencies at lower levels of education. This paper attempts to fill a gap in the present educational literature in that it tries to provide some empirical evidence for the theoretical argument that quality tertiary education requires a sound basis of students to draw from; i.e. a basis of students which should be restricted as little as possible by lack of access to secondary or even primary education, and/or by lack of access to sufficiently quality oriented schools.

Te-King Chien, (2007) aimed to establish an 11-step “improvement decision model” to enhance learning satisfaction. This model integrates Kano's model and the relevant concepts for decision making, and puts forward an “improvement decision diagram and principles”. This paper also establishes “constructs of the learning satisfaction measurement” and a “teaching quality management cycle” to make it easy for instructors, administrators and students to jointly upgrade teaching quality. The “improvement decision model” can effectively assist teachers to enhance their instructional materials and elevate student's learning satisfaction. With enthusiastic participation of four instructors, the results of the case study are found to be satisfactory and support the applicability of the model proposed in this paper.

Mónica García Melón et al. (2008) proposed a procedure to evaluate proposals for educational innovation projects. It was reported that the proposed methodology should help the institute of educational sciences of the Politechnical University of Valencia to choose the best Educational Project. It was aimed to provide the administration with a stringent evaluation methodology. Based on AHP the paper has been focused on the weight assignment of the different criteria chosen by the experts.

Subhajyoti Ray (2007) demonstrated the use of Analytic Hierarchy Process (AHP) to address the need of doctoral students for selection of a thesis supervisor. A survey of doctoral students was conducted to obtain a list of criteria that were significant for selection of a research guide and then modeled as an AHP problem. A survey of junior and senior doctoral students was also conducted to ascertain the relative weights of the criteria elements to demonstrate the application of the proposed method.

1.2 OBJECTIVES AND SCOPE OF THE PRESENT WORK

Literature depicts that much work has been explored on various aspects of quality evaluation and performance appraisal in various service sectors not only in education, but also in healthcare, hospitality, tourism, private or public sectors as well. However, it should be noted that service quality differs from product quality. Product quality can be estimated by some quantitative attributes which can be measured and the extent of quality of the product can be estimated. While in case of evaluating quality of a service sector (as a whole) or evaluating quality of an individual, most of the attributes become qualitative. As for example the quality of a teacher depends on his teaching strategy, teaching methodology (pedagogy of teaching), extent of knowledge, student interaction and many others. These attributes cannot be estimated quantitatively. Even there is no clear-cut indication on which criteria is the most important to be examined or which criteria imposes negligible influence on evaluating a teacher's quality. Therefore, survey data is generally required to pull out expert opinions collected from different personnel. Based on some multi-criteria decision making methodologies, these survey data are to be analyzed to estimate the relative priority weights of the said criterion. Previous researchers have proposed different statistics based multi-criteria decision making techniques to address this issue. But search is still being continued which indicates that more in-depth study, more efficient tools are to be developed and adapted in order to understand this type of behavioral science.

In consideration of the above, the present study highlights a multi-criteria decision making (MCDM) approach to be applied for overall quality evaluation which is necessary for teachers' performance evaluation (teachers appraisal). A survey of students was conducted to obtain a preference list of criteria that are found to be significant for evaluation of a quality teacher. These criteria selection has been conducted by applying grey relational analysis. The reason behind adapting this method is that it can analyze scaled response data. In any survey of this kind, data with precision is difficult to obtain because the responses are reflection of human judgment rather than experimental result. Therefore, the situation becomes fuzzy (grey) to understand i.e. difficult to infer some conclusions. Here, expert opinions (on qualitative index) are sought in numerical scale. Grey relational analysis has been found effective in extracting some conclusive remarks while analyzing this type of expert opinions. Important criterion for estimation of teachers' performance has been evaluated by grey relational analysis.

Based on those criterion overall quality and performance of a teacher has been computed by applying COPRAS-G method [Edmundas Kazimieras Zavadskas et al.2008)] adapted from the basic grey relational analyses. The method has been adapted because it can utilize numerical scores in the form of interval marking. Common methodologies reported in past research can handle quantitative numerical score. These methods cannot consider interval making assigned to a particular item. COPRAS-G method is capable of overcoming this. The paper illustrates detailed methodology of the aforesaid approach and highlights its effectiveness.

CHAPTER 2

TEACHERS' PERFORMANCE EVALUATION

2.1 GREY RELATIONAL ANALYSIS

The grey relational analysis which is appropriate for scaled (response) data analysis (scaled response) consists of the following steps, [Chien-Ho Wu, (2007)].

(a) Generation of reference data series x_0.

$$x_0 = \left(d_{01}, d_{02}, \ldots\ldots\ldots\ldots, d_{0m}\right) \tag{1}$$

Here m is the number of respondents. In general, the x_0 reference data series consists of m values representing the most favoured responses.

(b) Generation of comparison data series x_i.

$$x_i = \left(d_{i1}, d_{i2}, \ldots\ldots\ldots\ldots, d_{im}\right) \tag{2}$$

Here $i = 1, \ldots\ldots\ldots\ldots, k$. k is the number of scale items. So, there will be k comparison data series and each comparison data series contains m values.

(c) Compute the difference data series Δ_i.

$$\Delta_i = \left(\left|d_{01} - d_{i1}\right|, \left|d_{02} - d_{i2}\right|, \ldots\ldots\ldots\ldots\ldots\ldots, \left|d_{0m} - d_{im}\right|\right) \tag{3}$$

(d) Find the global maximum value Δ_{max} and minimum value Δ_{min} in the difference data series.

$$\Delta_{\max} = \overset{\max}{\forall i}\left(\max \Delta_i\right) \text{ and } \Delta_{\min} = \overset{\min}{\forall i}\left(\min \Delta_i\right) \tag{4}$$

(e) Transformation of individual data point in each difference data series to grey relational coefficient.

Let $\gamma_i\left(j\right)$ represents the grey relational coefficient of the j_{th} data point in the i_{th} difference data series, then

$$\gamma_i\left(j\right) = \frac{\Delta_{\min} + \varsigma.\Delta_{\max}}{\Delta_i\left(j\right) + \varsigma.\Delta_{\max}} \tag{5}$$

Here $\gamma_i\left(j\right)$ is the j_{th} value in Δ_i difference data series. ς is called distinguishing coefficient (= 0.5).

(f) Computation of grey relational grade for each difference data series.

Let Γ_i represent the grey relational grade for the i_{th} scale item and it is assumed that data points in the series are of the same weights, then

$$\Gamma_i = \frac{1}{m}\sum_{n=1}^{m}\gamma_i\left(n\right) \tag{6}$$

The magnitude of Γ_i reflects the overall degree of standardized deviance of the i_{th} original data series from the reference data series. In general, a scale item with a high value of Γ indicates that the respondents, as a whole, have a high degree of favoured consensus on the particular item.

(g) Sorting of Γ values into either descending or ascending order to facilitate the managerial interpretation of the results.

2.2 COPRAS-G METHOD

In order to evaluate the overall performance of a teacher, it is necessary to identify selection criteria, to assess information, relating to these criteria, and to develop methods for evaluating the criteria to meet the students' needs. Decision analysis is concerned with the situation in which a decision maker has to choose among several alternatives by considering a particular set of criteria. For this reason COPRAS method can be applied. The idea of COPRAS-G method with the criterion values expressed *in terms of intervals* is based on the real conditions of decision making and applications of the grey system theory. The COPRAS-G method uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree.

The procedure of applying the COPRAS-G method consists of the following steps.

1. Selecting the set of the most important criteria, describing the alternatives.

2. Constructing the decision-making matrix $\otimes X$:

$$\otimes X = \begin{bmatrix} [\otimes x_{11}] & \dots & \dots & [\otimes x_{1m}] \\ [\otimes x_{21}] & \dots & \dots & [\otimes x_{2m}] \\ \vdots & \dots & \dots & \vdots \\ [\otimes x_{n1}] & \dots & \dots & [\otimes x_{nm}] \end{bmatrix} =$$

$$\begin{bmatrix} [\underline{x}_{11}; \overline{x}_{11}] & [\underline{x}_{12}; \overline{x}_{12}] & \dots\dots\dots & [\underline{x}_{1m}; \overline{x}_{1m}] \\ [\underline{x}_{21}; \overline{x}_{21}] & [\underline{x}_{22}; \overline{x}_{22}] & \dots\dots\dots & [\underline{x}_{2m}; \overline{x}_{2m}] \\ \vdots & \vdots & \dots\dots\dots & \vdots \\ [\underline{x}_{n1}; \overline{x}_{n1}] & [\underline{x}_{n2}; \overline{x}_{n2}] & \dots\dots\dots & [\underline{x}_{nm}; \overline{x}_{nm}] \end{bmatrix}; \ j = \overline{1,n} \ ; \ \overline{1,m} \qquad (7)$$

Here $\otimes x_{ji}$ is determined by $\overline{x}_{ji}$ (the smallest value, the lower limit) and $\overline{x}_{ji}$ (the biggest value, the upper limit).

3. Determining significances of the criteria q_i.

4. Normalizing the decision-making matrix $\otimes X$:

$$\overset{\sim}{\underline{x}}_{ji} = \frac{\underline{x}_{ji}}{\frac{1}{2}\left(\sum_{j=1}^{n}\underline{x}_{ji} + \sum_{j=1}^{n}\overline{x}_{ji}\right)} = \frac{2\underline{x}_{ji}}{\sum_{j=1}^{n}\underline{x}_{ji} + \sum_{j=1}^{n}\overline{x}_{ji}};\ \overset{\simeq}{x}_{ji} = \frac{\overline{x}_{ji}}{\frac{1}{2}\left(\sum_{j=1}^{n}\underline{x}_{ji} + \sum_{j=1}^{n}\overline{x}_{ji}\right)} = \frac{2\overline{x}_{ji}}{\sum_{j=1}^{n}\left(\underline{x}_{ji} + \overline{x}_{ji}\right)};$$

$$j = \overline{1,n}\ ;\ \overline{1,m} \tag{8}$$

In formula (8) $\underline{x}_{ji}$ is the lower value of the i criterion in the alternative j of the solution; $\overline{x}_{ji}$ is the upper value of the criterion i in the alternative j of the solution; m is the number of criteria; n is the number of the alternatives compared.

Then, the decision-making matrix is normalized:

$$\otimes\tilde{X} = \begin{bmatrix} \left[\overset{\sim}{\underline{x}}_{11};\overset{\simeq}{x}_{11}\right] & \left[\overset{\sim}{\underline{x}}_{12};\overset{\simeq}{x}_{12}\right] & \cdots\cdots\cdots & \left[\overset{\sim}{\underline{x}}_{1m};\overset{\simeq}{x}_{1m}\right] \\ \left[\overset{\sim}{\underline{x}}_{21};\overset{\simeq}{x}_{21}\right] & \left[\overset{\sim}{\underline{x}}_{22};\overset{\simeq}{x}_{22}\right] & \cdots\cdots\cdots & \left[\overset{\sim}{\underline{x}}_{2m};\overset{\simeq}{x}_{2m}\right] \\ . & . & & . \\ . & . & \cdots\cdots\cdots & . \\ . & . & & . \\ . & . & & . \\ \left[\overset{\sim}{\underline{x}}_{n1};\overset{\simeq}{x}_{n1}\right] & \left[\overset{\sim}{\underline{x}}_{n1};\overset{\simeq}{x}_{n1}\right] & \cdots\cdots\cdots & \left[\overset{\sim}{\underline{x}}_{nm};\overset{\simeq}{x}_{nm}\right] \end{bmatrix} \tag{9}$$

5. Calculating the weighted normalized decision matrix $\otimes\hat{X}$. The weighted normalized values $\otimes\hat{x}_{ji}$ are calculated as follows:

$$\otimes\hat{x}_{ji} = \otimes\tilde{x}_{ji}.q_i \text{ or } \underline{\hat{x}}_{ji} = \underline{\tilde{x}}_{ji}.q_i \text{ and } \hat{\hat{x}}_{ji} = \tilde{\tilde{x}}_{ji}.q_i \tag{10}$$

In formula (10), q_i is the significance of the $i-th$ criterion. Now, the normalized decision-making matrix is of the form:

$$\otimes\hat{X} = \begin{bmatrix} \left[\otimes\hat{x}_{11}\right] & \left[\otimes\hat{x}_{12}\right] & \dots\dots\dots & \left[\otimes\hat{x}_{1m}\right] \\ \left[\otimes\hat{x}_{21}\right] & \left[\otimes\hat{x}_{22}\right] & \dots\dots\dots & \left[\otimes\hat{x}_{2m}\right] \\ . & . & & . \\ . & . & \dots\dots\dots & . \\ . & . & & . \\ . & . & & . \\ \left[\otimes\hat{x}_{n1}\right] & \left[\otimes\hat{x}_{n2}\right] & \dots\dots\dots & \left[\otimes\hat{x}_{nm}\right] \end{bmatrix} = \begin{bmatrix} \left[\underline{\hat{x}}_{11};\hat{\hat{x}}_{11}\right] & \left[\underline{\hat{x}}_{12};\hat{\hat{x}}_{12}\right] & \dots\dots\dots & \left[\underline{\hat{x}}_{1m};\hat{\hat{x}}_{1m}\right] \\ \left[\underline{\hat{x}}_{21};\hat{\hat{x}}_{21}\right] & \left[\underline{\hat{x}}_{22};\hat{\hat{x}}_{22}\right] & \dots\dots\dots & \left[\underline{\hat{x}}_{2m};\hat{\hat{x}}_{2m}\right] \\ . & . & & . \\ . & . & \dots\dots\dots & . \\ . & . & & . \\ . & . & & . \\ \left[\underline{\hat{x}}_{n1};\hat{\hat{x}}_{n1}\right] & \left[\underline{\hat{x}}_{n2};\hat{\hat{x}}_{n2}\right] & \dots\dots\dots & \left[\underline{\hat{x}}_{nm};\hat{\hat{x}}_{nm}\right] \end{bmatrix} \tag{11}$$

6. Calculating the sums P_j of the criterion values whose larger values are more preferable by the formula given below:

$$P_j = \frac{1}{2}\sum_{i=1}^{k}\left(\underline{\hat{x}}_{ji} + \hat{\hat{x}}_{ji}\right) \tag{11}$$

7. Calculating the sums R_j of the criterion values whose smaller values are more preferable by the formula:

$$R_j = \frac{1}{2}\sum_{i=k+1}^{m}\left(\underline{\hat{x}}_{ji} + \hat{\hat{x}}_{ji}\right); \quad i = \overline{k,m} \tag{12}$$

In formula (7), $(m-k)$ is the number of criteria which must be minimized.

8. Determining the minimal value of R_j as follows:

$$R_{\min} = \min_j R_j; \quad j = \overline{1,n} \tag{13}$$

9. Calculating the relative significance of each alternatively Q_j the expression:

$$Q_j = P_j + \frac{\sum_{j=1}^{n} R_j}{R_j . \sum_{j=1}^{n} \frac{1}{R_j}} \tag{14}$$

10. Determining the optimally criterion by K the formula:

$$K = \max_j Q_j; \quad j = \overline{1,n} \tag{15}$$

11. Determining the priority order of the alternatives.

12. Calculating the utility degree of each alternative by the formula:

$$N_j = \frac{Q_j}{Q_{\max}} \times 100\% \tag{16}$$

Here Q_j and $Q_{\max}$ are the significances of the alternatives obtained from equation (14).

2.3 SELECTION OF ATTRIBUTES INFLUENCING PERFORMANCE OF A TEACHER: APPLICATION OF GREY RELATIONAL ANALYSIS

In order to highlight application feasibility of grey relational analysis method, the present study considers an example on selection of important criteria for evaluation of a teacher's performance. Based on acquired knowledge from the literature, following factors have been selected for survey and assumed to influence quality as well as performance level of a teacher. These are as indicated below in Table 1.

Table 1: Attributes for teacher's performance evaluation

Sl. No.	Attributes
$\otimes x_1(A1)$	Pedagogy of teaching
$\otimes x_2(A2)$	Interaction with students
$\otimes x_3(A3)$	Time taken for Problem solving (decision making)
$\otimes x_4(A4)$	Depth of knowledge in own field
$\otimes x_5(A5)$	Dedication, Punctuality and involvement

Survey data i.e. respondents opinions (in selected scale, Table 2) collected from student community have been analyzed for ranking those attributes according to their order of priority.

For collection of expert opinions the following scale has been chosen. Respondents have been directed to rate each statement using a 5-point Likert type scale where 1 indicates "very low" and 5 represents "very high".

Table 2: Survey data

Sl. No.	Quality attributes for teachers' performance evaluation				
	$\otimes x_1\,(A1)$	$\otimes x_2\,(A2)$	$\otimes x_3\,(A3)$	$\otimes x_4\,(A4)$	$\otimes x_5\,(A5)$
1	4	4	3	5	5
2	4	4	5	4	4
3	4	5	4	4	4
4	4	5	3	4	3
5	4	5	4	4	5
6	4	5	5	5	4
7	4	5	4	5	5
8	4	5	4	5	4
9	5	5	4	4	5
10	4	3	3	4	4
11	4	4	4	5	4
12	4	4	4	4	4
13	4	4	5	5	5
14	4	4	5	4	5
15	5	5	5	5	4
16	3	4	3	3	4
17	4	4	4	4	5
18	1	2	3	2	2
19	3	3	3	5	5
20	4	5	5	5	5
21	3	4	5	4	4
22	2	2	1	5	5
23	5	5	5	5	5
24	5	5	5	5	5
25	4	4	4	5	5
26	5	4	4	4	4
27	4	5	5	4	5
28	5	5	5	5	5
29	5	5	4	5	3
30	4	5	4	4	5

Let, x_0 is the reference data series, because the response scale is a five point scale, x_0 is set to contain values of 5. x_1 to x_5 is the original comparison data series which contains responses of the respondents. The difference data series is shown in Table 3.

Table 3: The difference data series

Sl. No.	$\Delta_1(A1)$	$\Delta_2(A2)$	$\Delta_3(A3)$	$\Delta_4(A4)$	$\Delta_5(A5)$
1	1	1	2	0	0
2	1	1	0	1	1
3	1	0	1	1	1
4	1	0	2	1	2
5	1	0	1	1	0
6	1	0	0	0	1
7	1	0	1	0	0
8	1	0	1	0	1
9	0	0	1	1	0
10	1	2	2	1	1
11	1	1	1	0	1
12	1	1	1	1	1
13	1	1	0	0	0
14	1	1	0	1	0
15	0	0	0	0	1
16	2	1	2	2	1
17	1	1	1	1	0
18	4	3	2	3	3
19	2	2	2	0	0
20	1	0	0	0	0
21	2	1	0	1	1
22	3	3	4	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	1	1	1	0	0
26	0	1	1	1	1
27	1	0	0	1	0
28	0	0	0	0	0
29	0	0	1	0	2
30	1	0	1	1	0

Each data point in each difference data series has then been transformed to grey relational coefficient $\gamma_i(j)$, shown in Table 4. Finally grey relational grade Γ_i for each difference data series has been computed. These have been furnished in Table 4. Individual grey relational grades have been presented (descending order) below.

Table 4: Grey relational coefficients and grey relational grades

Sl. No.	$\gamma_1(A1)$	$\gamma_2(A2)$	$\gamma_3(A3)$	$\gamma_4(A4)$	$\gamma_5(A5)$
1	0.6667	0.6000	0.5000	1.0000	1.0000
2	0.6667	0.6000	1.0000	0.6000	0.6000
3	0.6667	1.0000	0.6667	0.6000	0.6000
4	0.6667	1.0000	0.5000	0.6000	0.4286
5	0.6667	1.0000	0.6667	0.6000	1.0000
6	0.6667	1.0000	1.0000	1.0000	0.6000
7	0.6667	1.0000	0.6667	1.0000	1.0000
8	0.6667	1.0000	0.6667	1.0000	0.6000
9	1.0000	1.0000	0.6667	0.6000	1.0000
10	0.6667	0.4286	0.5000	0.6000	0.6000
11	0.6667	0.6000	0.6667	1.0000	0.6000
12	0.6667	0.6000	0.6667	0.6000	0.6000
13	0.6667	0.6000	1.0000	1.0000	1.0000
14	0.6667	0.6000	1.0000	0.6000	1.0000
15	1.0000	1.0000	1.0000	1.0000	0.6000
16	0.5000	0.6000	0.5000	0.4286	0.6000
17	0.6667	0.6000	0.6667	0.6000	1.0000
18	0.3333	0.3333	0.5000	0.3333	0.3333
19	0.5000	0.4286	0.5000	1.0000	1.0000
20	0.6667	1.0000	1.0000	1.0000	1.0000
21	0.5000	0.6000	1.0000	0.6000	0.6000
22	0.4000	0.3333	0.3333	1.0000	1.0000
23	1.0000	1.0000	1.0000	1.0000	1.0000
24	1.0000	1.0000	1.0000	1.0000	1.0000
25	0.6667	0.6000	0.6667	1.0000	1.0000
26	1.0000	0.6000	0.6667	0.6000	0.6000
27	0.6667	1.0000	1.0000	0.6000	1.0000
28	1.0000	1.0000	1.0000	1.0000	1.0000
29	1.0000	1.0000	0.6667	1.0000	0.4286
30	0.6667	1.0000	0.6667	0.6000	1.0000
DOA	**0.707797**	**0.770793**	**0.744457**	**0.785397**	**0.793017**

It should be noted that a high value of Γ indicates that the expert opinions have a high degree of favored consensus on the particular item (significant factor on which majority is deeply concerned about). It has been observed that:

A5 (0.793017)>**A4** (0.785397)>**A2** (0.770793)>**A3** (0.744457)>**A1** (0.707797)

By this way criteria for performance evaluation of a teacher can be identified and ranked according to the relative importance as indicated in respondents' opinions.

2.4 ESTIMATION OF OVERALL QUALITY INDEX: APPLICATION OF COPRAS-G METHOD

Once the important criterion required for teachers' performance evaluation have been identified, the next step is to calculate overall quality (performance) index of individual teachers, which may help for comparison of a number of teachers and for selecting the best one among a group of teachers. The results of teacher evaluation are sometimes required for teachers' performance appraisal in relation to various academic purposes. Quantitative score for each criterion is generally multiplied by the corresponding priority weightage in order to estimate the contribution rendered by the individual quality attributes. These are to be finally accumulated to compute the overall quality index for assessment of teachers' performance. For this purpose the present study illustrates application feasibility of COPRAS-G method for quality evaluation in teacher's performance appraisal.

Respondents have been directed to rate each statement (individual attribute or criteria) using *interval marking*. Five key indicators $\otimes x_i$ were identified for teachers' performance evaluation (as indicated in Table 1). Optimization directions (optimal quality as well as performance level) of the selected criteria are as follows:

$$\otimes x_1, \otimes x_2, \otimes x_4, \otimes x_5 \ \underrightarrow{Optimal\ direction}(Max)$$

$$\otimes x_3 \ \underrightarrow{Optimal\ direction}(Min)$$

Numerical scores (in intervals) have been assigned to each quality attributes for individual teachers. Respondents' marking have been represented in Table 5. It indicates initial decision making matrix $\otimes X$ with the criterion values described in intervals. Priority weightage values for individual quality attributes have been assumed based on the results of grey relational analysis presented in section 3.1. It has been observed that priority wise A5 attribute should have highest weightage value whereas attribute A1 should be assigned lowest (minimum) weightage. Priority wise attribute ranking (weightage value in descending order) becomes **A5**, **A4**, **A2**, **A3** and **A1**.

Table 5: Initial decision making matrix
(Criterion values described in intervals $\otimes X$)

	$\otimes x_1$	$\otimes x_2$	$\otimes x_3$	$\otimes x_4$	$\otimes x_5$
Opt.	max	max	max	max	max
q_i	0.10	0.20	0.15	0.25	0.30
Teacher	$\otimes x_1$	$\otimes x_2$	$\otimes x_3$	$\otimes x_4$	$\otimes x_5$
	$\underline{x}_1, \overline{x}_1$	$\underline{x}_2, \overline{x}_2$	$\underline{x}_3, \overline{x}_3$	$\underline{x}_4, \overline{x}_4$	$\underline{x}_5, \overline{x}_5$
T1	90, 95	90, 95	60, 70	80, 90	60, 70
T2	60, 70	40, 60	80, 90	90, 95	90, 95
T3	80, 90	90, 95	90, 95	90, 95	90, 95

Weightage values of individual criteria attributes (presented in Table 1) have been assumed accordingly in judging quality levels of individual teachers. Therefore, weightage value of 0.30, 0.25, 0.20, 0.15 and 0.10 has been assigned to criteria **A5**, **A4**, **A2**, **A3** and **A1** respectively. The initial decision making matrix $\otimes X$ (Table 5) has been normalized first as discussed in section 3. The normalized decision making matrix $\otimes \hat{X}$ is presented in Table 6. Values of $P_j, R_, Q_$ *and* N_j have been computed using equations (11) to (16). These are furnished in Table 7. Based on the results of Table 7, it has been inferred that the teacher who corresponds to the highest utility degree should be selected. According to (utility degree) N , the ranks obtained in the procedure of teacher evaluation are as follows: $Teacher\,3 > Teacher\,1 > Teacher\,2$. Based on the results of this ranking, the third teacher has been selected best in quality as well as performance viewpoint.

Table 6: Normalized weighted decision making matrix $\otimes\hat{X}$

Teacher (T)	$\underline{\hat{x}}_1, \overline{\hat{x}}_1$	$\underline{\hat{x}}_2, \overline{\hat{x}}_2$	$\underline{\hat{x}}_3, \overline{\hat{x}}_3$	$\underline{\hat{x}}_4, \overline{\hat{x}}_4$	$\underline{\hat{x}}_5, \overline{\hat{x}}_5$
T1	0.0368, 0.0384	0.0768, 0.0800	0.0360, 0.0432	0.0760, 0.0840	0.0720, 0.0865
T2	0.0240, 0.0288	0.0352, 0.0512	0.0504, 0.0552	0.0840, 0.0880	0.1104, 0.1152
T3	0.0336, 0.0368	0.0768, 0.0800	0.0552, 0.0576	0.0840, 0.0880	0.1104, 0.1152

Table 7: On evaluation of utility degree

Teacher (T)	P_j	R_j	Q_j	N_j
T1	0.2753	0.0396	0.3360	94.65%
T2	0.2684	0.0528	0.3139	88.42%
T3	0.3124	0.0564	0.3550	100%

CHAPTER 3

CONCLUSION

Education is the basic human requirement and one should take effort to find the best educational institute, excellent teacher following whom he/she can achieve the goal. Teachers' quality evaluation and performance appraisal depend upon several attributes related to teaching strategy, teaching methodology, student-teacher interaction, mutual knowledge sharing and many others. There are general statistical techniques related to multi-criteria decision making are available for quantitative evaluation but these techniques are not reliable for interval quantitative score assigned to the attributes. Moreover, preference order of those attributes is hardly known exactly. It seems also difficult to assign individual attribute weightage according to their relative significance as well as order to preference. In consideration of the above in the foregoing study grey relational analysis has been used to analyze the survey data (scaled response) and explore the relation among them in terms of degree of importance. Finally based on COPRAS-G method optimal teacher performance has been evaluated. Based on aforesaid study the following conclusions can be drawn:

a) Teachers' performance evaluation is a multi-criteria decision making problem.
b) Grey relational analysis has been found fruitful in selecting important criteria for teachers' performance evaluation.
c) In actual multi-criteria modeling of multi-alternative assessment problems, the criteria values can be expressed in terms of intervals.

d) COPRAS-G (a COPRAS method with grey criteria values) is a method for assessing the alternatives by multiple criteria values expressed in terms of intervals.

e) This approach is intended to support decision making and to increase the efficiency of the resolution process.

f) The method COPRAS-G may be applied to solving a wide range of problems associated with MCDM.

The approach can not only identify important criteria for teacher's evaluation but also find out deficient items associated with a teacher who needs improvement in certain criteria. The overall quality index proposed in this study can be used for quantitative assessment of teachers' performance. This index helps the administrators of education while taking strategic decisions like recruitment and promotion of faculty for overall growth of the institutes. However, the study can be extended further to a broad based methodology by considering more number of criteria for evaluation. The methodology can also be employed for comparison of quality of faculty in different educational settings.

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COMMUNICATION

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