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# Performance Assessment of Engineering Educational Institutes in Madhya Pradesh using Topsis and GRA

**Murali Krishna.M, K.V.Subbaiah, K.Narayana Rao**

***Abstract*: This paper uses multi criteria decision making methods to measure the performance assessment in engineering educational institutions in the state of Madhya Pradesh, India. To cater the need of technical manpower, a very large number of private engineering colleges have been established in the state of Madhya Pradesh of central India within a short span. The diminishing quality made so many engineering colleges forced towards closure is a concern in the state today. Therefore, the need for performance assessment and ranking of these engineering institutions is predominant. For the proposed framework, Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) and Grey Relational Analysis methods are applied for performance assessment of 28 engineering educational institutions taking into account some selected criteria.***

***Keywords*: Service Quality, Performance assessment, Ranking, TOPSIS, GRA**

## I. INTRODUCTION

Among all service sectors, the educational sector particularly has a direct impact on the growth of society and economical development of the nation. In India, the governments at the center and state levels, through various regulatory bodies such as AICTE, UGC, NBA, NAAC monitor and assess the quality of technical education with a view to ensure the high caliber of education service. Yet, the quality of higher education in technical institutions falls short of attaining the global level excellence. The increased number of seats in state and central funded institutions, deemed universities and aided and unaided private institutions caused the mushrooming of engineering educational institutions in India. This opportunity provided the students to select the institute based on their interests. As the students are the key stakeholder in the educational industry, they deserve the best education.

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Therefore, to serve and attract the key stake holders as the primary customers, quality became the competitive weapon. The pinnacle was the period somewhere in the range of 2007 and 2009, when the nation included more than 7000 institutions, around 1/5th of total. As per the latest data, 59% of colleges were situated in rural and urban zones. Unexpectedly, as indicated by AICTE, about 200 inadequate and sub standard institutions have applied for closure. In last 5 years, most of the institutions have less than 20% enrollment and has been on decline since 2012-13. In view of the decline, AICTE has decided that atleast 50% of the programmes in technical institutions have to get their accreditation from National Board of Accreditation (NBA) by 2022. According to the officiate website of AICTE, the council has approved the progressive closure of more than 400 institutions having low or no enrollment in India from 2014-15 to 2017-18 and also mentioned in their database that around 10% of the programmes only are accredited.

The state of Madhya Pradesh consists more than 200 engineering colleges with more than one lakh students, over 58% seats going vacant due to non-availability of students annually. Due to the poor quality of educational infrastructure and incompetent student's quality, approximately 40% of the seats are enrolling annually. This has diminished the image of engineering education in Madhya Pradesh. These statistics made engineering education in the state thriving through a crucial phase in which performance of the institutions and the programmes is under scrutiny. The global competitiveness in the higher education has compelled the engineering institutions to re-evaluate the performance of the programmes, they offer, to match with the demand of the corporate sector.

## II. LITERATURE REVIEW

The performance evaluation of educational institutions/public universities using various multi criteria decision making methods have been done. Some of the works will be discussed in this section.

**Khan, M.S., et.al. [9],** proposed that Data Envelopment Analysis (DEA) can aggregate the input and output components in such situations for obtaining an overall performance measure of selected technical institutions in India were assessed for the service quality. The methodology also facilitated to identify the benchmarking institutions which can be referred by inefficient institutes to become efficient units.

**Preeti Tyagi et.al., [15]** evaluated the performance of academic departments through DEA models using different combinations of input and output variables based on activity-wise performance assessment of the departments of IIT Roorkee.

**Dipendra Nath Ghosh [4]**, evaluated faculty performance in engineering education by applying Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). He also introduced an approach that integrates AHP with TOPSIS algorithm to support teacher evaluation decisions for the ranking of the four faculty members for evaluating their performances.

**K G Durga Prasad et.al., [8]** demonstrated the novel application of six sigma approach for improving the quality in an Engineering Educational institution by eliminating the failure causes. In this paper, they proposed six sigma approaches to assure quality in education, desired placements in reputed companies, opportunity of higher studies, developing prospective entrepreneurs and higher percentage of pass outs.

**N. Chandra Shekhar et al. [13]** developed a methodology in this paper is useful to determine the OSQ of EEIs and to set priorities for improvement of the factors. In this study, the relative weights of the factors influencing the OSQ of an EEI are determined. They have also showed in the results that the contribution of professionalism, facilities, integrated education, responsiveness and empathy towards OSQ of engineering education.

**H-Y. Wu et.al., [5],** weighted the performance indices based on the official performance evaluation structure of Taiwan Assessment and Evaluation Association (TWAEA) then applied a hybrid multiple-criteria decision-making (MCDM) model to compare the official rankings of the 12 private universities with the obtained results.

**Tapas Kumar Sarkar [21]** provided an overview of Assessment in education in India. The paper traced the development of India's assessment system in education starting from primary to university level, then, it provided a brief statement about the legislation and policies on education. The author kept the focus on the new trends for education in India and on 'Sarva Siksha Mission' (Education for All). Lastly, the paper dealt with different International Assessment systems used in Indian schools.

**S. Sunitha and Malathy Duraisamy [20]**, used a non-parametric approach, namely, DEA to investigate the efficiency (technical and scale) for the time period 2005–2006 through institutional survey of seven engineering and seven polytechnic institutions in Kerala.

**N. Chandra Shekhar et al. [14]**, determined the quality gap of educational services based on differences between students' perceptions and expectations on 32 items of service quality provided by Engineering Education Institutions (EEIs) through the questionnaire survey. They also carried out Factor Analysis (FA) to identify the underlying dimensions in the service quality items. The relative importance of these factors is determined through AHP by using pair wise comparison matrix.

**Manik Chandra Das et.al.,[11]** described and illustrated an application of a structured approach to determine relative efficiency and ranking of a set of private engineering colleges under multi-criteria environment using Multiple Objective Optimization on the basis of Simple Ratio Analysis (MOOSRA) for performance evaluation of eight private engineering colleges taking into account some selected criteria. The subjective weights of the criteria are determined using fuzzy analytic hierarchy process (AHP).

**N. Chandra Shekhar et al.[7]**, integrated the concept of TOPSIS into the DEA framework in a fuzzy environment to measure the efficiencies of a set of DMUs and rank them with input–output levels. Various factors that affect the ranking of educational institutions have been categorized into seven inputs and two outputs. An integrated model has been evolved for assessing the effectiveness in terms of inputs and outputs. They implemented the proposed model on a case study. The study reported in this paper helps management to take effective decisions in improving the performance of EEIs and also helps for accreditation and better ranking of engineering education institutions.

**Amrita Bhattacharyya and Shankar Chakraborty [1]**, assessed the performance of eight Indian Institutes of Technology (IITs) using a combined approach of data envelopment analysis (DEA) and technique of order preference by similarity to ideal solution (TOPSIS). Further, they also suggested that the results would help the IITs in efficiently converting their inputs to outputs.

**Mohammed F. Aly et.al., [12],** proposed a balanced scorecard as a performance evaluation model for engineering educational systems. They also prioritized performance indicators within engineering education balanced scorecard using AHP-TOPSIS.

**Sobhan Sarkar and Bijan Sarkar [19]**, computed the Weightage value for each criterion by Subjective and Objective Weight Integrated Approach (SOWIA) and ranking is done by Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. Furthermore, they also correlated between the two methods i.e., fuzzy AHP-COPRAS and TOPSIS has been carried out in order to explore interrelationship of the methods used.

**Rajeev Ranjan, Shankar Chakraborty [17]**, evaluated the comparative performance of 20 NITs in India based on nine uncorrelated criteria using integrated PROMETHEE and GAIA methods. In order to avoid subjective judgments, Shannon's entropy method is used for computing the criteria weights.

**Shankar Chakraborty et.al.,[3]** compared the educational performance of 28 Indian states by the application of PROMETHEE-GAIA method for performance appraisal. They also employed a novel geographic information system (GIS) method and a hue-saturation-value color coding scheme in order to determine the influence of individual criterion on the overall state rank, thereby representing an integration of MCDM and GIS which has never been applied before for educational performance evaluation.

**Sobhan Sarkar and Bijan Sarkar [9]** proposed Subjective and Objective Weight Integrated Approach and ranking is done by Višekriterijumsko KOmpromisno Rangiranje (SOWIA-VIKOR) method to evaluate performance of seven IITs with their performance values in different six criteria. Furthermore, the sensitivity analysis is also carried out in order to explore how much deviation is encountered in each case when weightage value is changed for each criterion to have better insight of it.

## III. METHODOLOGY

In this paper, performance assessment of engineering educational institutions situated in the state of Madhya Pradesh in India is presented. The proposed approach is based on two-step TOPSIS and GRA methodology for selecting the best engineering educational institution which is more powerful than traditional methods. Several stakeholders gave their opinions for engineering educational institutions depending upon different criteria.

### A. *Frame work for modeling the academic soundness measures of EEIs*

The interdependence among different levels in engineering education institution academic soundness / performance framework is developed through review of literature and through discussion with experts in the field of engineering education. An engineering educational institution academic soundness/performance framework model and its decision environment are needed to improve the performance of EEI.
The framework of academic soundness/performance measures of EEI is shown in Figure 3.1. In this frame work, the decision elements are hierarchically decomposed into different levels. In this study, the criteria are considered through the literature survey.
The performance dimensions namely Education Quality (EQ), Administration Quality (AQ), Co-Creation (CC), Overall Outcome (OO) and Satisfaction (SA) are considered. The performance enablers under education quality are Faculty Competency (FC), Catering to Student Diversity (CSD), Coherent Course Structure (CCS), Teaching-Learning Process (TLP).
Under Administration Quality- Faculty Empowerment Strategies (FES), Financial Management and Resource Mobilization (FMRM), Physical Facilities (PF), Internal Quality Assurance System (IQAS). With respect to students' aspects- Professional Behavior (PB), Programme Outcomes (PO), Graduate Attributes (GA) and Cultural Social Life (CSL) are considered in Co-creation.

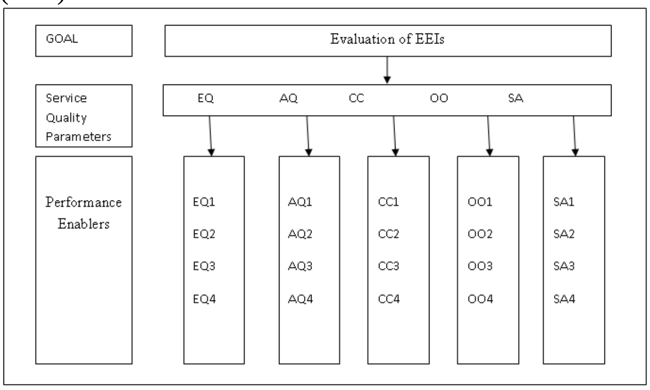


**Figure 1: Framework of performance measures of EEIs**

The enablers, Promotion of Research & Consultancies, Evaluation Process of Reforms, Planning & Organizational Abilities and Student Progression & Placements are considered in case of overall outcome.
The enablers viz., Comparison with Prior Expectations (PE), Perception of Family's' Satisfaction (PFS), Student Performance & Learning Outcomes (SPLO) and Reputation of the Institution (RI) are considered in case of satisfaction.
Modeling of academic soundness/performance measures of EEIs require the relative weights of the performance dimensions on each determinant and the relative weights of the enablers on the respective dimension. In this study, the final weights are obtained through Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) and grey relational analysis (GRA) approaches from the aggregated responses of stakeholders.

### B. *Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)*

To assess the collection of options based on multi criteria, TOPSIS is one of the analytical methods used in multi criteria decision making methods. The weights of evaluative indicators need to be determined in order to rank through MCDM. Jamali R and Sayyadi [16] mentioned the following algorithm to solve TOPSIS problem:
First step: Construct the decision matrix and determine the weight of criteria then calculate the normalized decision matrix.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2_{ij}}}$$

Now, performance evaluation of the 28 engineering educational institutes (EEIs), the decision matrix of Table 3.1 is developed accumulating the related information from the questionnaire through stakeholders. Employing the mentioned steps, this decision matrix is then normalized in Table 3.2.
Second step: Calculate the weighted normalized decision matrix
First weight of each criterion will be found and then weighed normalized decision matrix will be calculated through multiplying weight matrix into normalized decision-making matrix.
V=$N_D \times W_n \times n$
**Third step:** Determine the positive ideal and negative ideal solutions.
($V_j^+$) ideal option= [Vector of the best value of each indicator in matrix v]
($V_j^-$) anti- ideal options= [Vector of the worst value of each indicator in matrix]
For positive indicators the best value is the same as the highest one and the worst is the lowest one. For negative indicators, the best value is the same as the lowest one and the worst is the highest.
**Fourth step:** Calculate the separation measures from the positive ideal solution and the negative ideal solution.

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (Vi_j - V_j^+)^2} \qquad i = 1,2, \dots \dots \dots, m$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^-)^2} \qquad i = 1,2, \dots \dots, m$$

**Fifth step:** Calculate the relative closeness to the positive ideal solution and Rank the preference order or select the alternative closest to 1.
To do so, relative closeness ($C_i$) is found through the following relative and each option with higher $C_i$ is more appropriate.

$$c_i = \frac{S_i^-}{S_i^- + S_i^+}$$

In TOPSIS, Closeness coefficients of the EEIs are calculated and these EEIs are ranked as discussed in the steps third, fourth and fifth. The model calculations of the TOPSIS methodology are presented in Table 3.1 to Table 3.3.

Finally, the alternatives are ranked according to the ideal solution proximity values (Ci*) calculated within the existing criteria. The best alternative is the closest alternative to the ideal solution.

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| Weights | 0.347532 | 0.123377 | 0.270909 | 0.088182 | 0.17 | | Weights | 0.347532 | 0.123377 | 0.270909 | 0.088182 | 0.17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EEIs | EQ | AQ | CC | OO | SA | | EEIs | EQ | AQ | CC | OO | SA |
| EI 1 | 0.6993 | 0.6924 | 0.745 | 0.7275 | 0.7003 | | EI 15 | 0.6711 | 0.7909 | 0.7303 | 0.7097 | 0.7086 |
| EI 2 | 0.6509 | 0.6259 | 0.6218 | 0.6646 | 0.5807 | | EI 16 | 0.6876 | 0.7002 | 0.6369 | 0.6416 | 0.6417 |
| EI 3 | 0.5861 | 0.5418 | 0.711 | 0.4473 | 0.7068 | | EI 17 | 0.6526 | 0.5739 | 0.6372 | 0.6949 | 0.661 |
| EI 4 | 0.6768 | 0.613 | 0.5474 | 0.7604 | 0.6482 | | EI 18 | 0.6587 | 0.7287 | 0.7158 | 0.5004 | 0.7044 |
| EI 5 | 0.7397 | 0.7206 | 0.694 | 0.6724 | 0.5455 | | EI 19 | 0.5817 | 0.564 | 0.7119 | 0.5046 | 0.6112 |
| EI 6 | 0.6342 | 0.7631 | 0.6229 | 0.5715 | 0.6443 | | EI 20 | 0.6826 | 0.5822 | 0.709 | 0.5214 | 0.618 |
| EI 7 | 0.7497 | 0.7848 | 0.5945 | 0.7126 | 0.6994 | | EI 21 | 0.6656 | 0.6656 | 0.6237 | 0.7999 | 0.7142 |
| EI 8 | 0.5763 | 0.6967 | 0.6346 | 0.5566 | 0.6004 | | EI 22 | 0.6219 | 0.7112 | 0.7431 | 0.7024 | 0.6743 |
| EI 9 | 0.5439 | 0.6906 | 0.6433 | 0.542 | 0.6878 | | EI 23 | 0.6449 | 0.6125 | 0.6592 | 0.6021 | 0.6323 |
| EI 10 | 0.5609 | 0.6666 | 0.6379 | 0.7016 | 0.6633 | | EI 24 | 0.5894 | 0.7295 | 0.7422 | 0.7388 | 0.6827 |
| EI 11 | 0.6568 | 0.7378 | 0.7382 | 0.6906 | 0.6772 | | EI 25 | 0.7068 | 0.731 | 0.7755 | 0.6883 | 0.6904 |
| EI 12 | 0.6167 | 0.7256 | 0.7511 | 0.7215 | 0.7016 | | EI 26 | 0.5106 | 0.628 | 0.6544 | 0.7327 | 0.5969 |
| EI 13 | 0.6962 | 0.7012 | 0.6262 | 0.7415 | 0.6987 | | EI 27 | 0.7463 | 0.6114 | 0.7628 | 0.681 | 0.6726 |
| EI 14 | 0.7889 | 0.6699 | 0.6219 | 0.6718 | 0.7558 | | EI 28 | 0.7187 | 0.6085 | 0.6937 | 0.8184 | 0.6297 |

**TABLE 3.1: Normalized decision making matrix**

| EEIs | EQ | AQ | CC | OO | SA | | EEIs | EQ | AQ | CC | OO | SA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI 1 | 0.243 | 0.085 | 0.202 | 0.064 | 0.119 | | EI 15 | 0.233 | 0.098 | 0.198 | 0.063 | 0.12 |
| EI 2 | 0.226 | 0.077 | 0.168 | 0.059 | 0.099 | | EI 16 | 0.239 | 0.086 | 0.173 | 0.057 | 0.109 |
| EI 3 | 0.204 | 0.067 | 0.193 | 0.039 | 0.12 | | EI 17 | 0.227 | 0.071 | 0.173 | 0.061 | 0.112 |
| EI 4 | 0.235 | 0.076 | 0.148 | 0.067 | 0.11 | | EI 18 | 0.229 | 0.09 | 0.194 | 0.044 | 0.12 |
| EI 5 | 0.257 | 0.089 | 0.188 | 0.059 | 0.093 | | EI 19 | 0.202 | 0.07 | 0.193 | 0.044 | 0.104 |
| EI 6 | 0.22 | 0.094 | 0.169 | 0.05 | 0.11 | | EI 20 | 0.237 | 0.072 | 0.192 | 0.046 | 0.105 |
| EI 7 | 0.261 | 0.097 | 0.161 | 0.063 | 0.119 | | EI 21 | 0.231 | 0.082 | 0.169 | 0.071 | 0.121 |
| EI 8 | 0.2 | 0.086 | 0.172 | 0.049 | 0.102 | | EI 22 | 0.216 | 0.088 | 0.201 | 0.062 | 0.115 |
| EI 9 | 0.189 | 0.085 | 0.174 | 0.048 | 0.117 | | EI 23 | 0.224 | 0.076 | 0.179 | 0.053 | 0.107 |
| EI 10 | 0.195 | 0.082 | 0.173 | 0.062 | 0.113 | | EI 24 | 0.205 | 0.09 | 0.201 | 0.065 | 0.116 |
| EI 11 | 0.228 | 0.091 | 0.2 | 0.061 | 0.115 | | EI 25 | 0.246 | 0.09 | 0.21 | 0.061 | 0.117 |
| EI 12 | 0.214 | 0.09 | 0.203 | 0.064 | 0.119 | | EI 26 | 0.177 | 0.077 | 0.177 | 0.065 | 0.101 |
| EI 13 | 0.242 | 0.087 | 0.17 | 0.065 | 0.119 | | EI 27 | 0.259 | 0.075 | 0.207 | 0.06 | 0.114 |
| EI 14 | 0.274 | 0.083 | 0.168 | 0.059 | 0.128 | | EI 28 | 0.25 | 0.075 | 0.188 | 0.072 | 0.107 |

| | | | | | |
|---|---|---|---|---|---|
| Min | 0.1774 | 0.0668 | 0.1483 | 0.0394 | 0.0927 |
| Max | 0.2742 | 0.0976 | 0.2101 | 0.0705 | 0.1285 |

**TABLE 3.2 weighted pay off matrix**

According to the results after performing TOPSIS model the best alternative is found as EI 27 followed by EI 25, EI 1, EI 14, EI 15, EI 28, EI 5, EI 7, EI 11and EI 13 in top 10 rankings. EI 26 is the worst alternative. Distance from positive and negative ideal solution values and relative closeness to the ideal solution of each alternative are given in Table 4.6. According to the performance results, EI 27 gets the highest point among others with 0.76622 and EI 26 shows the lowest performance among the others with 0.27465.

## C. GREY RELATIONAL ANALYSIS (GRA)

Deng [6] proposed grey system theory to deal with poor, incomplete and uncertain information and can be applied to various fields. Detailed explanation about GRA method is presented in the following section.

Sallehuddin et.al, [16], described the three steps in GRA. Data pre-processing is the first step, in which pre-processing of the data is required the range or unit in one data sequence is different from others or the sequence scatter range is too large. Pre-processing of data is a method of transferring the original data sequence into a comparable sequence. Therefore, data must be normalized, scaled and polarized first into a comparable sequence before proceed to other steps. The processing is called generation of grey relation.

$$x^*(k) = \frac{x_i^0(k) - \min x_i^0(k)}{\max x_i^0(k) - \min x_i^0(k)} \quad \text{Eq.}(1(a))$$

If the expectancy is the lower-the-better, then it can be expressed by

$$x^*(k) = \frac{\max x_i^0(k) - x_i^0(k)}{\max x_i^0(k) - \min x_i^0(k)} \quad \text{Eq.}(1(b))$$

Where

i= 1,…,m; k =1,…n.

m is number of experimental data items,

n is the number of parameters;

$x_i^0(k)$ is the original sequence,

$x_i^*(k)$ is the sequences after data preprocessing,

$\min x_i^0(k)$ and $\max x_i^0(k)$ are the smallest and the largest value of $x_i^0(k)$

In this study, Equation (1(a)) is employed, since output of this study has the characteristic of the “higher is better”, ie., the higher value of grey relational grade implies a strong relationship between comparative and reference series. The range of data is adjusted so as to fall within [0,1] range. The second step is to locate the grey relational coefficient by using Eq. (2a) :

$$\xi_i(k) = \frac{\Delta\min + \zeta\Delta\max}{\Delta_{0j}(k) + \zeta\Delta\max}, \qquad Eq.(2a)$$

Where,

$\Delta_{0j}$ = deviation sequences of the reference sequence and comparability sequence

$\Delta_{0j} = \|x_0^*(k) - x_i^*(k)\|$,

$\Delta\min = \min\min_{\forall j \in i \forall k} \|x_0^*(k) - x_j^*(k)\|$,

$\Delta\max = \max\max_{\forall j \in i \forall k} \|x_0^*(k) - x_j^*(k)\|$,

$x_0^*(k)$ = the reference sequence and

$x_i^*(k)$ = the comparative sequence

$\zeta$ is known as identification coefficient with $\zeta \in [0,1]$ which can be acclimated to help improve refinement between normalized reference arrangement and normalized comparative series. Normally $\zeta = 0.5$ is used because it offers moderate distinguishing effect and stability. Furthermore, based on mathematic proof, the value change of $\zeta$ will only change the magnitude of the relational coefficient but it won’t change the rank of the grey relational grade. From the calculation, the values of $\Delta\min$ and $\Delta\max$ are respectively 0 and 1.

Then replace these values in Eq. (2a), and we obtain:

$$\xi_i(k) = \frac{0 + \zeta(1)}{\Delta_{0i}(k) + \zeta(1)}$$

$$= \frac{0.5}{\Delta_{0i}(k) + 0.5} \qquad Eq.(2b)$$

After the grey relational coefficient is derived, grey relational grade (GRG) is calculated by averaging the value of the grey relational coefficients. GRG is defined as the numerical measure of the relevancy between two systems or two sequences such as the reference sequence and the comparability sequence. The existing GRG between two series is always distributed between 0 and1. Grey relational grade can be calculated using formula below:

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k) \qquad Eq.(3)$$

Where $\gamma_i$ represents GRG; the level of correlation between the reference sequence and the comparability sequence.
Grey relation coefficients of the EEIs are calculated as discussed above. The EEIs are ranked based on the grey relation grade. The data shown in the table 3.1 is considered to evaluate the academic soundness. The model calculations are presented in Table 3.4 to Table 3.9.

| EEIs | EQ | AQ | CC | OO | SA |
|---|---|---|---|---|---|
| EI 1 | 0.6993 | 0.6924 | 0.745 | 0.7275 | 0.7003 |
| EI 2 | 0.6509 | 0.6259 | 0.6218 | 0.6646 | 0.5807 |
| EI 3 | 0.5861 | 0.5418 | 0.711 | 0.4473 | 0.7068 |
| EI 4 | 0.6768 | 0.613 | 0.5474 | 0.7604 | 0.6482 |
| EI 5 | 0.7397 | 0.7206 | 0.694 | 0.6724 | 0.5455 |
| EI 6 | 0.6342 | 0.7631 | 0.6229 | 0.5715 | 0.6443 |
| EI 7 | 0.7497 | 0.7848 | 0.5945 | 0.7126 | 0.6994 |
| EI 8 | 0.5763 | 0.6967 | 0.6346 | 0.5566 | 0.6004 |
| EI 9 | 0.5439 | 0.6906 | 0.6433 | 0.542 | 0.6878 |
| EI 10 | 0.5609 | 0.6666 | 0.6379 | 0.7016 | 0.6633 |
| EI 11 | 0.6568 | 0.7378 | 0.7382 | 0.6906 | 0.6772 |
| EI 12 | 0.6167 | 0.7256 | 0.7511 | 0.7215 | 0.7016 |
| EI 13 | 0.6962 | 0.7012 | 0.6262 | 0.7415 | 0.6987 |
| EI 14 | 0.7889 | 0.6699 | 0.6219 | 0.6718 | 0.7558 |
| EI 15 | 0.6711 | 0.7909 | 0.7303 | 0.7097 | 0.7086 |
| EI 16 | 0.6876 | 0.7002 | 0.6369 | 0.6416 | 0.6417 |
| EI 17 | 0.6526 | 0.5739 | 0.6372 | 0.6949 | 0.661 |
| EI 18 | 0.6587 | 0.7287 | 0.7158 | 0.5004 | 0.7044 |
| EI 19 | 0.5817 | 0.564 | 0.7119 | 0.5046 | 0.6112 |
| EI 20 | 0.6826 | 0.5822 | 0.709 | 0.5214 | 0.618 |
| EI 21 | 0.6656 | 0.6656 | 0.6237 | 0.7999 | 0.7142 |
| EI 22 | 0.6219 | 0.7112 | 0.7431 | 0.7024 | 0.6743 |
| EI 23 | 0.6449 | 0.6125 | 0.6592 | 0.6021 | 0.6323 |
| EI 24 | 0.5894 | 0.7295 | 0.7422 | 0.7388 | 0.6827 |
| EI 25 | 0.7068 | 0.731 | 0.7755 | 0.6883 | 0.6904 |
| EI 26 | 0.5106 | 0.628 | 0.6544 | 0.7327 | 0.5969 |
| EI 27 | 0.7463 | 0.6114 | 0.7628 | 0.681 | 0.6726 |
| EI 28 | 0.7187 | 0.6085 | 0.6937 | 0.8184 | 0.6297 |

| | | | | | |
|---|---|---|---|---|---|
| POSITIVE IDEAL | 0.7889 | 0.7909 | 0.7755 | 0.7999 | 0.7558 |
| NEGATIVE IDEAL | 0.5106 | 0.5418 | 0.5474 | 0.4473 | 0.5455 |

**TABLE 3.4 Data set and construct decision matrix**

STEP II

| EEIs | EQ | AQ | CC | OO | SA | | EEIs | EQ | AQ | CC | OO | SA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI 1 | 0.09 | 0.099 | 0.031 | 0.072 | 0.056 | | EI 15 | 0.118 | 0 | 0.045 | 0.09 | 0.047 |
| EI 2 | 0.138 | 0.165 | 0.154 | 0.135 | 0.175 | | EI 16 | 0.101 | 0.091 | 0.139 | 0.158 | 0.114 |
| EI 3 | 0.203 | 0.249 | 0.065 | 0.353 | 0.049 | | EI 17 | 0.136 | 0.217 | 0.138 | 0.105 | 0.095 |
| EI 4 | 0.112 | 0.178 | 0.228 | 0.04 | 0.108 | | EI 18 | 0.13 | 0.062 | 0.06 | 0.3 | 0.051 |
| EI 5 | 0.049 | 0.07 | 0.082 | 0.128 | 0.21 | | EI 19 | 0.207 | 0.227 | 0.064 | 0.295 | 0.145 |
| EI 6 | 0.155 | 0.028 | 0.153 | 0.228 | 0.112 | | EI 20 | 0.106 | 0.209 | 0.067 | 0.279 | 0.138 |
| EI 7 | 0.039 | 0.006 | 0.181 | 0.087 | 0.056 | | EI 21 | 0.123 | 0.125 | 0.152 | 0 | 0.042 |
| EI 8 | 0.213 | 0.094 | 0.141 | 0.243 | 0.155 | | EI 22 | 0.167 | 0.08 | 0.032 | 0.098 | 0.082 |
| EI 9 | 0.245 | 0.1 | 0.132 | 0.258 | 0.068 | | EI 23 | 0.144 | 0.178 | 0.116 | 0.198 | 0.124 |
| EI 10 | 0.228 | 0.124 | 0.138 | 0.098 | 0.093 | | EI 24 | 0.2 | 0.061 | 0.033 | 0.061 | 0.073 |
| EI 11 | 0.132 | 0.053 | 0.037 | 0.109 | 0.079 | | EI 25 | 0.082 | 0.06 | 0 | 0.112 | 0.065 |
| EI 12 | 0.172 | 0.065 | 0.024 | 0.078 | 0.054 | | EI 26 | 0.278 | 0.163 | 0.121 | 0.067 | 0.159 |
| EI 13 | 0.093 | 0.09 | 0.149 | 0.058 | 0.057 | | EI 27 | 0.043 | 0.18 | 0.013 | 0.119 | 0.083 |
| EI 14 | 0 | 0.121 | 0.154 | 0.128 | 0 | | EI 28 | 0.07 | 0.182 | 0.082 | 0.019 | 0.126 |

**TABLE 3.5 Constructing reference series and compare matrix**

STEP III

| EEIs | EQ | AQ | CC | OO | SA | | EEIs | EQ | AQ | CC | OO | SA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI 1 | 0.189 | 0.151 | 0.198 | 0.28 | 0.155 | | EI 15 | 0.161 | 0.249 | 0.183 | 0.262 | 0.163 |
| EI 2 | 0.14 | 0.084 | 0.074 | 0.217 | 0.035 | | EI 16 | 0.177 | 0.158 | 0.09 | 0.194 | 0.096 |
| EI 3 | 0.075 | 0 | 0.164 | 0 | 0.161 | | EI 17 | 0.142 | 0.032 | 0.09 | 0.248 | 0.116 |
| EI 4 | 0.166 | 0.071 | 0 | 0.313 | 0.103 | | EI 18 | 0.148 | 0.187 | 0.168 | 0.053 | 0.159 |
| EI 5 | 0.229 | 0.179 | 0.147 | 0.225 | 0 | | EI 19 | 0.071 | 0.022 | 0.165 | 0.057 | 0.066 |
| EI 6 | 0.124 | 0.221 | 0.076 | 0.124 | 0.099 | | EI 20 | 0.172 | 0.04 | 0.162 | 0.074 | 0.073 |
| EI 7 | 0.239 | 0.243 | 0.047 | 0.265 | 0.154 | | EI 21 | 0.155 | 0.124 | 0.076 | 0.353 | 0.169 |
| EI 8 | 0.066 | 0.155 | 0.087 | 0.109 | 0.055 | | EI 22 | 0.111 | 0.169 | 0.196 | 0.255 | 0.129 |
| EI 9 | 0.033 | 0.149 | 0.096 | 0.095 | 0.142 | | EI 23 | 0.134 | 0.071 | 0.112 | 0.155 | 0.087 |
| EI 10 | 0.05 | 0.125 | 0.091 | 0.254 | 0.118 | | EI 24 | 0.079 | 0.188 | 0.195 | 0.292 | 0.137 |
| EI 11 | 0.146 | 0.196 | 0.191 | 0.243 | 0.132 | | EI 25 | 0.196 | 0.189 | 0.228 | 0.241 | 0.145 |
| EI 12 | 0.106 | 0.184 | 0.204 | 0.274 | 0.156 | | EI 26 | 0 | 0.086 | 0.107 | 0.285 | 0.051 |
| EI 13 | 0.186 | 0.159 | 0.079 | 0.294 | 0.153 | | EI 27 | 0.236 | 0.07 | 0.215 | 0.234 | 0.127 |
| EI 14 | 0.278 | 0.128 | 0.075 | 0.225 | 0.21 | | EI 28 | 0.208 | 0.067 | 0.146 | 0.371 | 0.084 |

**TABLE 3.6 Normalization process and constructing normalization matrix**

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STEP IV

| | ETA+ | | | | | | | ETA+ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EEIs | EQ | AQ | CC | OO | SA | | EEIs | EQ | AQ | CC | OO | SA |
| EI 1 | 0.663 | 0.642 | 0.853 | 0.709 | 0.761 | | EI 15 | 0.599 | 1 | 0.796 | 0.662 | 0.789 |
| EI 2 | 0.561 | 0.517 | 0.534 | 0.566 | 0.502 | | EI 16 | 0.635 | 0.66 | 0.56 | 0.527 | 0.607 |
| EI 3 | 0.465 | 0.414 | 0.732 | 0.333 | 0.783 | | EI 17 | 0.564 | 0.448 | 0.56 | 0.627 | 0.65 |
| EI 4 | 0.611 | 0.498 | 0.436 | 0.817 | 0.621 | | EI 18 | 0.575 | 0.739 | 0.747 | 0.371 | 0.774 |
| EI 5 | 0.782 | 0.715 | 0.684 | 0.58 | 0.456 | | EI 19 | 0.46 | 0.437 | 0.735 | 0.374 | 0.549 |
| EI 6 | 0.533 | 0.864 | 0.536 | 0.436 | 0.613 | | EI 20 | 0.624 | 0.458 | 0.726 | 0.388 | 0.561 |
| EI 7 | 0.818 | 0.967 | 0.493 | 0.669 | 0.758 | | EI 21 | 0.588 | 0.585 | 0.537 | 1 | 0.809 |
| EI 8 | 0.453 | 0.652 | 0.556 | 0.42 | 0.532 | | EI 22 | 0.514 | 0.689 | 0.845 | 0.644 | 0.684 |
| EI 9 | 0.418 | 0.637 | 0.571 | 0.406 | 0.722 | | EI 23 | 0.55 | 0.497 | 0.603 | 0.471 | 0.588 |
| EI 10 | 0.436 | 0.586 | 0.562 | 0.642 | 0.656 | | EI 24 | 0.469 | 0.742 | 0.841 | 0.743 | 0.707 |
| EI 11 | 0.572 | 0.769 | 0.825 | 0.617 | 0.692 | | EI 25 | 0.682 | 0.746 | 1 | 0.612 | 0.729 |
| EI 12 | 0.506 | 0.73 | 0.878 | 0.692 | 0.765 | | EI 26 | 0.388 | 0.52 | 0.593 | 0.724 | 0.526 |
| EI 13 | 0.655 | 0.663 | 0.541 | 0.751 | 0.755 | | EI 27 | 0.805 | 0.496 | 0.933 | 0.597 | 0.679 |
| EI 14 | 1 | 0.593 | 0.534 | 0.579 | 1 | | EI 28 | 0.715 | 0.491 | 0.683 | 0.905 | 0.583 |

**TABLE 3.7 Constructing absolute values**

STEP V

| | ETA- | | | | | | | ETA- | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EEIs | EQ | AQ | CC | OO | SA | | EEIs | EQ | AQ | CC | OO | SA |
| EI 1 | 0.483 | 0.539 | 0.472 | 0.386 | 0.532 | | EI 15 | 0.5230 | 0.4140 | 0.4910 | 0.4020 | 0.5190 |
| EI 2 | 0.557 | 0.677 | 0.703 | 0.448 | 0.834 | | EI 16 | 0.4990 | 0.5270 | 0.6630 | 0.4760 | 0.6470 |
| EI 3 | 0.700 | 1.000 | 0.519 | 1.000 | 0.522 | | EI 17 | 0.5540 | 0.8460 | 0.6630 | 0.4160 | 0.6040 |
| EI 4 | 0.515 | 0.712 | 1.000 | 0.360 | 0.632 | | EI 18 | 0.5430 | 0.4850 | 0.5110 | 0.7690 | 0.5260 |
| EI 5 | 0.435 | 0.496 | 0.546 | 0.439 | 1.000 | | EI 19 | 0.7130 | 0.8880 | 0.5170 | 0.7550 | 0.7290 |
| EI 6 | 0.588 | 0.443 | 0.700 | 0.587 | 0.641 | | EI 20 | 0.5060 | 0.8140 | 0.5220 | 0.7040 | 0.7090 |
| EI 7 | 0.424 | 0.420 | 0.789 | 0.399 | 0.534 | | EI 21 | 0.5320 | 0.5870 | 0.6980 | 0.3330 | 0.5110 |
| EI 8 | 0.729 | 0.532 | 0.669 | 0.617 | 0.763 | | EI 22 | 0.6130 | 0.5100 | 0.4740 | 0.4090 | 0.5780 |
| EI 9 | 0.841 | 0.542 | 0.648 | 0.651 | 0.553 | | EI 23 | 0.5680 | 0.7140 | 0.6120 | 0.5320 | 0.6700 |
| EI 10 | 0.778 | 0.586 | 0.661 | 0.409 | 0.599 | | EI 24 | 0.6910 | 0.4840 | 0.4750 | 0.3770 | 0.5620 |
| EI 11 | 0.547 | 0.474 | 0.480 | 0.420 | 0.572 | | EI 25 | 0.4730 | 0.4820 | 0.4360 | 0.4220 | 0.5490 |
| EI 12 | 0.624 | 0.490 | 0.464 | 0.391 | 0.530 | | EI 26 | 1.0000 | 0.6720 | 0.6220 | 0.3820 | 0.7740 |
| EI 13 | 0.487 | 0.525 | 0.691 | 0.375 | 0.535 | | EI 27 | 0.4280 | 0.7170 | 0.4500 | 0.4300 | 0.5810 |
| EI 14 | 0.388 | 0.579 | 0.703 | 0.440 | 0.456 | | EI 28 | 0.4590 | 0.7260 | 0.5460 | 0.3220 | 0.6770 |

**TABLE 3.8 grey relational coefficients for each alternative**

| | | | | | |
|---|---|---|---|---|---|
| Wi | 0.347532 | 0.12338 | 0.2709 | 0.088182 | 0.17 |
| Wj^2 | 0.1208 | 0.0152 | 0.0734 | 0.0078 | 0.0289 |
| Wj/(sqrt(sum(Wj^2))) | 0.2435 | 0.0307 | 0.1480 | 0.0157 | 0.0583 |

| EEIs | $Q_j^+$ | $Q_j^-$ | $C_j$ | Rank | | EEIs | $Q_j^+$ | $Q_j^-$ | $C_j$ | Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| EI 1 | 1.799 | 1.1967 | 0.6005 | 3 | | EI 15 | 1.9077 | 1.1657 | 0.6207 | 1 |
| EI 2 | 1.329 | 1.5966 | 0.4543 | 24 | | EI 16 | 1.4828 | 1.3948 | 0.5153 | 16 |
| EI 3 | 1.353 | 1.8558 | 0.4217 | 27 | | EI 17 | 1.4136 | 1.5291 | 0.4804 | 20 |
| EI 4 | 1.4797 | 1.5969 | 0.481 | 19 | | EI 18 | 1.5905 | 1.4062 | 0.5307 | 14 |
| EI 5 | 1.5958 | 1.4468 | 0.5245 | 15 | | EI 19 | 1.2675 | 1.7864 | 0.415 | 28 |
| EI 6 | 1.4786 | 1.4678 | 0.5018 | 17 | | EI 20 | 1.3675 | 1.6142 | 0.4586 | 23 |
| EI 7 | 1.8376 | 1.2735 | 0.5907 | 5 | | EI 21 | 1.7458 | 1.3204 | 0.5694 | 10 |
| EI 8 | 1.296 | 1.6418 | 0.4411 | 26 | | EI 22 | 1.674 | 1.2815 | 0.5664 | 11 |
| EI 9 | 1.3666 | 1.6047 | 0.4599 | 22 | | EI 23 | 1.344 | 1.5357 | 0.4667 | 21 |
| EI 10 | 1.4297 | 1.5046 | 0.4872 | 18 | | EI 24 | 1.7369 | 1.2847 | 0.5748 | 8 |
| EI 11 | 1.7235 | 1.2367 | 0.5822 | 7 | | EI 25 | 1.8703 | 1.1721 | 0.6147 | 2 |
| EI 12 | 1.7714 | 1.2399 | 0.5883 | 6 | | EI 26 | 1.3643 | 1.7114 | 0.4436 | 25 |
| EI 13 | 1.6698 | 1.2963 | 0.563 | 12 | | EI 27 | 1.7413 | 1.2927 | 0.5739 | 9 |
| EI 14 | 1.8387 | 1.2728 | 0.5909 | 4 | | EI 28 | 1.6756 | 1.354 | 0.5531 | 13 |

**TABLE 3.9: Grey Relational Degree**

According to the results after performing GRA the best grey relational degree obtained by EI 15 followed by EI25, EI 1, EI 14, EI 7, EI 12, EI 11, EI 24, EI 27 and EI 21 in top 10 rankings based on the grey relational degree. According to the performance results, EI 15 gets the highest degree among the others with 0.6207 and EI 19 shows the lowest performance among the others with 0.4150.

**C. COMPOSITE RANK**

| S.N | EEIs | TOPSIS | GRA | Composite Rank | | S.N | EEIs | TOPSIS | GRA | Composite Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | EI 1 | 3 | 3 | 2 | | 15 | EI 15 | 5 | 1 | 3 |
| 2 | EI 2 | 22 | 24 | 23 | | 16 | EI 16 | 14 | 16 | 16 |
| 3 | EI 3 | 23 | 27 | 25 | | 17 | EI 17 | 18 | 20 | 18 |
| 4 | EI 4 | 20 | 19 | 20 | | 18 | EI 18 | 11 | 14 | 12 |
| 5 | EI 5 | 7 | 15 | 11 | | 19 | EI 19 | 24 | 28 | 27 |
| 6 | EI 6 | 21 | 17 | 19 | | 20 | EI 20 | 12 | 23 | 17 |
| 7 | EI 7 | 8 | 5 | 6 | | 21 | EI 21 | 16 | 10 | 15 |
| 8 | EI 8 | 26 | 26 | 26 | | 22 | EI 22 | 15 | 11 | 14 |
| 9 | EI 9 | 27 | 22 | 24 | | 23 | EI 23 | 19 | 21 | 21 |
| 10 | EI 10 | 25 | 18 | 22 | | 24 | EI 24 | 17 | 8 | 13 |
| 11 | EI 11 | 9 | 7 | 7 | | 25 | EI 25 | 2 | 2 | 1 |
| 12 | EI 12 | 13 | 6 | 8 | | 26 | EI 26 | 28 | 25 | 28 |
| 13 | EI 13 | 10 | 12 | 10 | | 27 | EI 27 | 1 | 9 | 5 |
| 14 | EI 14 | 4 | 4 | 4 | | 28 | EI 28 | 6 | 13 | 9 |

**TABLE 3.9: Composite Rank**

After computing the composite ranks of EEIs, it can be observed that the EI 25 standing with best performance followed by EI 1, EI 15, EI 14, EI 27, EI 7, EI 11, EI 12, EI 28 and EI 13 are in top 10 rankings respectively. It is also observed that almost 70% of EIs are standing approximately in same cluster.

In this paper, an attempt is made to evaluate the comparative performance of selected 28 EEIs in the state of Madhya Pradesh, based on the selected key performance parameters using TOPSIS and GRA methods. It is observed that, in composite ranking, leading EI 25 is standing in $2^{nd}$ rank both in TOPSIS and GRA, whereas EI 1, which is in $2^{nd}$ rank in its composite ranking, is standing in $3^{rd}$ in both the methods.

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Only EI 14 is standing in 4th rank, showing its consistency in TOPSIS, GRA and in composite ranking. EI 15 standing in 5th rank, stood in 1st rank in GRA and 3rd rank in composite ranking. EI 5 and EI 13, which are having place in TOPSIS ranking, lost its ranking in top 10 places of GRA. Similarly, EI 11 and EI 24 having place in GRA ranking, have lost ranking in top 10 of TOPSIS.

This performance evaluation analysis will help in identifying the strengths and weakness of performance of key parameters and its sub aspects, which has to be need improvement for better performance.

## IV. CONCLUDING REMARKS

The findings show that there is no significant difference between the EEIs rankings calculated using the same criteria and the same weights for different methods. In order to prove this statistically, the relationships between the EEIs rankings obtained by different methods were calculated for composite ranking.

With the acceleration of globalization, the education sector continues to develop in a competitive environment. Now, EEIs are compared with not only with the EEIs situated in nation, but also with the EEIs in other countries and thus they both continue to develop in scientific sense and attract more national / international students thus contributing economically to the regions in which they are located.

In this study, the rankings of the 28 EEIs arranged with the scores were compared with the rankings obtained with TOPSIS and GRA which are among the most criterion decision making methods and which were calculated using the same criteria. The rankings and criteria used weren't changed so that the rankings obtained could be comparable.

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