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Criterion Weights for Knowledge Management Integrated Quality Accreditation System for Indian Engineering Education Using Analytical Hierarchy Process

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The engineering education system of India is becoming more and more complex due to various reasons like unmanageable number of colleges affiliated to universities, wide spectrum of student quality, multi-boss system in management and conflicting interests of stakeholders. Ever since the Accreditation board of engineering and technology (ABET) of US, Malcolm Baldrige National Quality Award (MBNQA) of US and European Foundation for Quality Management (EFQM) of UK have been established, many other countries have developed their own version of national quality award (NQA) and accreditation systems. These NQAs and accreditation systems tend to follow the general framework of the MBNQA or ABET or EFQM with different emphases on criterion. Since MBNQA has a prominent knowledge management (KM) component in it and EFQM has a strong mechanism of measuring outcomes/results, it is attempted to develop a robust framework for Knowledge Quality Management (KQM) by integrating KM and outcome components into it using systems theory. Towards this, all possible attributes and indicators to study the interaction and interrelationship of various enablers and results have been identified. In order to assign weights to the identified system variables (Enablers and Results), responses were taken electronically on a pre-defined Excel template and weights are calculated by applying AHP method.

Keywords: Accreditation, Knowledge Management, Quality Management, AHP.

1. Introduction

Higher education in general, and engineering education in particular, as it has a direct bearing on the economy of the country, has been proliferated. But maintaining a balance between supply and demand is always a challenging task. Unless the engineering institutes produce engineers who are employable in the market or be entrepreneurs, most of the engineering institutes will be mere unemployment producing centres. Engineering education system is of paramount importance in generating the technical manpower required for building a strong nation. The demand has resulted in setting up of a large number of colleges in India, offering a variety of programs to meet the demand. With the ongoing liberalization and globalization of the economy, more and more foreign

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universities/institutes are entering into joint ventures with Indian universities/institutes. For this purpose, an attempt was made to propose effective knowledge performance measures, corresponding enablers and inhibitors.

The approaches and methods adopted to resolve these issues are very important in this situation, for the maintenance and improvement of quality standards of engineering education. A study of the present assessment methods of engineering programs such as Accreditation Board for Engineering and Technology (ABET) of US, National Board of Accreditation (NBA) of India, Malcolm Baldrige National Quality Award (MBNQA) of US, European Foundation for Quality Management (EFQM) of UK has been undertaken in this connection to analyze and compare their capabilities in promoting quality in engineering education. The methods based on the linear thinking and mental models of policy makers and administrators are insufficient to analyze the performance related issues of Indian engineering education system. The insights based on the studies on accreditation processes and also the quality award excellence models of various other countries such as ABET, MBNQA, EFQM etc. motivated us for research towards KM based Quality Management.

Engineering education system is a growing field and to strengthen the system there is a need to effectively assess various engineering institutions. The identification of strong and weak functions (components) is important for quality education to achieve higher standards through continuous improvement. The integration of KM and Quality in engineering education seems to be critical. It is attempted to develop a self assessing tool for Quality in Engineering education by incorporating systems theory and integrating KM as seen in MBNQA, EFQM and ABET. Applying knowledge to decision making has a significant impact on organizational performance than solely processing transactions for KM. Looking at the very complex nature of knowledge as well as quality management issues in Indian engineering education system, and to study the dynamics it is envisaged that the method of System dynamics can be used.

As Vishwanadhan (2008) pointed out, the following issues may lead to deleterious effects in the Indian Engineering Education system (IEES).

- Wide spectrum of student quality
- Lack of experienced faculty and their quality
- Mushrooming of colleges
- Location of colleges in remote places with non-proximity of industries
- Unmanageable number of colleges affiliated to a single university
- Multi-boss system-AICTE, state government, university and management
- Lack of appropriate performance measures
- Conflict about indicators of quality among experts
- Lack of proper methods of collecting, storage and analysis of information.
- Inadequacy of accreditation process to:
    - Make consensus about the validity of the process
    - Encourage continuous improvement.

The author has also presented the analysis and assessment capabilities of present NBA process of engineering programs to strengthen this argument. This paper contains sections like Literature Review, Problem on hand, Analytical Hierarchy Process, Research issues and Conclusions discussed hereunder.

2. Literature Review

Engineering institutions are basically the knowledge repositories which exist to equip the future engineers with required level of competence by imparting the underpinning knowledge, skills, attitudes, values, ethics and all other characteristics demanded by the engineering profession. Hence, the institutes should be equipped to transfer both 'explicit' and 'tacit' knowledge (Nonaka and Takeuchi, 1995) to the future engineers. The review of literature covered various facets of the technical education and is presented in brief hereunder.

2.1 Quality Excellence Models and Frameworks

Ever since the Malcolm Baldrige National Quality Award (MBNQA) was established in 1987 after the Deming prize, many other countries have developed their own version of a national quality award (NQA). These NQAs tend to follow the general framework of the MBNQA with different emphases on criteria items such as leadership, customer focus, resource management and impact on society. Ten major national quality awards (three European, two North American, four Asia Pacific and one South American) are as follows:

1. MBNQA: Malcolm Baldrige National Quality Award, 1987 (National Institute of Standards and Technology, 1987).
2. EFQM: European Quality Award, 1997 (European Foundation for Quality Managament, 1996).
3. NQAF: Brazil National Quality Award, 1996 (National Quality Award Foundation, 1996).
4. SQA: Swedish Quality Award, 1996 (Swedish Institute for Quality, 1996).
5. NZNQA: New Zealand National Quality Award, 1996 (New Zealand National Quality Awards Foundation, 1996).
6. UKQA: United Kingdom Quality Award, 1996 (British Quality Foundation, 1996).
7. RGNQA: Rajiv Gandhi National Quality Award, 1994 (Bureau of Indian Standards, 1994).
8. SQA: Singapore Quality Award, 1996 (Singapore Productivity and Standards Board, 1996).
9. CAE: Canadian Awards for Excellence, 1997 (National Quality Institute, 1997).
10. GPNQA: Golden Peacock National Quality Award, 1991 (Institute of Directors, India 1991)

While all the above NQAs were generally focused to industrial organisations, National Institute of Standards and Technology (NIST) in 1994 exclusively announced the launch of MBNQA Education Pilot Program, to determine the interest and readiness of education organizations to participate in a nationwide recognition program and to evaluate the Education Pilot Criteria.

The studies that have analyzed MBNQA and EFQM have generally focused on examining their internal structure adopting either a causal approach (Winn and Cameron, 1998, Wilson and Collier, 2000, Meyer and Collier, 2001, Pannirselvam and ferguson, 2001, Flynn and Saladin, 2001, Goldstein and Schweikhart, 2002, Ghosh et al., 2003, Lee et al., 2003, Badri et al., 2006) or a factorial approach (Dijkstra, 1997, Bou-Llusar et al., 2005, Curkovic et al., 2000). However, with the exception of Curkovic et al. (2000) for the MBNQA, none of them analyzed whether the internal structure of the models matches the definition of TQM. Also no study on these models or adapted models used the system dynamics approach. Bou-Llusar et al. (2005, 2009) very recently conducted empirical assessment whether quality award models such as MBNQA and EFQM represent TQM and found that (a) Social and technical dimensions are embedded in the model; (b) Both dimensions are inter-correlated; (c) They jointly enhance results. These findings support the EFQM Excellence model as an operational framework for TQM, and also reinforce the results obtained in previous studies for the MBNQA, suggesting that quality award models really are TQM frameworks.

However the authors of this paper realized that additional research is needed, mainly in the case of the MBNQA and EFQM Excellence model, to study the dynamic interaction among the criterion.

2.2 Quality Accreditation Systems for Engineering Education

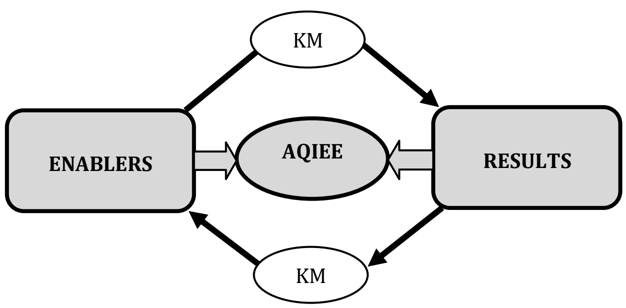
Accreditation of educational institutions all over the world specially engineering institutes has become almost mandatory. In the United States, the Accreditation Board for Engineering and Technology (ABET) is responsible for the specialized accreditation of educational programs in engineering and technology and related fields. It is the responsibility of the institution seeking accreditation of an engineering program to demonstrate clearly that the program meets the required eight criteria (ABET, 1997). These criteria, which are termed as EC 2000, are students, programme educational objectives, program outcomes and assessment, professional component, faculty, facilities, institutional support and financial resources, and program criteria. Similarly Russian Accreditation System for Engineering Education is also built up around eight criteria (RAEE, 2002). Canada follows a three criteria accreditation system (CEAB, 2002) for their engineering colleges. Accreditation Board of Engineering Education of Korea is the accreditation agency in Korea and follow a seven criteria system for the assessment of programmes (ABEEK, 2003). Japan Accreditation Board for Engineering Education (JABEE, 2003) specifies the standards of engineering education in terms of six criteria. ISO 9000 (BSI) is another framework, which is a procedural approach to quality assurance. Here standard of quality is defined according to stated and implied customer requirements, with procedures written and followed to assure that customer requirements are consistently delivered.

3. The Problem on Hand

In the present research, the focus is on the Indian Engineering Education system. As far as Indian engineering education system is concerned, NBA is the official performance assessment mechanism. Through a series of workshops and seminars of academicians, industrialists, and administrators, NBA has finalized the criteria and procedures for the accreditation process (Manual for NBA Accreditation, 2000). NBA has been assisting the stakeholders in technical education to identify those institutions and their specific programmes, which meet the norms and standards and criteria prescribed by AICTE. The process has been reviewed periodically to make it more effective. These revisions indicate a positive shift of assessment from resource perspective to process perspective. Improvements are still possible to reduce subjectivity from the process and to make the accreditation fool proof. NQA Excellence models in India such as GPNQA and RGNQA are in existence but no educational institution in general and Engineering education institutions in particular have applied to undergo the assessment through them.

As observed before, there is a need to have a model (Figure 1) in which KM is integrated with internationally acclaimed Quality Excellence models such as MBNQA and EFQM. This new model should have the capability of assessing the dynamics among various measurements used in the respective NQAs.

Figure 1: Conceptual research framework



In the proposed model, an additional sub-system capable of measuring, analysing and managing knowledge has been conceived and integrated with the elements of MBNQA and EFQM models as shown in Figure 2. It is proposed with this enhanced model to facilitate consideration of various scenarios, identify different strategies, generate possible outcomes, analyse the same and assess the effectiveness dynamically. For this the concept of SD has been considered as a study methodology. In order to compare the effectiveness of different strategies, a comprehensive performance measure called as “Accreditation Quality Index of Engineering Education (AQIEE)” has been developed. Figure 2 shows how the evaluation is proposed to be done. The AQIEE is defined as follows:

$$\mathbf{AQIEE} = \sum_{i=1}^{n} (W_i * ENB_i) + \sum_{j=1}^{m} (W_j * RES_j)$$

In order to carryout different simulation based exercises, the enablers and sub-enablers shown in Table-1 have been identified. The output obtainable will be grouped into different classes of results, which are shown in Table 1.

Figure 2: KM integrated Quality Excellence Model

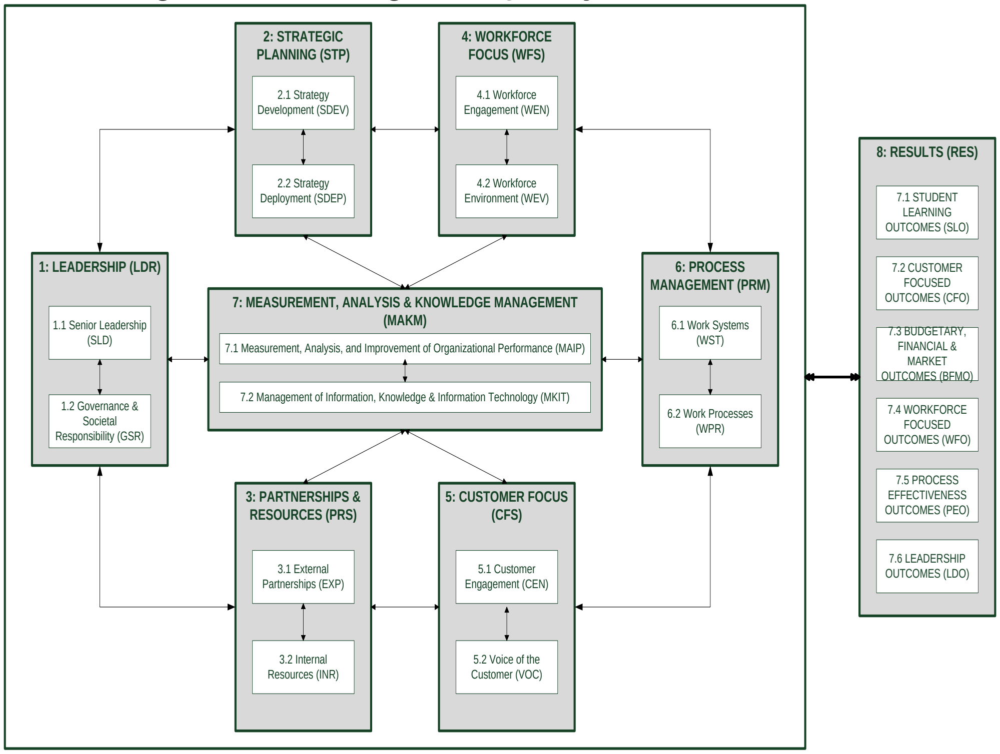


Table 1: List of Variables: Enablers, Results and Others

ENABLERS	SUB-ENABLERS
Leadership (LDR)	1.1 Senior Leadership (SLD)
	1.2 Governance & Societal Responsibilities (GSR)
Strategic Planning (STP)	2.1 Strategy Development (SDEV)
	2.2 Strategy Deployment (SDEP)
Partnerships and Resources (PRS)	3.1 External Partnerships (EXP)
	3.2 Internal Resources (INR)
Workforce Focus (WFS)	4.1 Workforce Engagement (WEN)
	4.2 Workforce Environment (WEV)
Customer Focus (CFS)	5.1 Customer Engagement (CEN)
	5.2 Voice Of The Customer (VOC)
Process Management (PRM)	6.1 Work Systems (WST)
	6.2 Work Processes (WPR)
Measurement, Analysis and Knowledge Management (MAKM)	7.1 Measurement, Analysis, And Improvement Of Organizational Performance (MAIP)
	7.2 Management Of Information, Knowledge & Information Technology (MKIT)
RESULTS (RES)	8.1 Student Learning Outcomes (SLO)
	8.2 Customer-Focused Outcomes (CFO)
	8.3 Budgetary, Financial, and Market Outcomes (BFMO)
	8.4 Workforce-Focused Outcomes (WFO)
	8.5 Process Effectiveness Outcomes (PEO)

	8.6 Leadership Outcomes (PEO)

Table-1 continued	
ENABLERS	**SUB-ENABLERS**
OTHER VARIABLES	
Accreditation Quality Index of Engineering Education (AQIEE)	Actual Budgetary, Financial, and Market Outcomes (ABFMO)
Gap in Student Learning Outcomes (GSLO)	Actual Workforce-Focused Outcomes (AWFO)
Gap in Customer-Focused Outcomes (GCFO)	Actual Process Effectiveness Outcomes (APEO)
Gap in Budgetary, Financial, and Market Outcomes (GBFMO)	Desirable Student Learning Outcomes (DSLO)
Gap in Workforce-Focused Outcomes (GWFO)	Desirable Customer-Focused Outcomes (DCFO)
Gap in Process Effectiveness Outcomes (GPEO)	Desirable Budgetary, Financial, and Market Outcomes (DBFMO)
Actual Student Learning Outcomes (ASLO)	Desirable Workforce-Focused Outcomes (DWFO)
Actual Customer-Focused Outcomes (ACFO)	Desirable Process Effectiveness Outcomes (DPEO)

4. Analytical Hierarchy Process (AHP)

MBNQA is an American award for American organizations. The criteria framework of the award is quite comprehensive and it comprises most of the basic tenets of TQM. For this reason, MBNQA has been a ‘role model’ in developing national quality awards in many other countries. In the multi-criteria decision making (MCDM) literature, it is well known that assigning weights to the criteria set is a ‘local phenomenon’. This means that the weights will be different for different decision makers. This is logical and a matter of common sense. In view of this, we can confidently state that the MBNQA criteria weights will not be the same in the Indian setting. The study presented has been carried out to obtain weights for the criteria shown in figure 2 for engineering education in the Indian context.

To determine the weights, we used the analytic hierarchy process (AHP) (Saaty, 1980). The AHP determines weights of a set of factors by comparing them pair-wise and it uses its own (1/9, 9) ratio scale judgments. The description of the scale is provided in Saaty (1980, p. 54). The MBNQA criteria framework has seven categories and each category has a number of subcategories.

Altogether eight pair-wise comparison matrices (PCMs) were formed, one for the categories and the remaining seven for the subcategories under each of the seven categories. Instead of using any traditional questionnaire, we formed eight empty PCMs that comprise only the headings in the first rows and first columns, and the responses were collected on a personal contact basis.

A substantial amount of the work has already been done on various other aspects of the MBNQA but minimal work on determining weights for the above categories of criteria applicable to different sectors and locations. In this paper, it is attempted to estimate the realistic weights of the criterion by collecting the responses from the academicians and administrators working in the chosen sector i.e. Engineering education sector.

4.1 Data Collection and Analysis

We managed to contact 31 academicians from three Engineering colleges (Two in Karnataka and one in Maharashtra). For all the respondents, prior appointments were arranged before going to meet them. The breakdowns of the respondents are as follows: Directors/ Principals-03, Deans/ Professors-10, Assistant Professors-15 and Training & Placement officers-03.

Data collection from every respondent started with an explanation of the (1/9, 9) ratio-scale, which was to be used in completing the PCMs. The explanation was repeated for all the respondents.

The weights of the criteria and sub-criteria from each individual's pairwise comparison matrices (PCMs) were not determined; rather the responses from all the respondents were aggregated using the geometric mean rule (Basak and Saaty, 1993). To compute geometric mean, the values are multiplied first and then a root equal to the number of individuals who provided the values is taken. For example, the geometric mean of all the 31 values as stated in Annexure-B for the comparison Leadership and Strategic Planning is,

$$\sqrt[31]{6 \times 2 \times 3 \times \ldots\ldots\ldots\ldots\ldots \times 4 \times 2 \times 1} = 2.83$$

Similarly, the geometric means of all other comparisons shown in Annexure-A were calculated and Team Expert Choice (Saaty and Forman, 2000) was used for this purpose. The aggregated PCMs and the computed weights for each matrix are shown in Tables 2 to 9. The weights shown in the last columns of the PCMs in these tables are all fractional. But these can easily be converted to integral weights, which are shown in Table 10.

Table 2: Geometric Means of Responses and Weights: Main Criterion

MAIN	LDR	STP	CFS	MAKM	WFS	PRM	RES	WEIGHTS	OTHER DETAILS
LDR	1.00	2.83	1.93	2.62	1.01	2.10	0.54	0.201915	Maximum Eigen Value =7.13701 C.I.=0.0228355
STP	0.35	1.00	1.42	1.95	0.76	1.43	0.73	0.127685	
CFS	0.52	0.70	1.00	1.34	0.54	1.36	0.56	0.102869	
MAKM	0.38	0.51	0.75	1.00	0.33	0.86	0.38	0.0714121	
WFS	0.99	1.32	1.85	3.03	1.00	2.97	0.90	0.198274	
PRM	0.48	0.70	1.16	1.16	0.34	1.00	0.49	0.0840227	
RES	1.85	1.37	2.63	2.63	1.11	2.04	1.00	0.213822	

Table 3: Geometric Means of Responses and Weights: Sub-Criterion under Leadership

1-LDR	SLD	GSR	WEIGHTS	OTHER DETAILS
SLD	1.00	1.42	0.586777	Maximum Eigen Value =2 C.I.=0
GSR	0.70	1.00	0.413223	

Table 4: Geometric Means of Responses and Weights: Sub-Criterion under Strategic Planning

2-STP	SDEV	SDEP	WEIGHTS	OTHER DETAILS
SDEV	1.00	0.52	0.342105	Maximum Eigen Value =2 C.I.=0
SDEP	1.92	1.00	0.657895	

Table 5: Geometric Means of Responses and Weights: Sub-Criterion under Customer Focus

3-CFS	CEN	VOC	WEIGHTS	OTHER DETAILS
CEN	1.00	0.59	0.371069	Maximum Eigen Value = 2 C.I.=0
VOC	1.69	1.00	0.628931	

Table 6: Geometric Means of Responses and Weights: Sub-Criterion under Measurement, Analysis & Knowledge Management

4-MAKM	MAIP	MKIT	WEIGHTS	OTHER DETAILS
MAIP	1.00	0.73	0.421965	Maximum Eigen Value =2 C.I.=0
MKIT	1.37	1.00	0.578035	

Table 7: Geometric Means of Responses and Weights: Sub-Criterion under Workforce Focus

5-WFS	WEN	WEV	WEIGHTS	OTHER DETAILS
WEN	1.00	0.39	0.280576	Maximum Eigen Value =2 C.I.=0
WEV	2.56	1.00	0.719424	

Table 8: Geometric Means of Responses and Weights: Sub-Criterion under Process Management

6-PRM	WST	WPR	WEIGHTS	OTHER DETAILS
WST	1.00	1.45	0.591837	Maximum Eigen Value =2 C.I.=0
WPR	0.69	1.00	0.408163	

Table 9: Geometric Means of Responses and Weights: Sub-Criterion under Results

7-RES	SLO	CFO	BFMO	WFO	PEO	LDO	WEIGHTS	OTHER DETAILS
SLO	1.00	1.15	2.79	1.35	1.06	1.87	0.228673	Maximum Eigen Value =6.04625 C.I.=0.00924933
CFO	0.87	1.00	2.11	0.77	1.03	1.26	0.174719	
BFMO	0.36	0.47	1.00	0.41	0.55	0.75	0.0873644	
WFO	0.74	1.30	2.44	1.00	1.72	1.57	0.216594	
PEO	0.94	0.97	1.82	0.58	1.00	1.08	0.160978	
LDO	0.53	0.79	1.33	0.64	0.93	1.00	0.131672	

Table 10: Malcolm Baldrige Education Criteria for Performance Excellence categories; their existing and proposed points (Indian context)

Sr. No.	Criterion & Sub-Criterion	MBNQA Points For Education	Points For Indian Industries (Agrawal's Model)	Proposed Points for Education
1	**LEADERSHIP (LDR)**	**120**	**125**	**202**
1.1	Senior Leadership (SLD)	70	75	119
1.2	Governance and Societal Responsibilities (GSR)	50	50	83
2	**STRATEGIC PLANNING (STP)**	**85**	**100**	**128**
2.1	Strategy Development (SDV)	40	45	44
2.2	Strategy Deployment (SDP)	45	55	84
3	**CUSTOMER FOCUS (CFS)**	**85**	**140**	**103**
3.1	Customer Engagement (CEN)	40	65	38
3.2	Voice of the Customer (VOC)	45	75	65
4	**MEASUREMENT, ANALYSIS AND KNOWLEDGE MANAGEMENT (MAKM)**	**90**	**60**	**71**
4.1	Measurement, Analysis, and Improvement of Organizational Performance (MAIP)	45	30	30
4.2	Management of Information, Knowledge, and Information Technology (MKIT)	45	30	41
5	**WORKFORCE FOCUS (WFS)**	**85**	**95**	**198**
5.1	Workforce Engagement (WEN)	45	55	56
5.2	Workforce Environment (WEV)	40	40	142
6	**PROCESS MANAGEMENT (PRM)**	**85**	**80**	**84**
6.1	Work Systems (WST)	35	35	50
6.2	Work Processes (WPR)	50	45	34
7	**RESULTS (RES)**	**450**	**400**	**214**
7.1	Student Learning Outcomes (SLO)	100	--	49
7.2	Customer-Focused Outcomes (CFO)	70	115	37
7.3	Budgetary, Financial, and Market Outcomes (BFMO)	70	75	19
7.4	Workforce-Focused Outcomes (WFO)	70	100	46
7.5	Process Effectiveness Outcomes (PEO)	70	40	35
7.6	Leadership Outcomes (LDO)	70	70	28

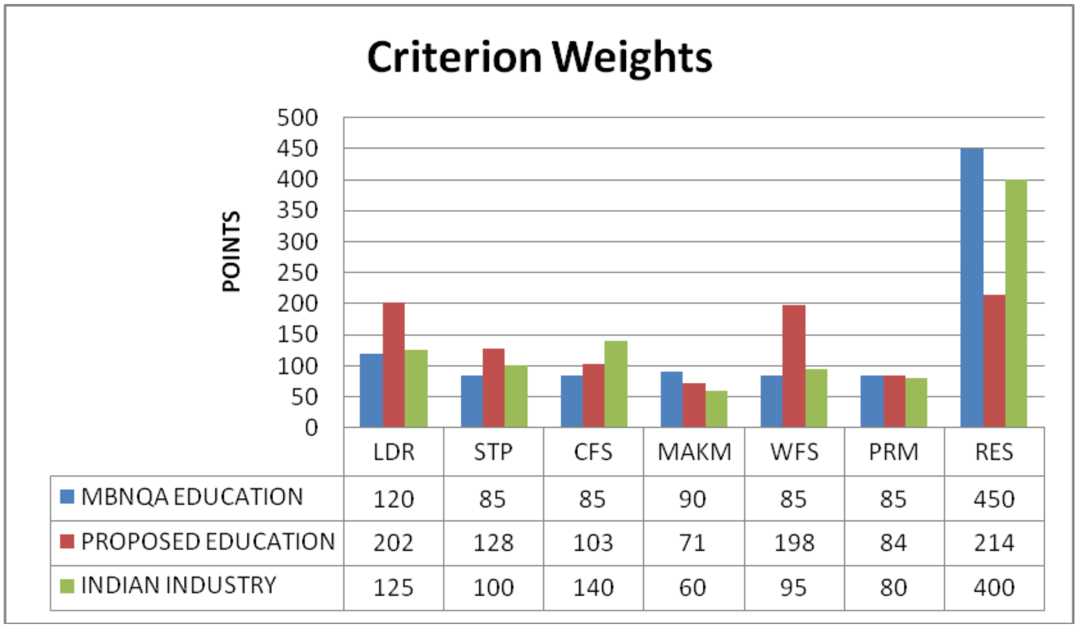


Figure 3: MBNQA Education Criteria for Performance Excellence categories; existing and proposed points (Indian context)

4.2 Some observations in the new set of weights

For comparison purposes, MBNQA weights are also shown in Table 10. From the proposed set of weights, the observations in the following section are clear.

4.2.1 Leadership

The category has received significantly higher weight compared to MBNQA. This is apparently because the respondents think that if the leadership is 'ok', then everything else will be 'ok' in the organization. One respondent openly said, 'I'll place leadership above all'. Furthermore, senior leadership has received more points compared to social responsibility as it does in the MBNQA framework.

4.2.2 Strategic Planning

This has also received higher points compared to MBNQA. However, unlike MBNQA, strategy deployment has received significantly higher points compared to strategy development. Out of 31 respondents, only seven said that strategy development was more important than strategy deployment, two said they were equally important, and the rest, i.e., 15 respondents said that strategy deployment was more important than strategy development. One respondent commented, 'Many times, we develop many things but we don't really deploy and we don't make them work.' In fact, in a survey of a broad cross section of CEOs, the Malcolm Baldrige Foundation learned that CEOs believed deploying strategy is three times more difficult than developing strategy (BNQP, 2005a).

4.2.3 Customer Focus

This also has received higher weight compared to MBNQA. Furthermore, 'Voice of customer' has received higher points than in MBNQA.

4.2.4 Measurement, Analysis and Knowledge Management

This has received lesser weightage here compared to MBNQA. This is because the respondents have assigned higher weights to all the previous three categories. Hence, as the total points are constant, some category is expected to receive lesser weight. However, it is to be noted that the difference between the two sets of points (proposed and MBNQA) is not significantly large.

4.2.5 Workforce Focus

This has received the highest amount of increase in terms of points. An organization's success depends upon the diverse backgrounds, knowledge, skills, creativity, and motivation of all its faculty and staff. Overall, the respondents strongly felt that if the staff's well-being and satisfaction were taken care of then it would be easier to achieve organizational performance results, especially student learning results.

4.2.6 Process Management

This category along with its subcategories, namely, 'Work systems' and 'Work processes', have received almost the same weight as in MBNQA.

4.2.7 Results

For this category, MBNQA points are 450 (almost half of the total points), whereas the proposed points total 214. This shows that the respondents have placed lesser weight on this category compared with MBNQA. However, this does not mean that all the respondents have done so. It may be noted that not only is 'results' judged to be the most important category by a majority of the respondents, but also its range of weights have higher values for both upper and lower limits than the other three categories like 'Leadership', 'Strategic planning', and 'Workforce focus'.

5. The Research Issues

After the realistic weightages have been estimated using AHP, it is necessary to assign these weights to the criteria set though various criterions from the MBNQA and EFQM were integrated into it. Further development of causal loop diagrams, stock-flow diagrams and system dynamics simulation model with a view to study the dynamic interaction of all identified criterion and predicting the future scenarios.

6. Conclusion

The literature published on Quality Excellence award models, Accreditation issues of Engineering education etc. was studied with a view to explore and identify a potential research problem. The scope of using SD as a research methodology and scope of carrying out a simulation study is discussed. A structural diagram for KQM system has been developed using the system parameters (enablers and results) identified from the literature and manuals. The proposed methodology, systems approach focuses on the interaction between various "Enablers" and "Results". KQMI variables may have different weights in different contexts, but it aids in understanding and evaluating the institutions' performance based on the realistic weightages. The CLDs for various loops and the integrated CLD for the entire proposed KQM model enabling development of a system dynamics (SD) model have been presented.

The formulation of an operational model of the KQM system is based on specific structural details like rates or policy variables, accumulation of level, auxiliaries, constants, information flows and delays. Flow diagrams represent such details and specific aspects of the model-structure. The causal loop shown for the KQM model will be converted into a stock-flow diagram (SFD) with the help of Stella software. The SD equations will be generated in the model, which represent the dynamics of the systems encapsulating the rate of changes with complex interactions.

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