Key barriers in the growth of engineering education in the context of Chhattisgarh state: a fuzzy Kano and TISM integrated approach

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Abstract: Today, countries depend on knowledge-driven innovation for economic growth which depends on the quality of the engineering education system and management. In India, the All India Council for Technical Education is the flag bearer of planning, formulation, and dissemination of technical education in the country. Since 2012–2013, there is a drastic decline in admissions in engineering courses across the country. Hence, there is a need to identify the barriers that dominate engineering education and that hinder the students from opting for engineering as a career option. The proposed work focuses on determining the key barriers to the growth of technical education in the state of Chhattisgarh by an integrated fuzzy Kano model and total interpretive structural modelling approach. The result of the study will provide deeper insight and a better understanding of the higher engineering scenario in the state and will help decision-makers to take constructive and progressive steps to improve the engineering education scenario.

Keywords: Kano model; total interpretive structural modelling; TISM; fuzzy Kano; engineering education management; key barriers; interpretive structural modelling; ISM; technical education; critical failure factors; CFFs; reachability matrix; HEI; digraph.

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1 Introduction

India if need to effectively compete in knowledge-driven and innovation-driven economic order in the 21st century, must produce high-quality engineering graduates who are in tune with the future skill requirements of the future industry. India has progressively built its engineering education capabilities over the decades and produces a large number of engineers every year in various disciplines (Subramanian, 2015). To withstand the tough innovative driven world market, our engineering education must respond to local challenges as well as global opportunities based on innovations and entrepreneurship (Banerjee and Muley, 2007). Hence, engineering education must prepare our engineers for the multi-disciplinary nature of the problems of modern organisations and societies.

In the society for the 21st century, higher education has become the most important tool for development and universities have become the real hub of knowledge generation. It is realised that in the 20th century when the world marched ahead into prosperity riding the waves of science and technology, technical education met many challenges and provide huge opportunities to move faster (Mohanty and Dash, 2016).

Since the early ‘80s, due to rapid industrialisation and economic growth, engineering and technical education in India have been developing faster and now India has the second-largest number of engineering students in the world.

The All India Council for Technical Education (AICTE) has been ably spearheading the planning, formulation, and dissemination of technical education across India. Over the years, it has undertaken several proactive steps for the growth of engineering education, maintenance of standards, and keeping the curricula current and relevant. In India, all the private and government technical universities and institutions that work under AICTE are to provide quality engineering education and achieve academic excellence in context to the students who choose engineering as a professional course to pursue.

However, the ground reality is far from the expectation. A large number of engineering students are getting a degree in different disciplines but the harsh fact is that 80% of Indian engineers are not fit for the jobs as per the annual employability survey 2019 conducted by Aspiring Minds. This is evident from various facts, i.e., declining admissions in engineering colleges, fewer students opting for science as a subject after 10th in 10 + 2 secondary education system.

Since 2016, the number of engineering seats has been on the decline. According to AICTE, it is around 75,000 annually. In 2016–2017, the total intake capacity at the undergraduate level was 1,571,220, of which total enrolment was 787,127, which is just around 50.1%. In 2015–2016, the total intake was 1,647,155, of which enrolment was 860,357, which was 52.2%. There will be around 80,000 fewer seats in engineering this year in the country. This will lead to around 3.1 lakh seats less in four years. According to the AICTE, nearly 200 'substandard' engineering colleges have applied for closure. AICTE wants to close down about 800 engineering colleges across India. There are no takers for their seats, and admissions are plunging in these colleges every year. Nearly 150 colleges are closed down voluntarily every year due to stricter AICTE rules. AICTE has approved the progressive closure of more than 410 colleges across India, from 2014–2015 to 2017–2018.

Chhattisgarh is a state formed in the year 2002 has the far worse situation in HEI. From Table 1, it is elicited that there has been a constant decline in the total number of engineering seats in the state as well as the total number of actual students admitted has also declined at a rapid rate. Due to this, the total number of engineering colleges has decreased from 57 in the year 2014 to only 38 in the year 2019.

Table 1 Engineering admission in Chhattisgarh state since 2012

Year	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Total seats	19,482	19,482	19,309	19,064	18,006	17,015	16,022	15,404
Pre-engineering test (PET) appeared	-	-	-	19,022	17,656	17,000	16,055	15,157
Seats filled	13,982	13,764	10,860	9,005	8,564	6,500	5,976	3,483
No. of colleges	57	57	57	48	48	47	45	38
Vacant seat %	28	29	43	46	49	67	73	77.38

For the identification of the barriers, a survey has been conducted among the various stakeholders of the engineering institution. Further, the proposed methodology employs a fuzzy Kano model (FKM) for barrier classification into various Kano categories. Total interpretive structural modelling (TISM) methodology is further applied to transform unclear, poorly articulated models of systems into clear, well-defined models by utilising the expert's knowledge to judge the variables and establish the relations among the variables. TISM helps the decision-makers to interpret the model structure easily and determine the interrelationship among the barriers. The remainder of the paper is structured as: Section 2 presents the literature review and in Section 3 backgrounds of the research work is covered. Section 4 covers the insights of the FKM. In Section 5, the steps of the proposed methodology are shown and in Section 6 the application of the proposed methodology is depicted. Section 7 presents the possible solutions to overcome the barriers and Section 8 covers the conclusions of the work. Finally, Section 9 presents the future scope of work.

2 Literature review

Chhattisgarh is a state of prospects. Endowed with an abundance of forest and mineral resources it has great prospects for industrial development. Rich in minerals like iron-ore, bauxites, coal, limestone and being a power surplus state, there is tremendous scope for steel and allied industries, aluminium industries and cement plants in the state. Technical education in Chhattisgarh is not new. When the state came into existence, ten engineering colleges came under this state. The growth of technical education before the formation and in its initial years of the formation of Chhattisgarh state has been very slow. The growth of industry after Chhattisgarh state forms demanded an urgent need for qualified personnel in technical education. So, the government allowed private participation in setting-up technical institutes on self-financing basic. As a result of the policy change, a large number of privately managed institutes were established in the past ten years (Table 2). At present, 50+ engineering colleges are running in this state (up to the year 2014–2015). Thereafter, it was observed that a sudden decline in the no. of engineering colleges began which in a recent survey has gone down to just 38 colleges having AICTE and CSVTU, a state govt. owned technical university affiliation.

Table 2 Growth of Indian Higher Education in India in past few years

Year	*Universities*	*Colleges*	*Enrolment (in millions)*
1947–1948	20	496	0.2
1950–1951	28	578	0.28
1960–1961	45	1819	0.6
1970–1971	93	3277	2.0
1980–1981	123	4738	2.08
1990–1991	164	5748	4.4
2000–2001	266	11146	8.8
2007–2008	442	18627	11.5
2009–2010	504	25951	13.6

2.1 Importance of technical education

Education makes a man realise himself and his goals and how to achieve the goals. Modern civilisation is dominated by science and scientific development and as a result of its specialisation in certain branches and industrialisation has become the most important aspect of scientific development.

Technical education is assuming greater importance as supposed that technical training makes us skilled. So that, we may be able to handle the machine properly and thus technical education makes specialists in certain domains of life. There are a large number of jobs that cannot be properly performed till relevant technical knowledge is acquired.

Technical education means equipping students with theoretical knowledge of fundamentals and experimental exposure about different kinds of machines, the ways of working with them, and different parts of machines besides industrials exposure. We need a technical workforce equipped with technical knowledge to run the agriculture sector, factories, industrial plants, and manufacturing centres.

2.2 Problems faced by technical education in India

The factors like availability of qualified teachers and supporting staff, adequate infrastructural facility, admission policy, well-designed courses curriculum, examination system, quality certifications, etc. play important role in deciding the quality of output from technical institutions.

Despite the best efforts, government bodies, like the Directorate of Technical Education (DTE) of various states, AICTE, and universities, achieving and maintaining desired quality standards of technical education in the country is still a challenge. The gap between industry and institute administration, external pressure from stakeholders, changing industry demands, conventional teaching-learning process, university syllabus constraints, lack of qualified faculty, poor R&D infrastructure has played a vital role in the deterioration of quality of technical education which has resulted in declining trend in admissions.

There is a dire need to address the problems emerging in most of the engineering institutes all over the country (not specific to any reason) to pay attention to impart quality technical education to students so that they can find a suitable return in life for the prime years of their life spent to acquire the technical education. At this stage, when our higher education system (HES) consists of 500+ university-level institutions and about 26,000+ colleges, there are many nagging concerns about its role and performance. But many of our reputed universities and colleges have lost their pre-eminent positions.

However, there is not a single university in the top 50 universities around the world and only IISc Bangalore and Indian Institutes of Technology (IIT) Bombay have reached the world repute but still have not achieved a great milestone yet as per the high cut-off's they have during admissions. In Chhattisgarh state, it is evident that there is not even a single college of international repute and instead most of the colleges are closing nowadays. In just five years, many colleges have seen shut down due to fewer admissions and hence this study is important to investigate those key barriers that have resulted in the deterioration of engineering education in the state.

3 Background of research work

- India produces a high number of engineers per year in various disciplines.
- Engineering education in India has gained the attention of youths in the last decade and this is evident by the opening of more private engineering colleges under AICTE.

- A large number of engineering students are getting a degree in different disciplines but job opportunities are scarce for them.
- Chhattisgarh state is one of the new states formed in the year 2000. Being new state engineering aspirants had great expectations for a bright future in the state.
- The declining number of engineering aspirants is alarming and the engineering education in the state is going through a tough scenario.

3.1 Objectives of the study

The objectives of the study have been determined as:

1. Understand the current engineering scenario in the state.
2. Study the current system from students/institutions/society perspectives.
3. Identification of the root barriers/causes for the decline of engineering education in the state.
4. Identify the expectation and needs of the engineering aspirants of the state.
5. Clustering the barriers/needs/expectations as per the significance of the future perspectives.
6. Identifying and recommending all the possible solutions for the removal of identified barriers.

4 Kano model

Kano model is a two-dimensional quality model based on the concept of customer quality developed by Professor Noriaki Kano in 1980 (Kano et al., 1984). This model helps decision-makers in knowing the level of satisfaction perceived by the customer when a product/service attribute is present or absent (Jain and Singh, 2020). Having a clear and better understanding of the relation between the level of customer satisfaction and product/service attribute helps decision-makers to improve the quality of product/service as per customer requirements resulting in a higher customer satisfaction level. Kano model helps the decision-makers to classify the attributes into five quality attributes (Figure 1):

1. Attractive quality (A).
2. One-dimensional quality (O).
3. Must-be quality (M).
4. Indifferent quality (I).
5. Reverse quality (R):
    a. *Time influence:* Kano diagram represents all types of needs in a single graph.

b *Categorisation of needs:* Define your users' needs in light of the Kano model. What are the basic expectations that they simply expect to be there and where would the absence of these features lead to frustration?

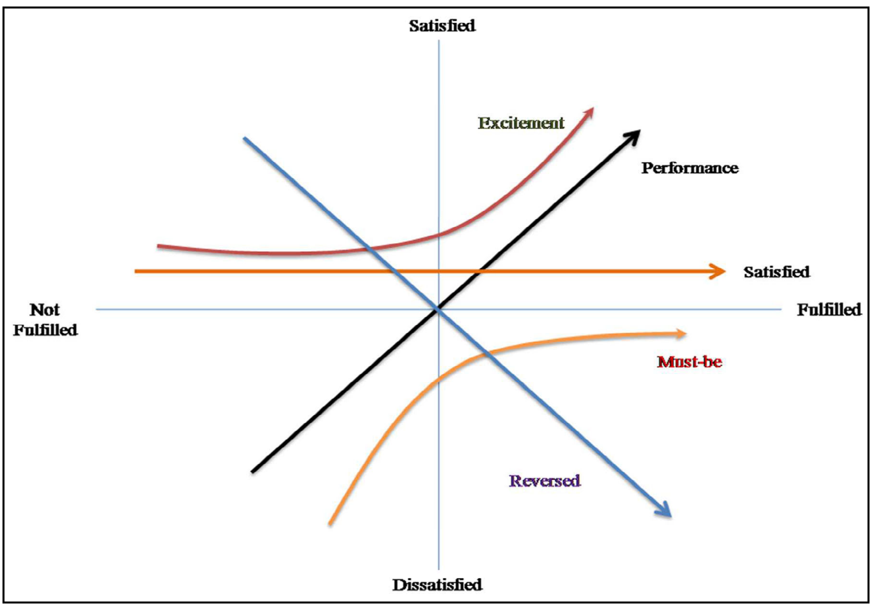
c *Competitive analysis:* Monitor your customer satisfaction and competition to ensure that features you think delight users have not slid into basic expectations and no longer help your customer satisfaction.

d *Innovation in design:* Find and focus on sustainable delighters that truly differentiate your product and continue to deliver customer satisfaction over time.

e *Prioritising needs:* It is intended to help prioritise customer needs.

f *Minimum viable product (MVP):* A minimum viable product has just those core features that allow the product to be deployed, and no more. Generation 1 has to cover the 'must-be'.

Figure 1 Kano model (see online version for colours)



4.1 Fuzzy Kano model

Authors and researchers have applied the Kano model in their work for the classification of identified criteria or attributes into different Kano categories and results have mainly been employed for new product development, selection of projects or finalisation of marketing strategies (Shahin and Shahiverdi, 2015; Wang and Fong, 2016).

However, the scope of application of the Kano model has not been limited to such areas only and as a result, the Kano model has been applied in various domains such as the service sector, auto-mobile industry, supply chain management, airlines service improvement, e-health awareness, student's satisfaction enhancement, project management, leadership style selection (Pai et al., 2018; Salehzadeh et al., 2015; Shahin and Shahiverdi, 2015; Wang and Wang, 2014).

Kano model has been integrated with other methods such as quality function deployment (QFD), Taguchi method, Kansei engineering, and various multi-criteria decision-making (MCDM) techniques for determining the relative weights of the criteria (Avikal et al., 2014; Ghorbani et al., 2013; Löfgren and Witell, 2008).

As the students have been the customers of HEI, their high level of satisfaction has been of prime importance for the management. A better understanding of the level of customer satisfaction perceived has helped the management to take strategic decisions for the future. As a higher level of customer satisfaction has helped the HEI to sustain the position in tough admission scenarios, hence, application of the FKM in the work has been justified.

Manski (1990) reported that human mentality and behaviour are accompanied by uncertainty and traditional questionnaires always over-interpreted. Further, Huang and Wu (1992) reported that customers cannot respond to their responses in a single answer. To overcome this uncertainty and vagueness in response from a respondent and proposed a FKM. Unlike traditional Kano model, the FKM allowed the respondent to register multiple responses for a single question (Jain et al., 2016). The fuzzy Kano approach is used as an effective tool to "analyze customer requirements from the perspective of products or services" (Kinker et al., 2021). The FKM can assist decision-making in the process of prioritising the service quality elements according to their impacts on customer satisfaction (Meng et al., 2015).

The standard roadmap to FKM encompasses the following steps:

1. *Identification of service quality elements* – The FKM basically needs the survey results of customers' satisfaction using the fuzzy Kano questionnaire. In general, the questionnaire is designed according to a set of customers' requirements. The prefatory category service requirements (SRs) are determined using Kano evaluation table.

2. *Determine and divide the market segments* – Here, the key factors/services are determined followed by their segmentation. Not all factors are same for every individual. Thus, it is necessary to classify all them.

3. *Design the fuzzy Kano questionnaire to acquire service quality elements* – Based on fuzzy Kano questionnaire, we get a glimpse of a more detailed representation of customers' perceptions about a service quality element. Furthermore, the evaluation process of service quality elements classification will become more robust and consistent by minimising the degree of subjectivity from the evaluator. However, the drawback is that the calculation process will be more convoluted than the traditional one.

4. *Construct the fuzzy Kano mode* – Afterwards, based on relative information of service quality elements obtained above, the fuzzy Kano mode is defined as follows. Let U and V be the universal set of functional and dysfunctional questions, $X = \{X_1, X_2, \ldots, X_p\}$ and $Y = \{Y_1, Y_2, \ldots, Y_n\}$ be the sets of p and n linguistic variables on U and V, respectively, which jointly construct a $p \times n$ matrix of two-dimensional quality model.

5 *Classify service quality elements by FKM* – Being repeated above-mentioned steps, the classification of service quality elements will be obtained. Classification as M, O, A and I is also done in this step.

A sample of TKQ and FKQ questionnaire has been exhibited in Table 3 and it is elicited that in TKQ respondent has the possibility of choosing a single response. However, FKQ incorporates fuzzy logic in the Kano model and provides the flexibility to the respondent of marking multiple responses for each question. The response of functional and dysfunctional form of questions is summarised in two matrixes, M_P and M_N, respectively.

$$M_P = \{0.3, 0.7, 0, 0, 0\}$$

$$M_N = \{0, 0, 0.2, 0.2, 0.6\}$$

But as per the Kano methodology requirement, the M_P vector is transposed and is being multiplied with M_N row vector to get a 5 × 5 matrix which can be compared with the Kano evaluation table for further analysis. Table 3 shows the comparison of responses for the Kano model and FKM.

Table 3 Comparative response of Kano model and FKM

		Like	*Must-be*	*Neutral*	*Live with*	*Dislike*
The functional form of the question	Traditional Kano model	✓				
	Fuzzy Kano model	40%	60%			
Dysfunctional form of a question	Traditional Kano model				✓	
	Fuzzy Kano model			20%	20%	60%

As per the Kano methodology requirement, the M_P vector is transposed and is being multiplied with M_N row vector to get a 5 × 5 matrix which can be compared with the Kano evaluation table for further analysis. Multiplication of M_P and M_N results in the formulation of matrix S as shown in equation (1).

$$s = \begin{bmatrix} 0 & 0 & 0.8 & 0.8 & 0.24 \\ 0 & 0 & 0.12 & 0.12 & 0.36 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tag{1}$$

Elements of matrix s are then compared to elements of the Kano evaluation table for the determination of the degree of membership of each criterion for different quality attributes. Elements of the traditional Kano evaluation table have been exhibited in Table 2. After comparison with the Kano evaluation table, the membership degree for each quality attribute is summed and fuzzy set T is established as shown in equation (2).

$$T = \left(\frac{0.36}{M}, \frac{0.24}{O}, \frac{0.16}{A}, \frac{0.24}{I}, \frac{0}{R}, \frac{0}{Q} \right). \tag{2}$$

4.2 Total interpretive structural modelling

The basic motive of interpretive structural modelling (ISM) is to identify the relationship among the considered elements, which further leads to perceive the structure of the system in a better way (Linstone et al., 1979; Watson, 1978). In ISM, interpretation for nodes is usually accomplished by describing the respective element indicating it. However, interpretation of the links is restricted to the contextual relationship between elements and direction of their relationship in a pairwise comparison (Lee et al., 2011). To resolve this issue, the 'interpretive matrix' is developed as a managerial tool, which provides absolute interpretation for relationships in structural models (Dubey and Ali, 2014; Haleem et al., 2012; Jena et al., 2017). TISM is an upgraded qualitative modelling technique that is the recent extension of traditional ISM (Priyadarsini and Suresh, 2020; Mathivathanan et al., 2021). TISM is the extension of ISM. TISM is a process that transforms unclear and poorly articulated mental models of systems into visible and well-defined models (Chaple et al., 2021). A TISM approach has been used to prepare a structured hierarchical inter relationship-based model (Kinker et al., 2020). The TISM methodology has gained popularity due to its ability to solve complex issues based on discrete mathematics. It is evident that TISM methodology has been successfully used by various researchers in the fields like flexible manufacturing system (Jain and Raj, 2015; Dubey and Ali, 2014), productivity (Sandbhor and Botre, 2014), strategy execution (Srivastava and Sushil, 2013), telecom sector (Yadav, 2014), total quality management (Singh and Sushil, 2013), cloud computing (Sagar et al., 2013), pharmaceutical (Wasuja et al., 2012), education sector (Prasad and Suri, 2011) and strategic management (Nasim, 2011) as well (Sindhwani and Malhotra, 2017). However, in recent years, the TISM methodology has also attracted criticism from scholars due to a lack of consensus in terms of the level of confidence which may be attributed to the results due to variations in experts' opinions (Baliga et al., 2021).

The standard roadmap to TISM approach encompasses the following steps (Ben Ruben and Varthanan, 2019):

Step 1 identification and definition of elements

Step 2 determination of contextual relationship

Step 3 interpretation of relationship

Step 4 interpretive logic of pairwise comparison

Step 5 reachability matrix and transitivity test

Step 6 level determination by partitioning reachability matrix

Step 7 develop digraph

Step 8 interpretive matrix

Step 9 total interpretive structural model.

4.2.1 Limitations of ISM

1 ISM methodology can only be utilised by individuals who are familiar with it and able to deduce the information.

2 It only assists in providing answers to ‘what’ and ‘how’ in theory building. However, it stays quiet for the causality of linkages and thus unable to answer ‘why’ in theory building.

3 It does not consider transitive linkages in the digraph.

As the interpretation for direct linkages is comparatively weak in ISM, it may misrepresent the entire decision-making process. Consequently, a model based on the ISM approach can be upgraded to a TISM-based model. TISM is established as a decision modelling approach and used by many researchers in diversified fields (Rajan et al., 2021). The various characteristics of the TISM approach are as follows.

4.2.2 Characteristics of TISM

1 It is interpretive as the opinions of the experts’ group determine how the different elements are connected and why these are supposed to connect in that way.

2 It is a modelling technique, as the contextual relationships, the entire structure, and interpretation for direct as well as significant transitive linkages are depicted by a digraph model.

3 It assists in simply portraying a complicated system.

4 It is developed to overcome the key drawback of ISM, i.e., poor interpretation of the links, by employing an interpretive matrix.

5 It provides interpretation for both the links and nodes in the structural model.

5 Proposed methodology

The proposed methodology is developed for discovering the key barriers which have restricted the growth of technical education in Chhattisgarh state over the years. The flowchart of the proposed methodology is shown in Figure 2. The proposed approach comprises of five steps as follows.

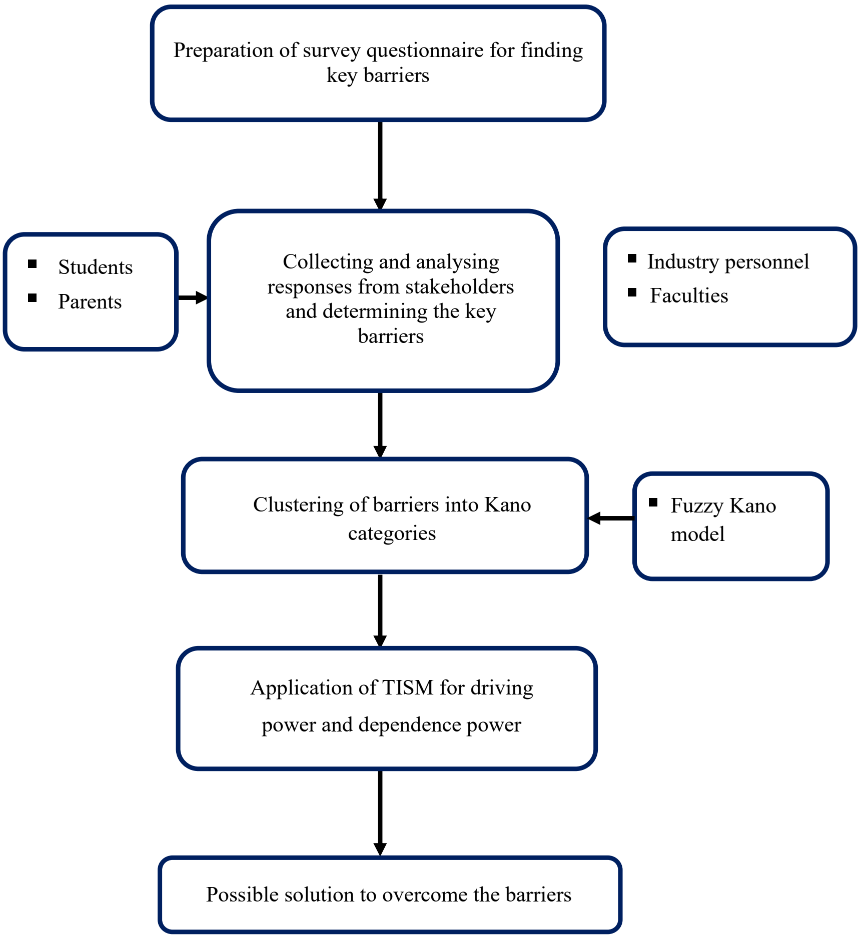
Step 1 Preparation of survey questionnaire for finding key barriers

In this step, a questionnaire will be prepared by the team under an expert and will be distributed among various departments of technical and non-technical higher education institutes for collecting responses. Few questions will be asked to find out the major key barriers in the growth of technical education in Chhattisgarh state.

Step 2 Collecting responses from stakeholders and determining the key barriers

In this step, all the responses will be collected from stakeholders and thoroughly analysed in presence of an expert. The data tool will be a questionnaire form and will be evaluated sincerely. In this study, eight key barriers or critical failure factors (CFFs) have been identified.

Figure 2 Flowchart of the proposed research methodology (see online version for colours)



Step 3 Clustering of barriers into Kano categories

Kano model is an instrument that has been widely used to perceive the voice of customer satisfaction. In this step, the key barriers will be clustered into the five Kano categories. The stakeholders will be approached for filling the Kano questionnaire with the provision of multiple responses.

Step 4 Application of TISM for drivers and dependence power

TISM model examines the logic behind the hidden relationship among the elements of the problem under study. This step will be considered as the advanced stage of ISM because ISM will not examine the logic behind the hidden interrelationships among the elements. In this step, the TISM approach is applied and the structural self-interaction matrix (SSIM), initial reachability matrix (IRM), final reachability matrix (FRM), and conical matrix and finally the digraph are developed.

Step 5 Possible solution to overcome the barriers

In this step, an attempt has been made to provide all possible solutions for the CFF identified in previous steps.

6 Application of the proposed methodology

The proposed methodology has been implemented in context with Chhattisgarh state for finding the key barriers for the growth of engineering education. All the steps were implemented sequentially and the details of each step of the proposed methodology are as follows.

Step 1 Preparation of survey questionnaire for finding key barriers

In the initial stages of the project, the team focused on preparing a comprehensive set of barriers through a survey at the state level. For this, a meeting has been conducted for brainstorming over some possible ways to conduct out the survey both in-house and outside the campus of the institute.

In the meetings, it has been decided that the survey should be comprehensive and should cover as large as large possible stakeholders for reliable results of the study. The members of the meeting have the opinion that the survey should be carried out in two ways:

1 one written

2 electronic/digital survey medium, i.e., Google Forms.

In our study, we have found eight key barriers from the digital survey conducted in various technical and non-technical colleges of Chhattisgarh state.

Data and samples

In this section, complete data and samples obtained from the survey across various institutes of Chhattisgarh state are presented. Figures 3 and 4 have given an insight into the targeted age groups, occupations, gender ratio during the survey and the contribution of various streams/branches focused during the survey at HS school, UG, PG, Diploma, PhD level along with other professionals of respective fields. Figure 3 shows the contribution of various technical and non-technical streams at both UG and PG level along with professionals based upon the no. of responses received. The maximum contribution has been from BE/BTech. The reason behind considering various branches has been to understand the viewpoint of students and professionals on the reasons that have attracted them to take a non-technical stream and how they have found their streams when compared to engineering. Apart from students, the survey has also collected valuable responses from parents, industry personnel and teaching staff of technical and non-technical educational institutions making the survey more diverse in its way.

The questions asked during the survey have come out with mixed responses with varying reasons put forward by no. of students for not going for the technical field. A variety of responses targeting various possible reasons and causes responsible for the decline in technical education's growth in Chhattisgarh state have been recorded.

Figure 3 Contribution of various streams during a survey for finding barriers (see online version for colours)

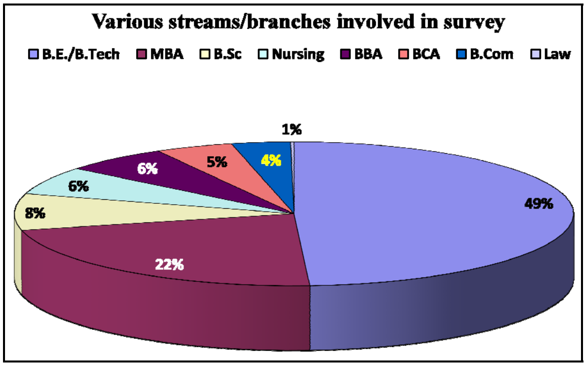
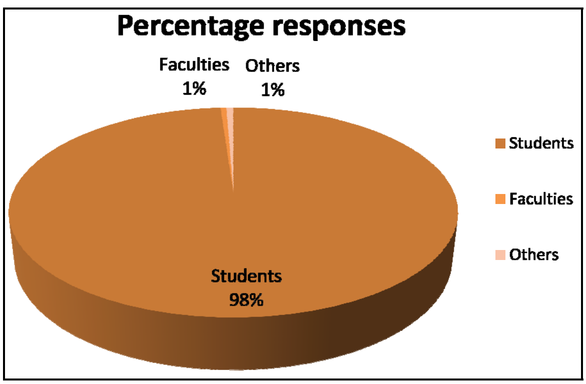


Figure 4 Occupations focused during the survey (see online version for colours)



The questions have been asked in such a manner that a particular candidate who is filling the form should be able to give a justified reason to the question on not choosing or choosing the technical stream, taking into consideration the possible causes being asked and also asking them the suitable suggestions they have felt to improve the current scenario of admissions in technical education in the state of Chhattisgarh.

6.1 Collecting and analysing responses from stakeholders and determining the key barriers

An extensive analysis and literature review have been done on the subject regarding quality improvement in technical education, many potential student requirements have been identified and these requirements have been discussed with a focus group comprised of four students. A questionnaire Google Form has been prepared. Nearly 400+ responses have been recorded and analysed by the members of the decision makers' team. The data tool has been questionnaire forms and has been evaluated sincerely. The data obtained has been tested using fuzzy Kano's model. Responses from different department students along with respective faculties have been considered for the same. The list of variables determined after analysing the responses is shown in Table 4.

Table 4 List of key barriers

CFF1	Lack of job opportunities
CFF2	More BPL families and economically challenged
CFF3	Present generation's interest is declining towards mathematics after matriculation
CFF4	Support of parents/guardians in nurturing talents from an early age
CFF5	Longer duration of BE/BTech programs
CFF6	Less inclination towards higher education
CFF7	No significant changes in the academic curriculum from years
CFF8	Lower packages offered to students in campus selections

6.2 Clustering of barriers into Kano categories

After the collection of responses, fuzzy Kano has been applied for the classification of CFFs into various Kano categories. The stakeholders have been approached for filling the Kano questionnaire with the provision of multiple responses. Applying the FKM evaluation table to the responses, the CFF has been classified into Kano categories. Four CFF are in must-be (M) category, three CFF are in the dimensional quality (O), and one CFF in the attractive quality (A) category (Table 5).

Table 5 Categorisation of variables into Kano categories

CFFs	*Description*	*Kano category*
CFF1	Lack of job opportunities	Must-be quality (M)
CFF2	More BPL families and economically challenged	Must-be quality (M)
CFF3	Present generation's interest is declining towards mathematics after matriculation	One-dimensional quality (O)
CFF4	Support of parents/guardians in nurturing talents from an early age	Attractive quality (A)
CFF5	Longer duration of BE/BTech programs	One-dimensional quality (O)
CFF6	Less inclination towards higher education	Must-be quality (M)
CFF7	No significant changes in the academic curriculum from years	One-dimensional quality (O)
CFF8	Lower packages offered to students in campus selections	Must-be quality (M)

6.3 Application of TISM for drivers and dependence power

The study has used a combined methodology of fuzzy Kano and TISM approach to come to a concluding proposed solution for the problem statement. Thus, the combined approach has included a literature review and experts' opinion in previous steps to identify and select the CFFs. In this step, TISM approach has been applied over CFF classified under attractive, must-be and one-dimensional Kano categories.

Table 6 Interpretive logic-knowledge-base

S. no.	*Enablers*	*Paired comparison of*	*Yes/no*	*In what way an enabler will influence/enhance another enabler? (reason in brief)*
1	E1-E8	Lack of job opportunities will influence lower packages offered to students in campus selections.	Y	Locally, there is deficiency of jobs in engg. in C.G. state which certainly leads to lower packages in campus selections and hence students are ready to take the jobs with even very low salary packages.
2	E8-E1	Lower packages offered to students in campus selections influences lack of job opportunities.	Y	Lower packages being offered to the students leads to a decline in the interest in job opportunities and expenses are not affordable. No chances of IT/software hubs to be created yet in near future.
3	E1-E7	Lack of job opportunities will influence no significant changes in academic curriculum from years.	N	No, significant changes in the academic curriculum is not influenced by the currently prevailing lack of job opportunities.
4	E7-E1	No significant changes in academic curriculum from years will influence lack of job opportunities.	Y	The existing academic curriculum doesn't match with today's industrial needs at all and as a result no new jobs can be created on the old curriculum being taught to thousands of students.
5	E1-E6	Lack of job opportunities will influence less inclination towards higher education.	Y	Parents are not ready to afford the expenditures of costly higher education knowing the unsafe future in jobs.
6	E6-E1	Less inclination towards higher education will influence lack of job opportunities.	Y	Decrease of students in some jobs due to additional qualifications required by the employers.
7	E1-E5	Lack of job opportunities will influence longer duration of BE/BTech programs.	N	Lack of job opportunities does not lead to longer duration of BE/BTech programs at all.
8	E5-E1	Longer duration of BE/BTech programs will influence lack of job opportunities.	N	Longer duration of BE/BTech programs at all does not lead to lack of job opportunities.
9	E1-E4	Lack of job opportunities will influence support of parents/guardians in nurturing talents from an early age.	N	Lack of job opportunities is not at all influenced by the support of parents/guardians in nurturing talents from an early age.
10	E4-E1	Support of parents/guardians in nurturing talents from an early age will influence lack of job opportunities.	N	Support of parents/guardians in nurturing talents from an early age does not lead to the lack of job opportunities.
11	E1-E3	Lack of job opportunities will influence present generation's interest is declining towards mathematics after matriculation.	Y	Over the years, students have found a decline in core jobs resulting in lack of interest in taking Mathematics as a major after matriculation and even no attractive packages in engineering.
12	E3-E1	Present generation's interest is declining towards mathematics after matriculation will influence lack of job opportunities.	N	Present generation's interest is declining towards mathematics after matriculation does not lead to lack of job opportunities.
13	E1-E2	Lack of job opportunities will influence more BPL families and economically challenged.	N	Lack of job opportunities does not lead to more BPL families and economically challenged.
14	E2-E1	More BPL families and economically challenged will influence lack of job opportunities.	N	As BPL and economically challenged families are involved more in unorganised sectors and hence does not lead to lack of job opportunities.

Table 6 Interpretive logic-knowledge-base (continued)

S. no.	*Enablers*	*Paired comparison of*	*Yes/no*	*In what way an enabler will influence/enhance another enabler? (reason in brief)*
15	E2-E3	More BPL families and economically challenged will influence present generation's interest is declining towards mathematics after matriculation.	N	This happens because they rely upon initial education only and later transform their kids into an earning member of family.
16	E3-E2	Present generation's interest is declining towards mathematics after matriculation will influence more BPL families and economically challenged.	N	Present generation's interest is declining towards mathematics after matriculation does not lead to more BPL families and economically challenged at all.
17	E2-E4	More BPL families and economically challenged will influence support of parents/guardians in nurturing talents from an early age.	Y	Since the family is living hand-to-mouth living hence, they cannot afford the expenditure of nurturing the talent of young ones from an early age.
18	E4-E2	The support of parents/guardians in nurturing talents from an early age will influence more BPL families and economically challenged.	N	Support of parents/guardians in nurturing talents from an early age does not lead to more BPL families and economically challenged at all.
19	E2-E5	More BPL families and economically challenged will influence longer duration of BE/BTech programs.	Y	Because BPL families cannot afford the costly education fee of engineering and that too paying high fee for four years is too hard for them.
20	E5-E2	Longer duration of BE/BTech programs will influence more BPL families and economically challenged.	N	Longer duration of BE/BTech programs does not lead to more BPL families and economically challenged.
21	E2-E6	More BPL families and economically challenged will influence less inclination towards higher education.	Y	Unable to meet expenditures of even graduation so not interested in going for higher education.
22	E6-E2	Less inclination towards higher education will influence more BPL families and economically challenged.	N	Less Inclination towards Higher Education doesn't lead to more BPL families and economically challenged.
23	E2-E7	More BPL families and economically challenged will influence no significant changes in academic curriculum from years.	N	More BPL families and economically challenged does not lead to no significant changes in academic curriculum from years.
24	E7-E2	No significant changes in academic curriculum from years will influence more BPL families and economically challenged.	N	No significant changes in academic curriculum from years do not lead to more BPL families and economically challenged.
25	E2-E8	More BPL families and economically challenged will influence lower packages offered to students in campus selections.	N	More BPL families and economically challenged does not lead to lower packages offered to students in campus selections.
26	E8-E2	Lower packages offered to students in campus selections will influence more BPL families and economically challenged.	Y	As they would not expect any progress in life with a lower package hence they never get interested in moving for graduation in technical field.
27	E3-E4	Present generation's interest is declining towards mathematics after matriculation will influence support of parents/guardians in nurturing talents from an early age.	Y	As nowadays, parents support children in nurturing talents in various fields like art, sports, music, etc. and allow them to pursue their career in the field of their talent.
28	E4-E3	Support of parents/guardians in nurturing talents from an early age will influence present generation's interest is declining towards mathematics after matriculation.	Y	Making career in the field of interest and talent is given due weightage by the parents.

Table 6 Interpretive logic-knowledge-base (continued)

S. no.	*Enablers*	*Paired comparison of*	*Yes/no*	*In what way an enabler will influence/enhance another enabler? (reason in brief)*
29	E3-E5	Present generation's interest is declining towards mathematics after matriculation will influence longer duration of BE/BTech programs.	N	Present generation's interest is declining towards mathematics after matriculation does not lead to longer duration of BE/BTech programs.
30	E5-E3	Longer duration of BE/BTech programs will influence present generation's interest is declining towards mathematics after matriculation.	N	Longer duration of BE/BTech programs does not lead to present generation's interest is declining towards mathematics after matriculation.
31	E3-E6	Present generation's interest is declining towards mathematics after matriculation will influence less Inclination towards higher education.	N	Present generation's interest is declining towards mathematics after matriculation does not lead to less inclination towards higher education.
32	E6-E3	Less inclination towards higher education will influence present generation's interest is declining towards mathematics after matriculation.	N	Less inclination towards higher education does not lead to present generation's interest is declining towards mathematics after matriculation.
33	E3-E7	Present generation's interest is declining towards mathematics after matriculation will influence no significant changes in academic curriculum from years.	Y	Due to no significant changes in curriculum students think of not choosing a tough subject even when there exists less opportunities after studying so much.
34	E7-E3	No significant changes in academic curriculum from years will influence present generation's interest is declining towards mathematics after matriculation.	Y	They feel that unless a change is made in the old curriculum, there are no more new job opportunities and as a result better to take non-tech with almost same package and less effort.
35	E3-E8	Present generation's interest is declining towards mathematics after matriculation will influence lower packages offered to students in campus selections.	N	Present generation's interest is declining towards mathematics after matriculation does not lead to lower packages offered to students in campus selections.
36	E8-E3	Lower packages offered to students in campus selections will influence present generation's interest is declining towards mathematics after matriculation.	Y	Students find same level of packages being offered even to non-tech students and henceforth they find it unnecessary to take subjects like mathematics.
37	E4-E5	Support of parents/guardians in nurturing talents from an early age will influence longer duration of BE/BTech programs.	N	Support of parents/guardians in nurturing talents from an early age does not lead to longer duration of BE/BTech programs.
38	E5-E4	Longer duration of BE/BTech programs will influence support of parents/guardians in nurturing talents from an early age.	N	Longer duration of BE/BTech programs does not lead to support of parents/guardians in nurturing talents from an early age.
39	E4-E6	Support of parents/guardians in nurturing talents from an early age will influence less inclination towards higher education.	Y	Nurturing in an early age in other fields of interest like music, art, etc. declines inclination in technical field and higher education in the same.
40	E6-E4	Less inclination towards higher education will influence support of parents/guardians in nurturing talents from an early age.	Y	For rich and BPL families skills and talent is given more preference to higher education in technical field.
41	E4-E7	Support of parents/guardians in nurturing talents from an early age will influence no significant changes in academic curriculum from years.	N	Support of parents/guardians in nurturing talents from an early age does not lead to no significant changes in academic curriculum from years.

Table 6 Interpretive logic-knowledge-base (continued)

S. no.	*Enablers*	*Paired comparison of*	*Yes/no*	*In what way an enabler will influence/enhance another enabler? (reason in brief)*
42	E7-E4	No significant changes in academic curriculum from years will influence support of parents/guardians in nurturing talents from an early age.	Y	Since over the years, parents have observed that the current academic curriculum in engineering is not making their warden industry ready hence any good salary and job is not found.
43	E4-E8	Support of parents/guardians in nurturing talents from an early age will influence lower packages offered to students in campus selections.	N	Support of parents/guardians in nurturing talents from an early age does not lead to lower packages offered to students in campus selections.
44	E5-E6	Longer duration of BE/BTech programs will influence less inclination towards higher education.	Y	The long and costly education in UG level of engineering certainly declines the interest in students for opting higher education against jobs.
45	E6-E5	Less inclination towards higher education will influence longer duration of BE/BTech programs.	N	Less inclination towards higher education does not lead to longer duration of BE/BTech programs.
46	E5-E7	Longer duration of BE/BTech programs will influence no significant changes in academic curriculum from years.	N	Longer duration of BE/BTech programs does not lead to no significant changes in academic curriculum from years.
47	E7-E5	No significant changes in academic curriculum from years will influence longer duration of BE/BTech programs.	Y	No significant changes in the academic curriculum from years does not lead to longer duration of BE/BTech programs.
48	E5-E8	Longer duration of BE/BTech programs will influence lower packages offered to students in campus selections.	N	Longer duration of BE/BTech programs does not lead to lower packages offered to students in campus selections.
49	E8-E5	Lower packages offered to students in campus selections will influence longer duration of BE/BTech programs.	N	Lower packages offered to students in campus selections does not lead to longer duration of BE/BTech programs.
50	E6-E7	Less inclination towards higher education will influence no significant changes in academic curriculum from years.	Y	Less inclination towards higher education results in decrease in no. of seats and engg. institutes in recent years and hence least emphasis is laid on change in academic curriculum.
51	E7-E6	No significant changes in academic curriculum from years will influenceless inclination towards higher education.	Y	As students feel that due to lack of job opportunities and not a great hike in package, it is waste of time and money to opt for higher education.
52	E6-E8	Less inclination towards higher education will influence lower packages offered to students in campus selections.	Y	Decrease in no. of seats in engg. institutions somewhere affects competence among the few students left that result in low packages.
53	E8-E6	Lower packages offered to students in campus selections will influence less inclination towards higher education.	Y	Lower packages even after completing higher education declines the interest of students in it.
54	E7-E8	No significant changes in academic curriculum from years will influence lower packages offered to students in campus selections.	Y	Because in today's rapidly changing and developing technology, no change in the old curriculum leaves an engineering student unskilled and he has to thereafter satisfy with any lower package he gets in campus selection.
55	E8-E7	Lower packages offered to students in campus selections will influence no significant changes in academic curriculum from years.	N	Lower packages offered to students in campus selections does not lead to no significant changes in academic curriculum from years.

Thus, the logic behind the paired relationships has been interpreted in the form of 'interpretive logic-knowledge-base', and the results of paired comparison and interpretation related to the enablers of our case study have been shown in Table 6.

6.3.1 Development of SSIM

The SSIM for assessing LSS-CFFs for implementing the LSS framework has been developed based on expert's opinions. In this, various techniques have been used such as brainstorming, interview, and nominal group techniques, to develop a contextual relationship among identified CFFs. The relationship has been obtained through ISM principles. The four symbols have been used to create the relation between CFFs.

Thus, symbol 'V' represents the variable 'i' will help to achieve variable 'j', symbol 'A' represents the variable 'j' will help to achieve variable 'i', symbol 'X' represents the variable 'i' and 'j' will help to achieve each other, and symbol 'X' represents the variable 'i' and 'j' are unrelated (Table 7).

Table 7 VAXO model for the problem

	CFF8	*CFF7*	*CFF6*	*CFF5*	*CFF4*	*CFF3*	*CFF2*	*CFF1*
CFF1	X	A	A	O	O	V	O	-
CFF2	A	O	V	V	V	O	-	
CFF3	A	X	O	A	X	-		
CFF4	A	A	X	O	-			
CFF5	O	O	X	-				
CFF6	X	X	-					
CFF7	X	-						
CFF8	-							

Table 8 IRM for assessment of CFFs

	CFF1	*CFF2*	*CFF3*	*CFF4*	*CFF5*	*CFF6*	*CFF7*	*CFF8*
CFF1	1	0	1	0	0	1	0	1
CFF2	0	1	0	1	1	1	0	0
CFF3	0	0	1	1	0	0	1	0
CFF4	0	0	1	1	0	1	0	0
CFF5	0	0	1	0	1	1	0	0
CFF6	1	0	0	1	1	1	1	1
CFF7	1	0	1	1	0	1	1	1
CFF8	1	1	1	1	0	1	0	1

6.3.2 Development of IRM

The IRM has been developed with the transformation of SSIM symbols into binary digits. The transformation process depended on the following rules has based on ISM principles (Table 8):

Rule 1 If (‘i’, ‘j’) entry in the system is ‘V’, then the (‘i’, ‘j’) entry in the IRM becomes ‘1’ and ‘0’ when (‘j’, ‘i’).

Rule 2 If (‘i’, ‘j’) entry in the system is ‘A’, then the (‘i’, ‘j’) entry in the IRM becomes ‘0’ and ‘1’ when (‘j’, ‘i’).

Rule 3 If (‘i’, ‘j’) entry in the system is ‘X’, then the (‘i’, ‘j’) entry in the IRM becomes ‘1’ and ‘1’ when (‘j’, ‘i’) also.

Rule 4 If (‘i’, ‘j’) entry in the system is ‘O’, then the (‘i’, ‘j’) entry in the IRM becomes ‘0’ and ‘0’ when (‘j’, ‘i’) also.

6.3.3 Development of FRM

After the VAXO model and IRM have been prepared, the FRM, a binary matrix where the VAXO model has been converted into 1 and 0. The FRM has been developed after checking the transitivity which has occurred during the development of IRM and has been removed that if there has been any.

From the FRM, for each factor, reachability set and antecedent sets have been derived. The reachability set has consisted of the factor itself and the other factor that it may impact, whereas the antecedent set has consisted of the factor itself and the other factor that may impact it. Thereafter, the intersection of these sets has been derived for all the factors and levels of different factors have been determined (Table 9).

Table 9 FRM (IRM) for assessment of CFFs

	CFF1	*CFF2*	*CFF3*	*CFF4*	*CFF5*	*CFF6*	*CFF7*	*CFF8*	*Driving power*	*Rank*
CFF1	1	0	1	0	0	1	0	1	4	2
CFF2	0	1	0	1	1	1	0	0	4	2
CFF3	0	0	1	1	0	0	1	0	3	1
CFF4	0	0	1	1	0	1	0	0	3	1
CFF5	0	0	1	0	1	1	0	0	3	1
CFF6	1	0	0	1	1	1	1	1	6	3
CFF7	1	0	1	1	0	1	1	1	6	3
CFF8	1	1	1	1	0	1	0	1	6	3
Dependence power	4	2	6	6	3	7	3	4		
Rank	3	1	4	4	2	5	2	3		

6.3.4 Level partition

The partitions in different levels have been done based on the reachability and antecedent set. The reachability and antecedent set has been obtained from the FRM. In this step, the level partitions of variables under consideration have been performed to understand the level-wise placement of variables.

Thus, in this case, a total, five iterations (five levels) have been performed (Table 10).

Table 10 Iteration results for assessment of CFFs

Sr. no.	*Reachability set*	*Antecedent set*	*Intersection set*	*Level*
1	1, 3, 6, 8	1, 6, 7, 8	1, 6, 8	
2	2, 4, 5, 6	2, 8	2	
3	3, 4, 7	1, 3, 4, 5, 7, 8	3, 4, 7	1
4	3, 4, 6	2, 3, 4, 6, 7, 8	3, 4, 6	1
5	3, 5, 6	2, 5, 6	5, 6	
6	1, 4, 5, 6, 7, 8	1, 2, 4, 5, 6, 7, 8	1, 4, 5, 6, 7, 8	1
7	1, 3, 4, 6, 7, 8	3, 6, 7	3, 6, 7	
8	1, 2, 3, 4, 6, 8	1, 6, 7, 8	1, 6, 8	

6.3.5 Development of conical matrix

The conical matrix has been developed by clustering the CFFs of the same level across rows and columns. The arrangement of those levels in the conical matrix has been based on their occurrence in the iteration steps. The drive power of a factor has been derived by summing up the number of ones in the rows and its dependence power by summing up the number of ones in the columns. The conical matrix for this study has been shown in Table 11.

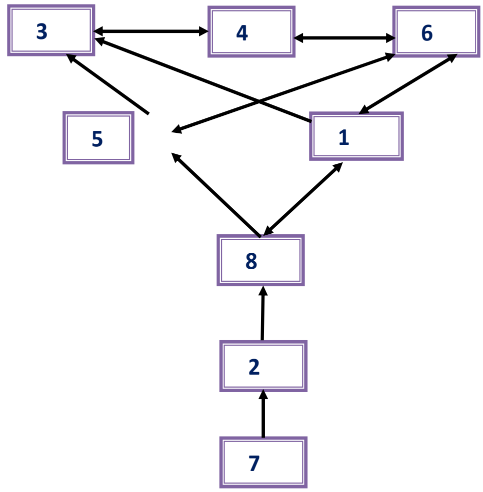
Table 11 Conical matrix for assessment of CFFs

	CFF3	*CFF4*	*CFF6*	*CFF1*	*CFF5*	*CFF2*	*CFF7*	*CFF8*
CFF3	1	1	0	0	0	0	0	1
CFF4	1	1	1	0	0	0	0	0
CFF6	0	1	1	1	1	0	1	1
CFF1	1	0	1	1	0	0	1	0
CFF5	1	0	1	0	1	0	0	0
CFF2	0	1	1	0	1	1	0	0
CFF7	1	1	1	1	0	1	1	0
CFF8	1	1	1	1	0	0	1	1

6.3.6 Development of digraph

After removing the indirect links, a final digraph has been developed. A digraph has been used to represent the elements and their interdependencies in terms of nodes and edges or other words digraph has been the visual representation of the elements and their interdependence (Figure 5). In this development, the top-level factor has been positioned at the top of the digraph and the second-level factor has been placed at the second position and so on until the bottom level has been placed at the lowest position in the digraph.

Figure 5 Digraph of the proposed model (see online version for colours)



The detailed explanation based on the digraph for the various levels is as:

- CFF7 → CFF2

  As shown in the digraph CFF7 (highest driving power), i.e., no significant changes in curriculum for years affects CFF2 as most of the BPL families have a set ideology that the present curriculum for technical education does not meet today's industrial requirements therefore if the BPL children continue the same education, they are unable to get good jobs/perks in today's scenario and their BPL status continues and may worsen in some cases. And the result is their domination by the BPL burden.

- CFF2 → CFF8

  The students hailing from BPL families get admission in technical courses easily due to some concessions and government schemes and somehow complete the four years but still, they are not capable of getting good internships as well as additional interdisciplinary courses due to lack of investment, failing the necessary skill set to be embodied into them as required by today's industrial sector. Thus, if the student gets a job from campus placement, the CTC/packages are not high.

- CFF8 → CFF5

  Being offered lower packages during the campus placements in the above context, an atmosphere is created in the minds of students and their families that such a long duration of BE/BTech course is not worthy rather some other vocational or technical courses of shorter duration may be a better choice.

- CFF5 → CFF3

  The longer duration of technical courses has certainly decreased the interest of the present generation in mathematics after matriculation. Hence, the students are opting for other courses such as CA, ICWA, mass communication, etc.

- CFF5 → CFF6

  The longer duration of technical courses at the UG level has led the present generation towards shorter and skilful technical courses resulting in a decline in their interest in technical higher education. Students feel that even after spending four years at the UG level is not enough for getting a good job with a high salary then why waste two more years and invest more money when no such special hike will take place.

- CFF8 → CFF1

  Lower packages offered to the students in campus placement leave them open to accept these jobs since no big core companies are interested in Chhattisgarh that offer jobs with handsome packages resulting in a lack of job opportunities for the students of this state.

- CFF1 → CFF8

  Due to the undergoing recession in engineering industries, there is a lack of job opportunity and today COVID-19 has also made conditions worst. Therefore, in such a situation the students have to satisfy with a lower package and at the same time industries also do not have better job opportunities. Therefore, industries also hire students at low packages.

- CFF1 → CFF3

  Lack of job opportunities with good packages in the above context has decreased the student's interest and opting mathematics (PCM) after matriculation, rather they prefer non-tech streams.

- CFF1 → CFF6

  The lack of job opportunities with handsome packages after completion of a long duration of higher technical education has certainly declined the interest of the present generation towards higher education. Another significant factor is the lack of availability of institutes of higher repute in the state.

- CFF6 → CFF1

  Due to less inclination towards higher technical education with longer duration and in absence of additional skills or courses at postgraduation level has created the lack of job opportunities.

- CFF4 → CFF6

  The support of parents or guardians to their wards in nurturing them from an early age has left them free for opting courses in music, sports, dancing, and other fields of talent, which has resulted in lesson inclination towards higher technical education.

- CFF6 → CFF4

  Less inclination towards has technical education has resulted in the fact that the parents/guardians today are ready to nurture their wards from an early age for other activities/talents/courses.

- CFF3 → CFF4

  The decline in interest of today's generation towards mathematics (PCM) and Science, Technology, Engineering and Maths (STEM) after matriculation has motivated the parents/guardians to promote their wards to opt for other activities/courses as per their choice/talent.

- CFF4 → CFF3

  The changing mentality of parents/guardians today starts to nurture their children from an early age in different activities/talents of their choice has certainly declined the interest in opting Mathematics after matriculation a want simply to complete their matriculation education with easy-going subjects like arts, commerce, etc. As the mindset of the student is that opting mathematics will consume not only high time of day but also require enormous efforts which will hinder their progress in the field of their choice, e.g., music, sports dance, etc.

7 A possible solution to overcome the barriers

As per the study of Section 4.4 of Section 4 on how the lower level has been affecting the top level, some possible solutions have been provided in this section with a solution to each CFF being discussed in detail below.

7.1 CFF1 – lack of job opportunities

Although formed in 2001, still today Chhattisgarh state is seen as an agro-economy-based state with the least consent given by governments upon advancement in industry and quality of education being provided. Nearly 19 years have passed since its formation day and even today no IT hub has been created, no special economic zones (SEZs), no collaborations made with big industrial giants yet, no focus has been put over the improvement of infrastructure as per industrial demands in today's date in the already made engineering institutes as discussed in Section 2 of this study.

The state government especially the Ministry of Higher Education of Chhattisgarh and Skill Development, Science and Technology, DTE should come together on a common platform and focus on rigorous industrial growth to create a better no. of job opportunities and the government should also look for the necessary amendments and creation of new employment generation schemes like Sampoorna Gramin Rozgar Yojana (SGRY), Swarnajayanti Gram Swarozgar Yojana (SGSY), National Rural Employment Programme (NREP), Rural Landless Employment Guarantee Programme (RLEGP), Integrated Rural Development Programme (IRDP), etc. not only for rural areas but also generate new and worthy employment opportunities for all the budding and passed out engineers of the state. Also, the government needs to focus on opening new industries.

7.2 CFF2 – economically challenged people and government schemes

Today, many government schemes under the Government of India and Social Welfare Department, Government of Chhattisgarh have been made and implemented to assist the BPL families like National Family Assistance Scheme (NFAS), PM Ujjwala Yojana

(PMUY), Noni Suraksha Yojana, Jawahar Utkarsh Yojana, etc., but still no significant uplift has been observed in the financial status of BPL families resulting in no decrement in BPL numbers. To overcome this BPL status, its necessary for children and working members of the family to undergo various skill development courses provided by the government to transform themselves into skilled labour, and their children need to go for education at least up to UG level so that significant progress can happen in their life leading to an uplift in financial status and decrease in BPL families of the state.

Also, it has been observed that scholarships being provided to children of BPL families are not enough to meet today's demands. For an instance in states like Karnataka and Madhya Pradesh even male children of BPL families are given great financial support under education assistance schemes (scholarship matching the annual fee of HEI). Therefore, the think tanks of the state government need to implement better schemes as per current situations regardless of the gender of children and also make necessary timely amendments as per the economic situation.

7.3 CFF3 – present generation's interest is declining towards mathematics after matriculation

There is no denying fact that today's primary and engineering education too has become more of rote learning and passing examinations by mugging up theoretical concepts with least importance to practical knowledge as compared to the foreign educational institutes and deemed universities. Due to this, the required qualities/skills set to become industry ready are not inculcated in the students and over some time it has been also observed that students have become lethargic and do not wish to choose subjects/courses demanding a high level of efforts and even many have a fear for mathematics. As a result of this, the students after matriculation incline more towards simple courses offering less practical and more of the theory which they find easy to tackle. This is also evident in almost all government and private schools of Chhattisgarh state as no. of sections of mathematics (PCM) have decreased over the decade passed and this can only be improved again by proper changes in school syllabus and more interactive teaching methods especially for career-making subjects like mathematics to increase the interest level of students towards it.

7.4 CFF4 – support of parents/guardians in nurturing talents from an early age

Over the years of its formation of Chhattisgarh state, the families have become economically sound and therefore parents/guardians are ready to bear the financial risk. Thus, they promote their wards towards the fields of talent. It is also to be noted that it's not wrong to encourage your wards towards some other curricular activities/courses but it is to be understood that not everyone can become an artist and hence there is an alarming need for all the family is to understand that they should try to encourage the innovative and creative nature of their child in whatever field he is good at and aim for transforming their mindset into not only artistic fields nut also towards entrepreneurship so that not only he/she gets a stable life but also becomes a job provider. Under the Start-up India Campaign launched by the Government of India was first addressed by Hon'ble Prime Minister in his 15 August 2015 address and motivated the youth to become a job provider rather than just being a job seeker.

7.5 CFF5 – longer duration of BE/BTech programs

Many young students who enter the field of engineering education have found that the four year BE/BTech programs in any discipline/branch takes a lot of time in comparison to other the nation's prestigious institutes, the IIT has been awarding award four years BTech degree in 3.5 years, from the year 2016. IITs are planning to introduce a new credit score system, which replaces the current four-year BTech degree with a 3.5-year degree from the academic year 2016–2017. IIT Kharagpur Director Dr. Partha Pratim Chakrabarti has announced this credit scores system. Following the US system, IITs plan to give time to the students to complete the BTech program in a time frame. As per the US credit score system, a credit score is a number representing the creditworthiness of a particular person on a particular course. According to this, a four-year course can be completed in 3.5 years. Hence, students can use the remaining six months for entrepreneurship. This system should also be applied in universities affiliated with AICTE and UGC.

Recently, keeping in view the latest industry trends, digital economy, and market requirements, the curriculum revision is made by AICTE after collecting input from all the key stakeholders of the management identified the six key learning outcomes of MBA/PGDM programs as they felt there is a need to prepare MBA/PGDM students for a volatile uncertain, complex and ambiguous (VUCA) world. So apart from the core and elective courses few additional vital programs (with appropriate credits) like MOOC courses, industry or academic internships, global virtual team project, etc. have been added to the curriculum. In mechanical engineering to specialisation in mechatronics is being provided in the new curriculum. Such changes in the old and traditional curriculum into an industry-oriented curriculum are the need of the hour.

7.6 CFF6 – less inclination towards higher education

Although there have been enough stipend schemes, e.g., in MTech through GATE, and other PG courses but still over the past few years, it has been observed that there is a decline in interest towards technical higher education and this issue can only be resolved when the mindset of the student is changed and is motivated for studying hard. Apart from this, it is also necessary that several significant changes should be made in the current curriculum of technical higher education so that it should also become industry-oriented unlike the upgradations sat the UG level and this certainly will keep the enthusiasm into the student's mindset pursuing higher education and hence they will not be gripped in the fear of job opportunities.

7.7 CFF7 – no significant changes in the academic curriculum from years

It has been observed that unlike foreign universities the Indian universities do not practice the review system to make necessary and timely changes in the curriculum. Also, professors are set free to teach their students the latest trending courses as per their industrial demands, but sadly it does not happen in Indian state government-owned universities. The suggestive measures for this problem are as follows:

1 The academic curriculum of universities should be reviewed in every 2 to 3 years by a special board at both the central and state level.

2 The board should include experts from all major technical branches, management, and also industry experts with immense experience in their fields. The board should be given the right to amend as well as make a new curriculum after review.

3 The colleges should be set at least 50% free to teach the subjects they feel worthy enough as per industrial needs. The colleges should also be given the provision to select any interdisciplinary course from the list of optional courses created by the board as discussed in the above point.

4 As per the latest change made by AICTE in the curriculum which provides the engineering students to go for internships right from the first year of engineering is certainly being expected by all to be a positive step in facing the challenges in engineering education and jobs.

7.8 CFF8 – lower packages offered to students in campus selections

As per the ongoing traditional atmosphere of most of the engineering colleges, there is very little probability for the student to get embodied with the right skills set as demanded by today's industries even in the long duration of four years. As a result, no big industrial giants are attracted for neither pool placements nor off-campus placements in the state. Thus, the namesake institutes invite companies with low pay scales just to show the placement figures. As a result of this students, either do not join the job or else even if few of them join they work under worse conditions and feel unsatisfied and at the end leave the job after a couple of months.

The suggestive measures for this problem are as follows.

National Board of Accreditation (NBA) has been accorded permanent signatory status of the Washington Accord on 13th June 2014. As per the Washington Accord Agreement, recognition of programs by other signatories applies only to programs accredited by NBA that are offered by education providers accepted by NBA.

According to Washington Accord, 12 program outcomes (POs) should be inculcated in each engineering graduate at the end of four years. And if these POs are not inculcated, then the graduate engineer cannot be even recognised at the national level. Therefore, all the engineering colleges are required to make their students realise the importance of these POs as early as possible and teach and shape them accordingly:

1 The institute should encourage the teaching staff and all students to be competent and professors should go through faculty development programs (FDPs) regularly and students should also go through the courses of MHRD platforms like Swayam or NPTEL. A set target of completing at least one course in each semester should be made to raise the competency and knowledge level in students and faculties to obtain necessary certifications for specialisation in respective fields.

2 All engineering institutes should open the centre of excellence (COE), sign-up memorandum of understanding (MOU) with core industrial giants and organise timely workshops and training sessions and keep them open to all faculties and students. Also, industry-funded labs should be opened and industrial experts should come to provide hands-on training experience.

3 The engineering institutes should provide the latest international and national journals regarding engineering and be updated with the latest advancements happening in technology and should be encouraged by faculties to create more projects and build relevant skills.

4 The institutes should not only focus upon the academics of students but also on the overall personality development of budding engineers. For this, institutes should hire professionals of personality development and assign lectures every week or month. Also, timely workshops should be organised by experts of PD, and institutes should ensure maximum participation and motivate them to improve themselves.

5 Special attention should be given to improve the communication skills of all the students right from the beginning of their engineering education. To maintain the competence and enthusiasm among the students' language clubs should be made and regular competitions at inter-section, inter-branch, and campus-level should be organised.

8 Conclusions

NEP 2020 aims at overhauling and re-energising of the HES for redesigning and overhauling ass the HES suffering from fragmented ecosystem, less development of cognitive skills and learning outcomes, a rigid disseverment of disciplines, with early specialisation and streaming of students into narrow areas of study, limited access to socio-economically disadvantaged areas, with few HEIs teaching in local languages, etc. These challenges can only be met when the students are opting STEM courses after matriculation. Decline of students in STEM and thereafter in engineering courses will adversely affect the objectives of NEP. Further, the decreasing inclination of the youth towards engineering education is a major concern for the country's innovation plans also. The purpose of this study is to identify the expectations and the barriers from the student's perspective in the context of socio-economic and technical aspects.

In this work, the gap between the conceptions and expectations of the students was analysed to identify the most significant attributes of quality as the voice of the customer with a survey. After the survey, eight key barriers are identified and classified with the FKM under three categories: attractive, one-dimensional and must-be. Further, the TISM approach has been applied for devising a hierarchical structure based on driving and dependence power. The outcome of the work facilitates the policymakers to make decisions to mitigate the barriers. The effective steps and effective monitoring can assist in increasing the interest of youths in engineering education which can leverage the government missions like 'Aatmanirbhar Bharat' (Self-Reliant India) and objectives of NEP 2020. Other than the fulfilment of these requirements, we may step towards the promotion of improved quality education to transform students into industry-ready candidates as suggested in this study and enhancing the gratification of students.

9 Future scope of work

This work opens new avenues for researchers and academicians for future work. The future scope of this work can be determination of more barriers for engineering education by considering the scenario of other states of India. Researchers are encouraged to analyse these barriers and come out with concrete solutions for the removal of barriers. Further, as future work analytic network process (ANP), a more general form of the analytic hierarchy process (AHP) used in multi-criteria decision analysis can be used to find out the solution in network form. Futuristic techniques such as artificial neutral network (ANN) can be applied to have an in-depth analysis the researchers are encouraged to apply various heuristic techniques to the model and compare the results for building a more robust methodology. This work has been done in context of HEI. However, the researchers are encouraged to apply the work in finding the barriers of the students which restrict them from opting the STEM courses at the very beginning. Further, the work provides a foundation for the academician's to identify the educational barriers in their respective domains such as commerce, arts and can have a better and deep insight of the education scenario. This will help them to make plans and policies for imparting quality education in all the domains of higher education.

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