A Rough Set Based Total Quality Management Approach in Higher Education

Ahmad Taher Azar, Renu Vashist and Ashutosh Vashishtha

Abstract Contrary to the popular belief that TQM is a poor fit in higher education sector, this research proposes a Rough Set Theory (RST) based model for grading educational institution using TQM parameters. It is a well established fact that TQM needs major reshaping before it can be effectively applied in higher education sector for quality assessment and improvement. This chapter takes a balance view by employing RST approach in TQM architecture and eliminating the much publicized shortcomings of TQM approach. RST theory has advantage of working on a small size of data containing vague and imprecise information which is widely prevalent in education sector. A carefully drafted questionnaire, containing nine attributes, is used for generating research data from the different stake holders in higher educational institutes of India. Nine modified condition attributes are selected on the basis of literature survey and expert views which are subsequently treated with RST analysis. One decision parameter 'Grade' depends on nine independent condition attributes. The resultant model contains only two significant attributes namely, 'Effective Learning and Teaching' and 'Administrative Setup' which can effectively determine the grading of educational institutions. Results of this study may be utilized to improve the higher education quality through appropriate grading mechanism based on self assessment of quality parameters by the different stakeholders of the education sector. The study confirms that TQM can be useful to enhance both quasi-academic areas such as 'administrative setup' along with core academic area 'effective teaching and learning'.

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1 Introduction

Over the last several decades the term 'quality management' has evolved as an obsession with business and non business entities for achieving the goals of sustainable profits, competitiveness and long term survival. It is equally gaining attention from educational sector companies, universities, colleges and government agencies of education sector. The genesis of quality management has its roots in manufactured product, productive process and can be traced to the work of Shewhart in the 1930s (Shewhart 1931). Many years later after the World War II Deming, Juran, Feigenbaum and others formulated quality based management techniques which inherited the Shewhart's philosophy of quality but extended it into business applications across many organizations. Total Quality Management (TQM) increasingly used as an effective business strategy to capture wider market share and gaining competitive edge (Rehder and Ralston 1984; Fortuna 1990; Fisher 1993; Ruben 1995). TQM is not only a tool, which is ready to use, but there are number of principles and methods, which needs to be applied according to organizational needs. There are some early evidences of adoption of TQM in USA higher education system in the non academic areas such as administration and support functions (Ruben 1995; Koch and Fisher 1998; Yorke 1999) whereas application of TQM in core academic areas remains debatable and very selective (Vazzana et al. 2000). This is largely because TQM is essentially evolved in manufacturing based industries and switching it to extensively human specific higher education sector pauses incompatibility issues (Houston and Studman 2001).

All over the world Higher Education in general and technical education in particular transforming its focus from 'elite oriented' to 'mass oriented' (Weeks 2000) and therefore, developing market orientation like other business organizations. Higher educational institutions with traditional ways of working are finding it increasingly difficult to cope with the pressure of change. This is more so in developing and under developing countries where public funding for higher education is limited and national objective of increasing higher education enrollment may not be achieved without private funding. This brings into focus the utility of TQM into higher education sector with the business like goals of reducing operating costs; increasing fees based revenue, improving student's satisfaction, employability and faculty retention (Zabadi 2013).

Successful Implementation of TQM to improve academic content delivery and overall functioning of higher education institution continues to be a daunting task for the reasons spelled out earlier. This chapter aims to improve TQM utility in professional higher education sector by introducing Rough Set Theory (RST) based approach. RST of (Pawlak 1982, 1991) was developed as an alternative data analysis tool but subsequently made inroads into the areas of Artificial Intelligence,

Cognitive Sciences, Knowledge Discovery, Decision Analysis and Expert Systems. RST has an important advantage that it can handle inexact, uncertain and vague datasets (Maji and Roy 2002). The chapter attempts to fit TQM model into the professional higher education system on the basis of selected ten attributes out of which nine are conditional or independent attributes and one is decision or dependent attribute. The empirical data is collected from the respondents in select higher education institutions of India through a questionnaire.

2 Related Work

Total Quality Management has been successfully implemented in some Higher Education Institutions, and it has improved the quality of higher education in those institutions. In the last decade, TQM has emerged an important topic of research. There is a growing interest of researcher in this topic, which can be tested by the number of publications in this particular area.

The theoretical essence of the Deming approach to TQM concerns the creation of an organizational system that fosters cooperation and learning for facilitating the implementation of process management practices, which, in turn, leads to continuous improvement of processes, products, and services as well as to employee fulfillment, both of which are critical to customer satisfaction, and ultimately, to firm survival (Deming 1982, 1994). It is possible to extract from the total quality management philosophy, a set of traits, values, and behaviors that can lead to positive outcomes for organizations (Anderson et al. 1994).

Quality in higher education means enabling students to achieve learning goals and academic standards in effective educational environment (Venkatraman 2007).

Research proved that faculty has a major impact on students teaching (Hill et al. 2003) and is the main strength in an educational institution (Gary et al. 2005). Quality in teaching and learning can only be enhanced if the faculty members are satisfied and content (Chen et al. 2006). According to Imai (2006), Kaizen theory is all about employing small continuous steps to improve business organizations. Consequently, it is a humanistic approach that involves everyone in the organization from top managers to the employees. The concept is communicated from the top and implemented by the employees.

Extant literature emphasized the importance of employee's job satisfaction and performance in higher education (Ooi et al. 2007). Universities must provide competitive levels of work environment conducive to faculty needs in order to attain faculty commitment. This can only be achieved if universities emphasize continuous improvement and identify mechanisms for quality improvement (Chen et al. 2006). In literature, number of areas for faculty development can be found with reference to TQM, such as teaching and research activities, administration and management support, salary and promotion, professional development, overall working environment, and decision making (Chen et al. 2006). An excess of research can be found regarding student satisfaction in education (Sirvanci 2004).

Employees are internal customers in any organization (Sallis 2002) and quality of that organization cannot be improved without the satisfaction of their employees (Ooi et al. 2007). Becket and Brookes (2008) undertakes a critical evaluation of the different methods used to assess the quality of provision in higher education departments in the UK. Al-Tarawneh (2011) studies the role of management in higher education institutions and for implementing TQM in universities which need the participation of all to ensure survival and continuity of universities.

Manjula et al. (2012) propose a new capability maturity decision making model based on rough computing for extracting key process areas and its relevance for the development of quality education.

Andollo et al. (2013) examined the influence of training and empowerment and effective communication as an aspect of quality management system on service provision.

Acharjya and Bhattacharjee (2013) propose a performance evaluation for educational institutions using rough set on fuzzy approximation spaces with ordering rules and information entropy. In order to measure the performance of educational institutions, they construct an evaluation index system.

The study conducted by Altahayneh (2014) indicated that TQM principles were poorly implemented in Jordanian colleges of physical education and the findings revealed that academic rank, years of experience, and education level did not significantly affect the faculty members' perceptions of TQM implementation.

3 A Systemic View of TQM

A comprehensive examination of TQM literature provides an insight into major quality improvement parameters like, strategic planning, customer focus, leadership, information analysis, process management, supplier management, and human resource management (Sila 2007). This is a macro view on TQM practices in various organizations most of which are manufacturing or production based organizations. Another view on TQM states that it is an integration of all organizational functional areas such as marketing, finance, production, human resource, design, engineering, so that customer need and organizational objectives can be synchronized (Hung 2007). There is another extremely interesting interpretation of TQM which highlights TQM as a system of three inter related and interdependent components, namely, values, methodologies, and tools that are used tighter to enhance the satisfaction of internal as well as external customers (Hellsten and Klefsjo 2000). **This view is important in the light of fact that education institutions have faculty as internal customers and students as external customers**. Deming's 14 TQM principles (see Table 1) provides a general direction to any organization for improving overall quality in most holistic fashion but these principles need to be reengineered when applying them to professional higher education sector.

Organization lacking a democratic culture and participative management style may not be perfect candidate for applying TQM, moreover, if the organization is

Table 1 Deming's 14 principles

S. No.	Deming's principles
1	Create constancy of purpose for improving products and services
2	Adopt the new philosophy
3	Cease dependence on inspection to achieve quality
4	End the practice of awarding business on price alone; instead, minimize total cost by working with a single supplier
5	Improve constantly and forever every process for planning, production and service
6	Institute training on the job
7	Adopt and institute leadership
8	Drive out fear
9	Break down barriers between staff areas
10	Eliminate slogans, exhortations and targets for the workforce
11	Eliminate numerical quotas for the workforce and numerical goals for management
12	Remove barriers that rob people of pride of workmanship, and eliminate the annual rating or merit system
13	Institute a vigorous program of education and self-improvement for everyone
14	Put everybody in the company to work accomplishing the transformation

Source Deming (1982)

too rigid to accept the new reforms than TQM applications will be a futile exercise. Figure 1 shows different organizations that follows some or all the principles of TQM. It is important to understand that Fig. 1 represents organizational alignment with external environment which, in other words, means that organizations learn to change, as the surrounding environment changes in the presence of TQM. Obviously, this realignment is absent in non TQM organizations and present in case of fully TQM compliant organization.

Unlike business organization, educational institutions of highest learning produce social goods in the form of intellectual capital for the economy as a whole and therefore the word 'management' needs to be interpreted differently. The *management* in TQM refers to everyone, starting from the top level to the lower level, who behaves as the manager of his own responsibilities (Sallis 2002). Similarly, in educational institution faculty and students are two focal points around which the entire organizational support system and auxiliary services revolve. Student and faculty have diversified responsibilities and manage these in the same manner as does the business manager and thereby suggesting the possible success of any TQM approach.

4 Rough Set Methodology for TQM in Higher Education

4.1 Empirical Analysis

Self assessment is a critical component of TQM process as it provides the deep insight of the educators or other higher education stake holders (Higher education

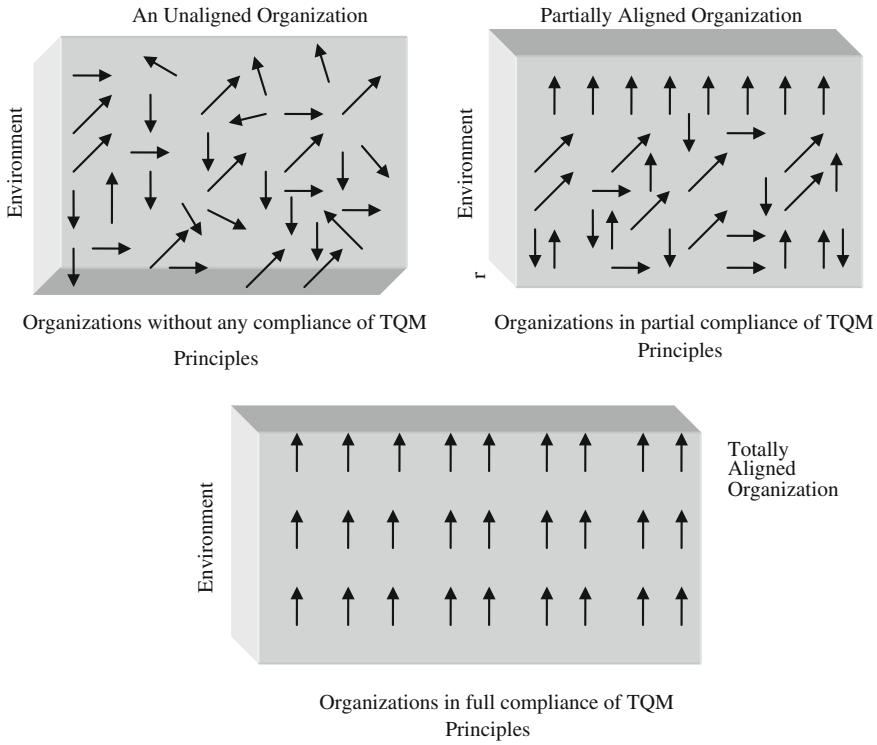

Fig. 1 Organizational alignment

Management boards and National Education Regulatory bodies) to make a considered judgment about institution performance and plugging the gaps to achieve the TQM goals. In order to further the goal of continuous improvement for delivering the quality education it is imperative for the educators to identify the roadblocks and weaker areas. Ten self assessment indicators developed by Sallis (2002) have been globally used and acknowledged in the realm of higher education. With a view to administer the research tool (Questionnaire) to a select pool of professional higher education respondents (Students, faculty, staff) belonging to Engineering and Management stream. Self assessment indicators have reduced to nine, retaining three generic parameters (effective learning and teaching, leadership and students) and including six new parameters (Administrative setup, Research, Faculty with experience and industrial exposure, Industry—Institute Interface, Placement, Infrastructure). However, these six parameters may have some indirect similarities to generic parameters of Sallis in terms of sub parameters but by and large the modified parameters remain different and serve the purpose to generate the data set from the particular pool of survey respondents. It is obvious that higher education is vastly diversified domain and TQM practices are likely to yield better

results if these are designed with some tailor made adjustments to address the specific needs of a particular sub set of this domain.

A research instrument in the form of a survey questionnaire containing nine parameters or attributes has been developed (see Table 2). Selection of six modified parameters is done on the basis of literature review, inputs from higher education experts and interviews with various stakeholders in higher education. Prior to finalizing the questionnaire, it was pilot tested on carefully selected small group of respondents. Finalized questionnaire has been administered to faculty, students and administrative staff from Indian higher education institutions. A sample size of 50 respondents is being used for this study. The sample size has been kept small because Rough Set Analysis yields much accurate results on a smaller dataset. Respondents were asked to rate each condition attribute on a scale of 1–4 where 1 refers to "poor" and 4 to "excellent".

In Table 3 the criterion for Grade (Decision) is:

- Grade 1 is awarded for excellent performance of the educational Institution implying that there are majority of strengths and little or no weaknesses.
- Grade 2 is awarded for good performance of the educational Institution which implies that strengths outweigh weaknesses.
- Grade 3 is awarded for average performance of the educational Institution implying that there is a balance of strengths and weaknesses.
- Grade 4 is awarded for below average performance of the educational Institution. This means that weaknesses outweigh strengths.
- Grade 5 is awarded for poor performance of the educational Institution indicating that there are majority of weaknesses and little or no strength.

4.2 Rough Set Analysis

Rough Set Theory (RST) is useful and valid mathematical tool which deals with imprecise, vague and uncertain information. RST treats knowledge as an ability to classify objects relative to classes using indiscernible relation. Rough set analysis basically starts from a table called information table because with every object in this universe some information is associated. Information table contains objects which are represented by values of attributes. Objects containing the same information are indiscernible.

An information system is a pair $S = (U, A)$, $X \subseteq U$ *and* $P \subseteq A$ where U is a nonempty finite set called the universe and A is a nonempty finite set of attributes, i.e., $a: U \rightarrow V_a$ for $a \in A$, where V_a is called domain of a. A decision table is a special case of information system

Table 2 Attribute normalization and classification

S. no.	Attribute	Notation	Classification
1	Effective learning and teaching	a	Poor (1)
	• Appropriateness of learning methods		Good (2)
			V.good (3)
	• Curriculum		Excellent(4)
	• Teaching and evaluation		
2	Leadership	b	Poor (1)
	• Top management composition		Good (2)
	• Departmental/school level supervision		V.good (3)
	• Student leadership		Excellent (4)
3	Administrative setup	c	Poor (1)
	• Timely availability of information		Good (2)
			V.good (3)
	• Implementation of decisions		Excellent (4)
	• Quality of support staff		
4	Research	d	Poor (1)
	• Faculty research publications		Good (2)
	• Sponsored research projects and consultancy		V.good (3)
	• Student research projects		Excellent (4)
5	Faculty	e	Poor (1)
	• Faculty teaching experience		Good (2)
	• Faculty with industrial exposure		V.good (3)
	• Faculty qualifications and communication skills		Excellent (4)
6	Industry institute interface	f	Poor (1)
	• Special lectures by industrial experts		Good (2)
			V.good (3)
	• Industrial tours		Excellent (4)
	• Industrial sponsorship to various events		
7	Placement	g	Poor (1)
	• Placement cell and staff		Good (2)
	• Campus placements		V.good (3)
	• Salary package offered		Excellent (4)
8	Infrastructure	h	Poor (1)
	• Physical environment (class rooms, labs, sports, canteen)		Good (2)
			V.good (3)
	• Academic infrastructure(library, online journals)		Excellent (4)
	• Health facilities		
9	Students	i	Poor (1)
	• Handling of student affairs		Good (2)
	• Monitoring students progress		V.good (3)
	• Student satisfaction		Excellent (4)

Table 3 Sample dataset

Objects	a	b	c	d	e	f	g	h	i	Grade(D)
1	3	3	4	4	4	3	4	3	2	2
2	2	2	2	2	2	1	1	3	3	2
3	3	3	4	2	3	2	3	4	2	2
4	2	1	3	2	2	1	1	4	4	2
5	2	2	2	2	2	2	3	3	2	2
6	3	2	4	3	3	2	2	3	2	2
7	3	4	4	3	3	4	4	3	3	2
8	2	2	3	2	3	2	1	3	2	3
9	3	2	3	2	3	2	1	3	4	3
10	3	2	4	4	4	3	2	3	3	3
11	3	2	4	3	4	2	2	4	3	3
12	3	2	3	3	3	2	1	2	4	3
13	2	2	2	2	3	2	1	2	4	3
14	3	2	3	2	2	1	1	2	3	3
15	3	4	3	3	3	4	2	3	2	3
16	3	3	3	3	4	3	2	3	2	3
17	3	3	3	2	4	2	1	3	4	3
18	2	2	2	3	2	2	2	1	2	4
19	2	3	3	2	3	2	3	2	3	4
20	3	3	2	3	2	3	3	2	3	4
21	3	3	2	3	3	3	3	2	3	4
22	2	2	2	1	3	2	1	1	2	4
23	2	2	1	1	2	1	1	3	3	4
24	2	2	3	2	3	2	1	2	3	4
25	2	1	1	2	2	2	2	3	3	4
26	3	3	3	3	2	3	3	3	2	4
27	3	3	3	3	1	2	2	2	3	4
28	1	1	1	1	2	1	1	2	1	5
29	3	3	3	3	1	3	3	2	2	5
30	1	1	1	1	1	2	1	1	2	5
31	1	1	1	2	1	1	1	2	1	5
32	1	3	3	1	2	1	1	3	2	5
33	1	1	1	2	1	2	1	2	1	5
34	1	1	1	1	1	1	2	2	1	5
35	1	2	1	1	1	2	2	2	1	5
36	1	1	1	1	2	1	1	3	2	5
37	1	2	2	2	1	1	2	3	1	5
38	1	2	1	1	1	4	3	2	1	5
39	2	3	2	2	3	2	1	2	3	5
40	4	3	3	3	2	4	3	2	2	1
41	4	3	3	3	4	4	4	3	3	1

(continued)

Table 3 (continued)

Objects	a	b	c	d	e	f	g	h	i	Grade(D)
42	2	3	3	4	2	3	4	4	1	1
43	4	4	4	3	4	3	4	3	4	1
44	4	4	4	4	4	4	4	4	2	1
45	4	4	3	2	4	4	3	3	3	1
46	4	4	3	3	4	3	3	4	3	1
47	4	3	3	4	3	4	3	4	3	1
48	4	4	3	4	4	3	4	3	4	1
49	1	2	2	2	2	2	3	3	2	1
50	3	3	2	2	2	4	3	4	3	1

$$S = (U, A = CU\{d\})$$

where attribute in C are called condition attributes and d is a designated attribute known as decision attribute.

Now, define two approximations $\underline{P(X)}$ and $\overline{P(X)}$ called the P-lower and the P-upper approximation of X respectively where

$$\underline{P(X)} = \bigcup x \in U\{P(x) : P(x) \subseteq X\} \text{ and}$$
$$\overline{P(X)} = \bigcup x \in U\{P(x) : P(x) \cap X \neq \phi\}.$$

Lower approximation will consist of all the members of the information system which surely belongs to the set and Upper approximation consist of all the members of the information system which possibly belongs to the set.

The boundary region is given by the set difference $\overline{P(X)} - \underline{P(X)}$ consists of those objects that can neither be ruled in nor ruled out as members of the target set X. If the boundary region is empty i.e. $\overline{P(X)} = \underline{P(X)}$ then the set is crisp otherwise the set is rough (inexact).

Rough set is organized in the form of information table or decision table, whose columns are labeled as condition and decision attributes and rows of the table contain the example (Pawlak and Skowron 2007a). Entries in the table represent the attribute values. Rows of Table 3 which is a decision table are called *examples* (objects, entities). Properties of examples are perceived through assigning values to some variables. Condition attributes of decision table are also called independent variable and decision attribute is called the dependent variable. The dependent variable is a function of independent variable and the value of dependent variable is solely depends on the values of independent variable. Analysis of Table 3 is done using Rose 2 S/W of rough set (Predki and Wilk 1999).

The set P of attributes is the *reduct* (or covering) of another set Q of attributes if P is minimal and the Indiscernibility relations, defined by P and Q are same.

A reduct can be thought of as a sufficient set of features sufficient, that is, to represent the category structure and no attribute can be removed from reduct set without changing the equivalence classes. There may be $2^n - 1$ reducts of a decision table and it is not always feasible to find all the reducts of a set (Pawlak and Skowron 2007c). Therefore the reduct of an information system is *not* unique.

Reducts of Table 3 as discover by Rose2 s/w are

$R_1 = \{a, b, c, e, f, h\}$
$R_2 = \{a, c, e, h, i\}$
$R_3 = \{a, c, d, e, i\}$
$R_4 = \{a, b, d, e, g, i\}$
$R_5 = \{a, c, e, f, g, i\}$
$R_6 = \{a, b, c, d, g, h\}$
$R_7 = \{a, b, c, e, g, h\}$
$R_8 = \{a, b, c, f, g, h\}$
$R_9 = \{a, b, d, g, h, i\}$
$R_{10} = \{a, b, d, g, h, i\}$

The set of attributes which is common to all reducts is called the *core*. The core is the set of attributes which is possessed by every legitimate reduct, and therefore core consists of attributes which cannot be removed from the information system without causing collapse of the equivalence class structure. RST considers that the core is the set of necessary attributes and it is the set of most important attributes of the dataset and if any of the core attribute is eliminated from the dataset then it shoddily affect the classification (Pawlak and Skowron 2007b). It is pertinent here to mention that the core set may be empty for some datasets.

$$Core = \cap\, Reduct$$

where *Reduct* is the set of all the reducts.

$$Core = R_1 \cap R_2 \cap R_3 \cap R_4 \cap R_5 \cap R_6 \cap R_7 \cap R_8 \cap R_9 \cap R_{10}$$

Therefore core of Table 3 is:

$$Core = \{a\} = \{\text{Effective learning and teaching}\}$$

This is the most significant attribute of Table 3.

The lower and upper approximation of the table is given by the Fig. 2. The accuracy of approximation is given by

$$\alpha_P(X) = \frac{|\underline{P}(X)|}{|\overline{P}(X)|}$$

where |X| denotes the cardinality of $X \neq \varphi$ and Obviously $0 \leq \alpha \leq 1$.

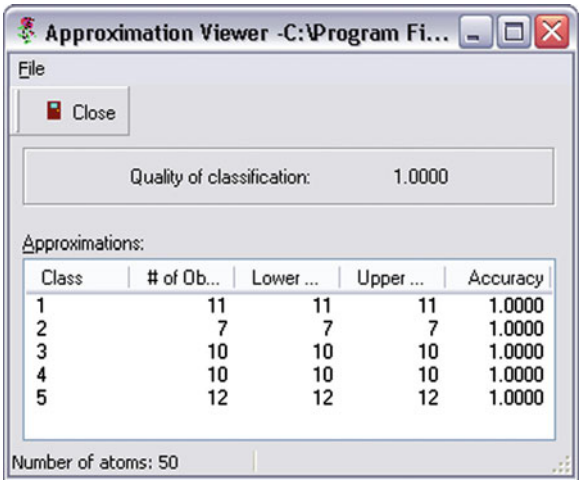

Fig. 2 Lower and upper approximation and accuracy of classification

If

$$\alpha_P(X) = 1,$$

then the set is crisp with respect to P and if

$$\alpha_P(X) < 1,$$

which means set is rough with respect to P.

The lower and upper approximation and the classification accuracy of decision Table 3 are shown in Fig. 2.

Decision Rules

Extracting decision rules from the decision table is one of the important aspects of RST. Numbers of attribute reduction algorithm are available which can lead to more accurate and simple decision rules. These decision rules can directly determine the performance of information system. Decision rules are generally represented in the form of 'if-then' form. Reduct based rules can also be generated which are lesser in number and yet significant (Vashist and Garg 2011, 2012). The set of decision rules are also called decision algorithm.

Heuristic rules for decision Table 3 as extracted by Rose 2 S/W are represented as follows:

Rule 1 (a = 4) => (D = 1); [8, 8, 72.73 %, 100.00 %] [8, 0, 0, 0, 0] [{40, 41, 43, 44, 45, 46, 47, 48}, {}, {}, {}, {}] or

Rule 1 If (Effective Learning and Teaching = excellent) then(Grade = excellent).

Rule 2 (a = 1) & (c = 1) => (D = 5); [8, 8, 66.67 %, 100.00 %] [0, 0, 0, 0, 8][{}, {}, {}, {}, {28, 30, 31, 33, 34, 35, 36, 38}] or

Rule 2 If (Effective Learning and Teaching = poor) and(Administrative Setup = poor) then (Grade = poor).

5 Discussion

Higher education institutions like universities, colleges, research institutes have extensively relied on qualitative and quantitative tools of quality (such as interviews, focus groups, survey questionnaire and observation studies) to measure the perception of students and other stakeholders regarding the quality of education. This chapter also employed one such tool, namely, survey questionnaire because of its ease and accuracy in comparison to other tools. More importantly, RST as data mining technique can better extract information from a close ended questionnaire rather than other highly qualitative data collection instruments.

Several quality models have been employed and tested in higher education to achieve the perennial goal of quality improvement like TQM, QFD, Six Sigma, ISO 9001, the Malcolm Baldrige National Quality Award, the EFQM Model, SERVQUAL and many more (Houston and Studman 2001; Wiklund et al. 2003; Kanji et al. 1999; Talib 2013). However, our choice of TQM attributes or parameters is largely based on the fact that TQM remains the generic philosophy which continues to influence other quality models in one way or other. Nine condition attributes and one decision attribute are used for RST analysis. The value of decision or dependent attribute depends on the values of nine condition or independent attributes and each condition attribute further has three sub attributes. Decision attribute assume values ranging from grade 1 to grade 5 and condition attributes assume values ranging from 1 to 4. RST analysis (see Table 3) returns 'Effective Learning and Teaching' attribute as the most significant attribute of the dataset because it appears as 'Core'. A brief discussion of this attribute follows:

Core: Effective Learning and Teaching

Condition attribute 'Effective Learning and Teaching' has sub attributes 'Appropriateness of learning methods', 'Curriculum' and 'Teaching and Evaluation'. There are varieties of learning methods (Traditional Class room teaching, Information Technology based teaching aids, case study method, industrial training and projects etc.) and the choice of a particular learning method or combination of those depends on intra institution and inter institution factors. However, their appropriateness certainly influences the learning and teaching potential of the students and faculty. Similarly, curriculum quality and design is institution specific and depends on the competence of students and faculty. Modern day higher education imbibes the practice of flexible curriculum and regular revision of the same. Since, this study deals with professional education belonging to the disciplines of management and engineering therefore industry participation in curriculum development constitute an important element. 'Teaching and evaluation' sub attribute refers to quality of teaching and academic evaluation. This includes student perception of teaching

effectiveness and accuracy of academic evaluation as reflected from number of re-evaluation requests or display of answer sheets to students. 'Effective Learning and Teaching' as Core attribute signifies that this is indispensible for the purpose of quality grading of the higher education institutions and any attempt to eliminate this attribute will result into incorrect grading. The Rough Set analysis also generated two rules from heuristic method. The first rule establish that

If (Effective Learning and Teaching = excellent) then (Grade = excellent).

This rule indicates that if 'Effective Learning and Teaching' is 'excellent' then the resulting grade of the institution will also be 'excellent'. The strength (or accuracy) of this rule is 72.73 %.

Similarly, second rule states that

If (Effective Learning and Teaching = poor) and (Administrative Setup = poor) then (Grade = poor).

Thereby, indicating that if 'Effective Learning and Teaching' is 'poor' and also, 'Administrative Setup' is 'poor' then the resulting grade of the institution is also 'poor'. The strength (or accuracy) of this rule is 66.67 %.

In other words, the interpretation of second rule implies that the condition attribute 'Administrative Setup' must be poor along with 'Effective Learning and Teaching' in order to grade the institution 'poor'. It must be notices that Condition Attribute 'Administrative Setup' is second most significant attribute of the dataset containing nine condition attributes.

Condition Attribute: 'Administrative Setup'

This attribute includes three sub attributes i.e. 'Timely availability of information', 'Implementation of decisions' and 'Quality of support staff'. 'Timely availability of information' refers to quick, accurate and timely distribution of critical information to various stakeholders of the education system. This has different meaning for different persons, for example there is plethora of information such as examination date sheet, results declaration, shortage of attendance, change in class time table, change of guest lecture venue, new eligibility norms for admission, Campus placements, training schedule, sponsored research etc. which has different meaning for different persons. Similarly, speedy implementation of decisions is equally critical in a tightly packed academic schedule. Delayed decisions regarding students, faculty and support staff may tarnish the image of the institution and brings in a typical bureaucratic organizational culture. 'Quality of support staff' refers to the non teaching, administrative and ministerial employees who perform range of service like typing, accounting, finance, purchase, laboratory staff, engineering wing, transportation services and much more. Any compromise on this parameter may derail the education institution and cripple the academic functioning altogether. Moreover, there is tendency in institution to cut down the operating expenses and shift the administrative task to faculty who is primarily for research

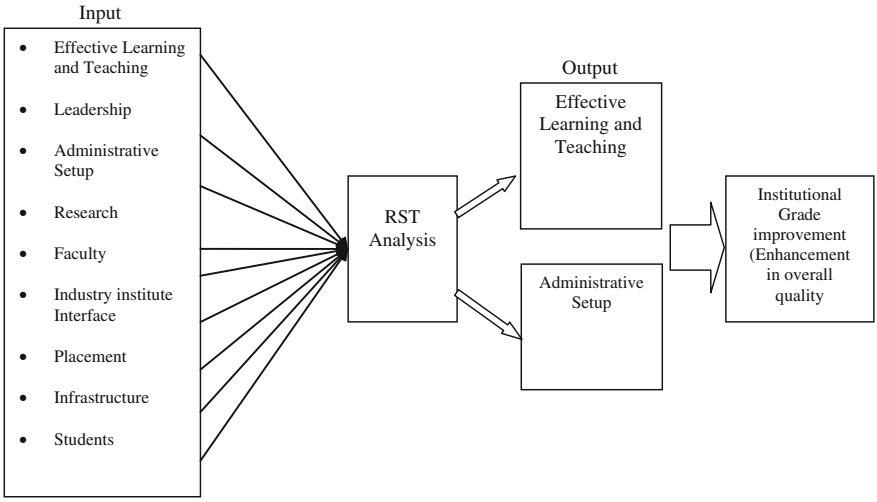

Fig. 3 RST based TQM model for higher education

and teaching. This may result into overburdened and disoriented faculty which ultimately leads to quality degradation.

According to the results of RST analysis the remaining seven condition attributes are lesser significant and therefore does not contribute much to the decision (Grading of the institution).

The proposed RST based TQM model emerges from the results of RST analysis as depicted in Fig. 3. Self assessment of quality parameters in higher education by three different stake holders, namely, faculty, students and staff are treated with RST analysis and two significant condition attributes emerges as the major pillars of this model. Grading of higher education institution may be improved if these two attributes are given maximum attention. However, this should not be interpreted that other attributes are meaningless but the outcome of this model reflects the RST approach of fine tuning the vague and uncertain data.

6 Conclusion

The last 5 years have seen a phenomenal surge in the popularity of global and local rankings of universities along with some complexities and problems (Hazelkorn 2011). The sudden rush for prestigious rankings and grading by different rating agencies has initiated a debate about their validity, accuracy and real worth. This ascertains the growing importance of institutional grading as an important measure of quality assessment in the highly competitive arena of global higher education. This research aims to contribute through the use of the proposed model to enhance the total quality education through a modified grading mechanism which is focused

exclusively on two parameters rather than bundle of vague parameters. It has been argued that TQM philosophy is based on customer defined quality concept which is unique to a business organization and poorly fits in the context of higher education which is sensitive to economic and social environment surrounding it. Opponents of TQM in higher education also reason that quality is subjective perception in education sector for students, faculty and other stakeholders whereas it has a definite meaning in business units producing goods and services for a specific customer. We disagree with this view as students employability is a major concern in professional education which in turns depends on skill sets of graduating students in tune with industry's expectation. Any mismatch at this stage (i.e. between education supplier and employers expectations) may defeat the entire purpose of higher education and may result into unemployable graduates who are a poor fit to the industry.

This model is an attempt to highlight the application of TQM approach and RST in improving the quality of professional higher education. Results are based on a country specific respondent's survey from engineering and management segments of higher education. In order to extend the results across the other segments of higher education a cross country survey may be conducted which is likely to give more generalized version of the proposed model. Further, similar research may be carried out with different set of TQM attributes and RST may be replaced by some other data mining tool.

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