RESEARCH ARTICLE OPEN ACCESS

Application of Quality Function Deployment in an Engineering College Using Analytical Hierarchy Process

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Abstract
Quality Function Deployment (QFD) technique as a TQM tool, has found wide applications in manufacturing as well as service industries. However its application and practice in educational institutes is still not popular. This paper based on the study in an engineering college is an attempt to demonstrate and encourage the application of QFD for planning and improvement of quality to gain competitive edge by satisfying student needs. The responses of 329 students and 35 faculties were obtained through a questionnaire. Importance ratings for student needs were calculated using AHP and pair wise comparison. These ratings were used for construction of relationship and correlation ship matrices and construction of HOQ. Goals for each customer requirements (CR) and technical requirements (TR) were set after competitive assessment of four other local colleges. All the four phases of QFD from planning to design, delivery and control were constructed. The outcomes of each HOQ suggest "How's" for each "What" and the importance rating for each of them, which can be used for reforming the quality of engineering education in the college under study.

Key Words- Quality Function Deployment, Customer's (Students/Faculty) Need Analysis, Prioritization of CR, House of Quality

I. INTRODUCTION

Quality is now a key competitive weapon to serve and attract primary customers (students) in engineering education due to the stiff challenge from the increasing number of domestic and foreign institutions. But quality is fuzzy as it means differently to different people at different times and in different environment. As a result any endeavor to improve quality becomes attractive and different Starting early at stone age tools, customized production of earth ware to inspection of mass produced items to quality assurance and quality of design, the history of quality improvement has matured with tools and techniques of TQM. Of the various quality tools and techniques, Quality Function Deployment (QFD) appeals most as a systematic and simple application to incorporate student needs in quality of education. Traditionally, in most nations, the needs of the students are planned at the highest level in the government. In India, the Ministry of Human Resource Development and its constituent bodies like University Grants Commission (UGC), All India Council of Technical Education (AICTE) and National Board of Accreditation (NBA) are the policy makers. National Policy on Education (NPE) 1986, revised 1997, includes the policies for technical education for the nation. AICTE lays down the norms like infrastructure, facilities, number of faculties, their qualifications, laboratories, equipment and other amenities in the college. Universities input the knowledge and know-how in the curriculum and other regulations for conduct of the programs. As per

Myron Tribus [11] these are the features of the designed quality for the technical colleges. However, quality is the way the features are delivered. Laboratories may be unkempt, equipment may not always work, and instructions may be poor It is the delivered quality that differentiates one college from the other. Tribus[11] is still right today about his observation that, though educators are among the first to write about new ideas, they are almost always the last to apply them to their own activities. Colleges of management remain ill managed and engineering institutions do not apply engineering methods to their own operations. Therefore the quality movement has still not made a dent in the universities and colleges. This study attempts to demonstrate application of QFD in an engineering college.

II. LITERATURE REVIEW

A. Concept of Quality Function Deployment (QFD)

Quality is generally viewed as "conformance to specifications or norms". The QFD philosophy moves away from this traditional view that "we know best what the students want" to a new culture of "let's hear the voice of the students" This allows the colleges to become more proactive rather than waiting for student complaints and doing crisis management. It also provides for comparison with other colleges (competitors) thus helping to establish

a competitive edge. To build or improve quality of education, the student requirements have to be service delivery to upstream at the service design stage. Student needs are expressed as *what* they want, usually in their own language without any implications of its feasibility. The college must figure out how these *what's* can be translated into *how's*, which are quantitative, measurable and actionable specifications. QFD is a technique that does this in a systematic way, using quality tools.

QFD was developed by Yoji Akao, during late 1960s in Japan with a purpose to satisfy customers (quality) by translating their needs into a design and assuring that all organizational units (function) work together to systematically break down their activities into finer and finer details that can be quantified and controlled (deployment). Glenn Mazur[1993], a pioneer in extending the application of QFD to service industries, brings out differences between traditional and modern quality systems and the importance of QFD. Traditional approach of ensuring "nothing wrong" does not mean that "everything is right". For example if there are no suggestions from the students it does not mean they are satisfied. The modern quality system maximizes positive qualities to create value through considered and addressed. This needs shifting of primary focus from the use of Kano model and suggests tools for service QFD like matrices, cause and affect analysis, affinity/relationship diagrams, Pareto diagram, AHP etc. QFD focuses on delivering value by seeking both spoken and unspoken needs, translating them into specifications and communicating them throughout the institute. QFD also allows students to prioritize their requirements, benchmark with competitors and optimize to gain greatest competitive advantage. Maguad, Ben A[[10] demonstrates the application of QFD in design of an undergraduate business program and insists that the college must first identify the customers (students, parents, faculty and other stakeholders), understand their expectations, and then serve them in meaningful ways. The voice of the students must be incorporated into the design and translated into academic specifications so that everybody can understand and uses it to align the processes to meet the needs of students first time and every time. Vivienne Bouchereau [18] views QFD as a visual connective process to help teams focus on the needs of the customers throughout the total development cycle of a product or service

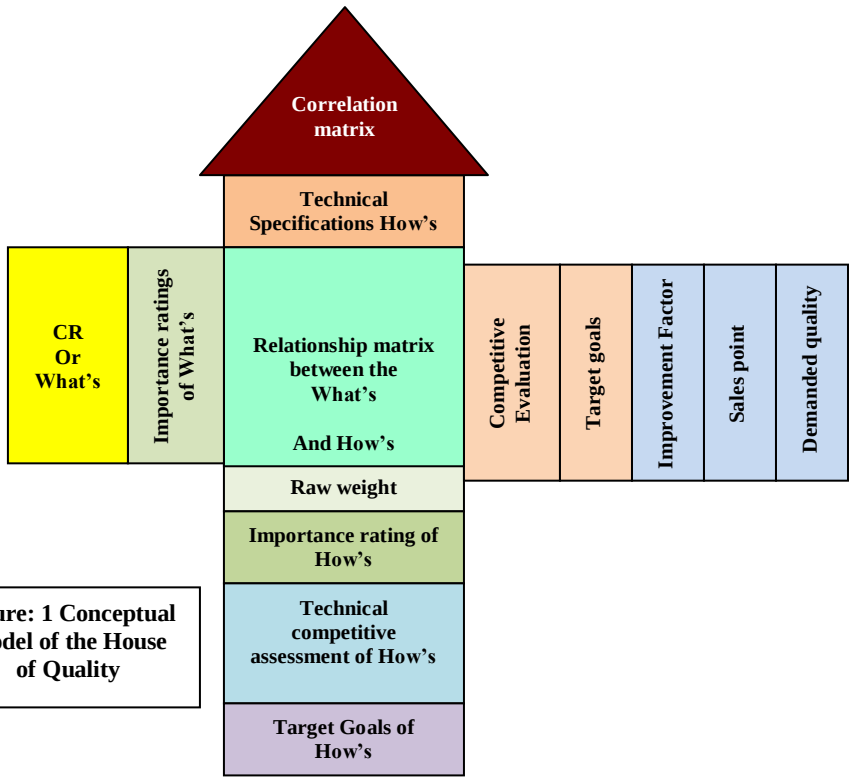

Figure: 1 Conceptual Model of the House of Quality

B .Process of QFD and the House of Quality (HOQ)

Step 1 Student's requirement**.** The starting point of any QFD is CR or SR (student's requirement) which is often non-measurable, such as academic environment/culture, teaching methods etc. These are prioritized and converted into technical specifications.

It is a matrix consisting of a vertical column of *what's* and a horizontal row of *How's*. *What's* are SR and *How's* are ways of achieving them. The matrix is generally known as the HOQ due to its

shape. The general QFD model includes the components shown in Fig1.

Step 2 Students importance ratings. The students provide numerical rankings to these *what's* in terms of their importance to them. A numerical ranking of 1-3-5- 9 is often used, where number 9 represents the most important and 1 the least. To cater for inconsistencies in human judgment, normally AHP with pair wise comparison or other methods can be used to convert rankings into importance ratings.

Step 3 Competitive evaluation A comparison is made between the own college and the competitors. Ranking scale of 1 -3- 9 or 1-3-5 is used which serve as the benchmark to establish a goal that we want to achieve for each SR. Dividing goal rating (where we want to be) by our current ranking (where we are now), an improvement ratio is calculated for each SR. Sales point is another weighting factor that shows which SR has more important effect on the marketing image of our college to ensure competitive advantage. By multiplying the importance rating with improvement factor and the sales point we can calculate raw (absolute) weight and then converting them into percentage we get the demanded quality for each SR.

Step 4 Technical requirements (TR) They are the specifications that are to be built into a service to satisfy SR.
Referred as *How's* they are the answers to SR as to how can the requirements be satisfied.

Step 5 Relationship matrix shows the relationship between SR and TR i.e. *what's* versus *How's*. It is the centre part of HOQ A weight of 1-3-9 or 1-3-5 is often used for representation of relationship. Graphical symbols may also be used.

Step 6 Correlation matrix is the the roof of the HOQ and is used to identify which *How's* are support each another and which are in conflict.. Negative correlation represents situation that will probably require trade-offs. The positive and negative ratings are usually quantified using 2, 1, -1, and -2 ratings or by symbols.

Step7 Importance ratings of *How.'* For each column, sum all the row-numbers, each of which is equal to the product of relationship rating and student's important rating. This is called raw weight which can be converted into relative weight (%) and importance ranking (1-3-5-7-9).

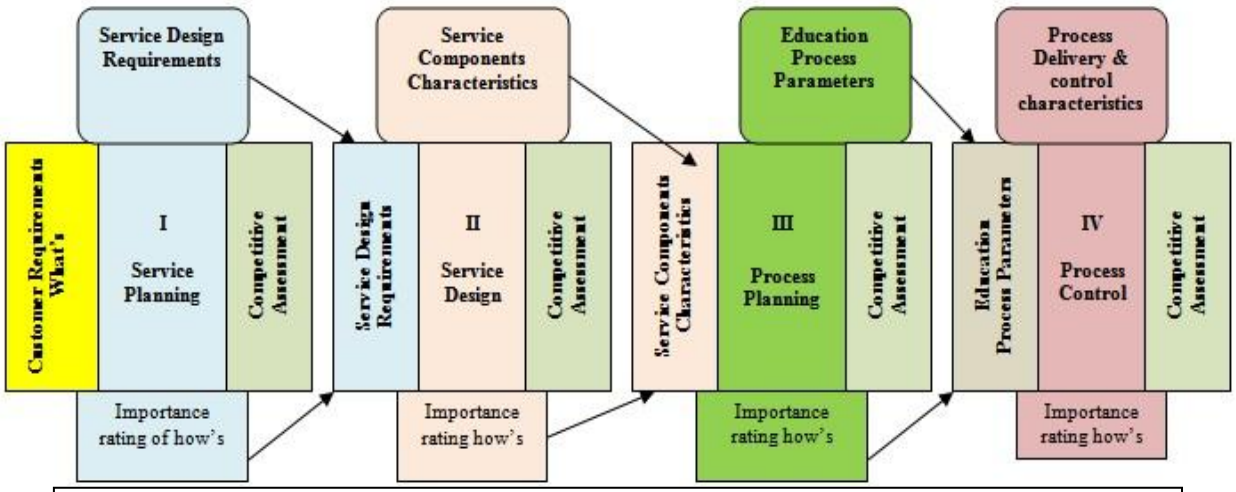

Figure: 2 Four phases of the House of Quality, adapted from Vivienne Bouchereau et al [2000]

Step 8 Technical competitive evaluation is similar to SR evaluation used for comparing own college with the competitors to find out if these TR are better or worse than competitors. Again, 1 to 5 or 1 to 9 ratings are used.

Step 9 Target goals of How's provide specific guidance for what have to be achieved and are quantified in order to be specific and actionable.

The complete QFD process involves four phases as shown at Fig: 2

C. The Customers of Engineering Education

An important step in QFD is identifying customers of education. There is however little agreement between the experts as to who are the true customers (students, faculty, parents or the employers). According to Vikram Singh [17] the commercial view that "customer (student) is always right" is not taken appropriately by the faculty as 'satisfaction of wants' does not necessarily lead to high quality education. This belief is based on the assumption that a happy student may be the one who just wants to pass and graduate, as opposed to actually learning and growing (long-term gain).

Despite the term we choose to use, the student is the primary component of the customers served by the college. However the other stakeholders must receive recognition and respect in the provider/consumer chain i.e. faculty, parents and the industry (employer or colleges of higher studies)

Nina Becket et [13] there is still no consensus on how best to measure and manage quality within higher education institutions because quality has different meanings for different stakeholders. While external stake holders are interested in quality assurance, the internal stakeholders value enhancement which is 'the process of taking deliberate steps at college level to improve the quality of learning opportunities'. G. Srikanthan and Dalrymple [6], are of the view that TQM model cannot be out rightly applied to Education and stress on the distinction between the two types of processes. First, is the services to the students from academic (like library, enrolment, examination) and general administration function (security, amenities, recreation, cafeteria). For these areas TQM is appropriate model similar to other services like banking or travel. Second, the teaching and learning functions for which TQM is inappropriate.

Anil R Sahu [1] holds the view that quality of technical education has two important aspects first – Design or inbuilt quality which includes curriculum and course material and second Manufactured or Delivered quality that depends on faculty's personal qualities, competence and performance learning and teaching activity.

E .Student's Need Analysis

Like any other service organization, the student needs vary and must be analyzed and structured for generating solutions. AICTE/NBA have identified eight parameters and given them weight ages to grade the institutes. These address the needs of the students as well as the quality of the education to be maintained by the colleges. Many authors have also researched this issue and listed the requirements as a measure of education quality. S. S. Mahapatra and M. S. Khan [15] have identified 28 attributes of quality under six dimensions based on the data collected across the country (India) from different institutes and the stakeholders like students, parents, recruiters through survey. These secondary data are quite useful in need analysis. However it is necessary to collect primary data from a particular college to get a more realistic information.

D. Quality of Engineering Education

The literature in the field of education is rich in information about quality of education. As per

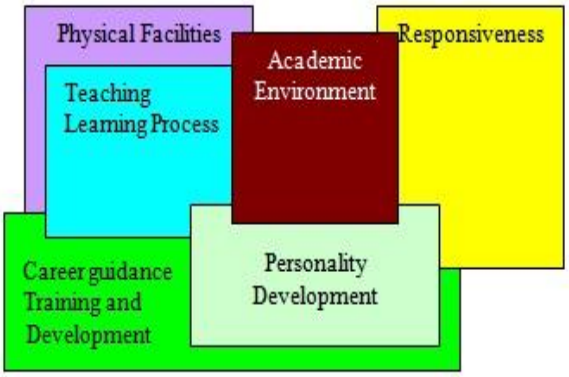

Fig: 3 Affinity diagram

F. Affinity Diagram

During the literature review and brainstorming sessions with the experts and other functions it was soon realized that the student needs may be quite large in numbers, which can make the exercise of construction of matrices too cumbersome and unwieldy. So these were organized and group them under six dimensions using affinity diagram (Fig 3).

G. Cause and Effect (CE) Diagrams

Glenn Mazur [4] argued that if causes of negative outcomes could be diagrammed, why can't the design elements that contribute to positive outcomes, such as customer needs, be identified the same way. This concept was used to analyze the student needs using cause and effect diagrams for six dimensions of quality, treating them as effect (positive quality) and finding out the causes through Cause (needs) to fulfill them. For example, to have good 'career guidance training and placement' students may demand continuous training and development, career counseling, entrepreneurship development and opportunities for placement. Further each of these four causes may have sub causes as shown in Fig 4. Similar diagrams were drawn for other five dimensions of quality to identify needs. However due to space constraint only one diagram has been shown here.

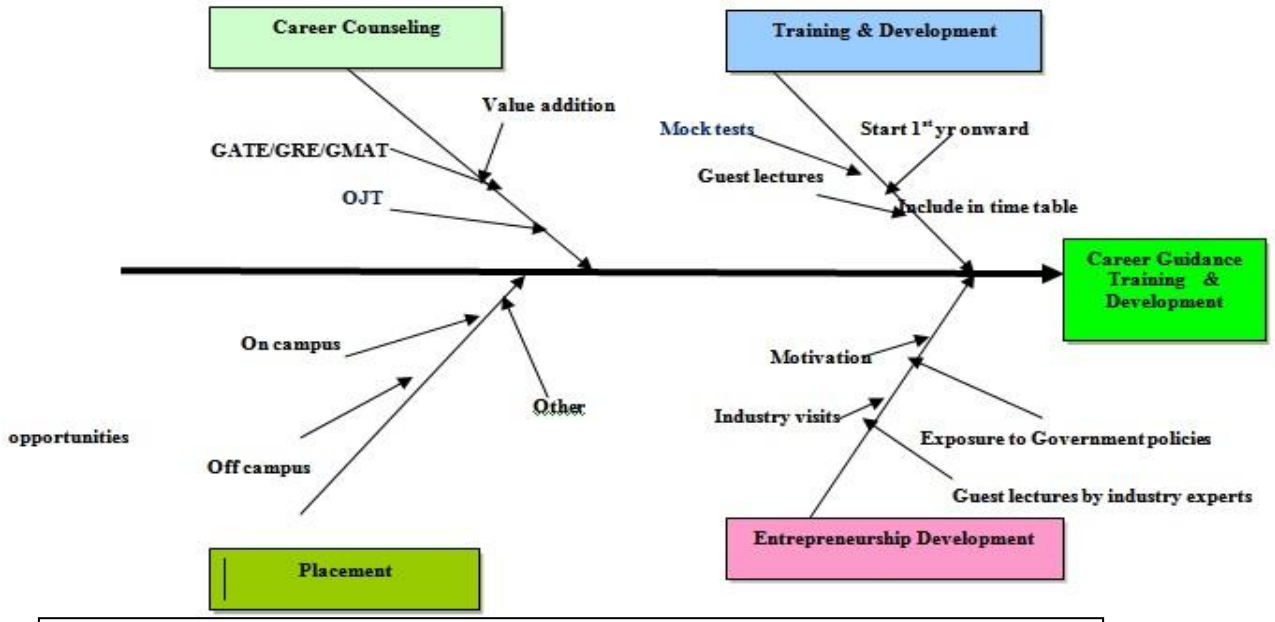

Figure: 4 Cause and Affect Diagram for need analysis: Career Guidance Training & Development

H. Relevance of the study

Published work on application of QFD in an engineering college is limited to the topics on curriculum design, vocational training, TQM etc. Only few papers are based on primary data on student needs and most QFD applications stop after the first matrix (HOQ).Though TQM has found wide acceptance, in India the contributions on application of QFD even for product design and manufacturing appears to be limited.. Possibly due to the classified nature of information about product design the work is not made public. Further the student needs like other commercial customers remain vague and change from time to time, country to country, within the country and even from college to college e.g. between Government and private colleges of engineering. Jeff Jawitz [7] found large variations in student needs between whites-blacks, male-female, other demographic and socio-political characteristics. Many students in South Africa and Western countries take admission in engineering as late as 25 years of age and not immediately after 12^{th} class as common in India. Therefore any attempt to apply QFD in an engineering college is likely to be unique and exciting. The study is also relevant in the current scenario of declining student satisfaction and standards of education

III. COLLECTION AND ANALYSIS OF DATA

A. Questionnaire.

To collect the primary data on student needs and opinions of the faculty a common questionnaire was designed. First six questions were on general demographic information. like branch of study, gender etc for establishing relationships. Seventh question was to familiarize the students with the dimensions of quality and to rank them in order of their priority. A brief was included to help them understand as to what items

Table: 1Voice of the students: Design of questionnaire
Question No 1 to 6: Demographic information.
Question No 7 : Ranking of quality dimensions
Academic environment Q8. Academic leadership and motivation is necessary for pursuit of excellence in an engineering college.
Responsiveness Q12 Actions on feedback and suggestions of students must be communicated to the students within seven days. Q14. College offices need to be prompt, responsive, efficient and courteous in providing services.
Facilities Q 9 Availability of infrastructure, services and their upkeep to generate sense of pride and satisfaction amongst students.
Personality Development Q13. Strategy for development of personality traits in students should be planned for the entire duration of the course.
Teaching Learning Process Q10**.** Faculty need to develop innovative methods to relate theory with practice and create interest of students in the subject. Q11.Habit of self learning needs to be developed in students through tutorials, assignments, projects and question –answers.
Career Training & Development Q15. Career guidance and placement information must be communicated to students from the 1^{st} year onwards. Q16. Training and development classes should be part of the time table and be realistic.
Q17. What should the college do to improve the attendance of the students?

contribute to these dimensions. Nine closed questions (No 8 to16) were asked for identifying the needs, where respondents were required to mark their choice on a scale, 1 to 9, one being strongly unfavorable (strongly disagree) and nine being strongly favorable (strongly agree). Last question, No 17 was open ended seeking their suggestions to improve the attendance of the students. Refer table 1. Questionnaire was tested on randomly chosen ten students and five faculties and was found appropriate.

B. Sampling Plan.

Universe to be covered was limited to 1375 students of one engineering college, from first year to final year covering all branches of engineering available in the college e.g. mechanical, civil, electronics & communication, computer science & engineering and information technology. Sample frame considered was year wise students. Sampling unit was 'the student/faculty' and method used was simple random.. Calculation of minimum sample size was done as per formula below: S Shajahan [21].

$n = p\ \% \times q\ \% \times [z/e\ \%]^2$. Where n- minimum sample size p- Proportion of abnormal response (specified category), q- Proportion of normal response., **z** -Value corresponding to level of confidence 95% = 1.96, e- Margin of error 5%,

$n = 20 \times 80 \times [1.96/5]^2 = 245$, Actual Samples collected- 329

Out of 329 responses, the gender distribution was 223 male and 106 female all under the age of 22. Majority of students (257) belonged to urban area, with only 72 students from rural background. Similarly only 30% students had taken loan for their study. The students were selected at random about 15 from each class of 60 students. Brief information about the purpose of study and the questionnaire was mentioned before taking responses.

Tables 2 and 3 show the responses of the students and faculty to the questionnaire no 8 to 16. We find differences in perceptions between faculty and the students especially on need question numbers 9, 12, and 14 (infrastructure, feedback and responsiveness).While students may have taken them as normal expectations from the college, the faculty take them as most important. Lower ranking of Q No 12 'response to student's feedback' by the faculty is a matter of concern. This is may be due to the fear of accepting criticism.

B. Prioritization of customer requirements

Determination of correct importance to SR is essential as they affect the target values of *How's,* the service characteristics. Prioritization of SR can be viewed as complex multi-criteria-decision making problem. Many methods have been devised to find importance rating. Simplest method is to get the ranking of importance from the students on a point scoring scale. However this method has been criticized as being too qualitative and not able to capture human perception effectively. Among the many multi criteria decision making techniques, like conjoint analysis, artificial neural network, fuzzy logic, AHP is more popular due to lesser complexity.

Table: 2 Student's Response to Need Questionnaire
(Ranking scale 1 to 9)

Needs → / Year ↓	Q8 ACAD LEADER SHIP	Q9 INFRA-STRUCTURE	Q10 METHODS OF TEACHING	Q11 SELF LEARNING	Q12 STUDENT'S FEEDBACK	Q13 PD STRATEGIES	Q14 RESPONSIVE ADMIN	Q15 PLACE-MENT INFO	Q16 REALISTIC TRG & DEVP
1st	528	546	580	576	526	552	548	596	524
Ranking	1	3	7	5	1	5	3	9	1
2 nd	586	520	656	554	638	604	628	656	878
Ranking	3	1	7	3	5	5	5	7	9
3rd	663	721	745	605	701	673	687	725	660
Ranking	3	7	9	1	7	5	5	9	3
4 th	455	464	547	441	523	521	527	545	213
Ranking	5	5	9	3	7	7	7	9	1
Total Points	2232	2251	2528	2176	2388	2350	2390	2522	2492
Ranking	3	3	9	1	5	5	5	9	7

Table: 3 Faculty Response to Student's Need Questionnaire (Ranking 1 to 9 scale)

Needs	Q8 ACAD LEADERSHIP	Q9 INFRA-STRUCTURE	Q10 METHODS OF TEACHING	Q11 SELF LEARNING	Q12 STUDENT'S FEEDBACK	Q13 PD STRATEGIES	Q14 RESPONSIVE ADMIN	Q15 PLACEMENT INFO	Q16 REALISTIC TRG & DEVP
Total Points	243	263	283	277	251	259	267	275	271
Ranking	1	7	9	9	3	5	7	9	7

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C. The Analytic Hierarchy Process.

AHP is a structured technique for dealing with complex decisions where the decision problem is first decomposed into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. Once the hierarchy is built, its various elements are systematically evaluated by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, one can use concrete data about the elements, or own judgments about the element's relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations**.** [Wikipedia] A numerical weight or priority is derived for each element of the hierarchy, allowing elements to be compared to one another in a rational and consistent way. In the final step of the process, numerical priorities are calculated for each of the decision criteria. These numbers represent the element's relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action.. The procedure for using the AHP can be summarized as:

1. Model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives.
2. Establish priorities among the elements of the hierarchy by making a series of judgments based on pair wise comparisons of the elements. For example, when comparing methods of teaching with responsiveness, students may prefer the former as extremely important.
3. Synthesize these judgments to yield a set of overall priorities for the hierarchy.
4. Check the consistency of the judgments.

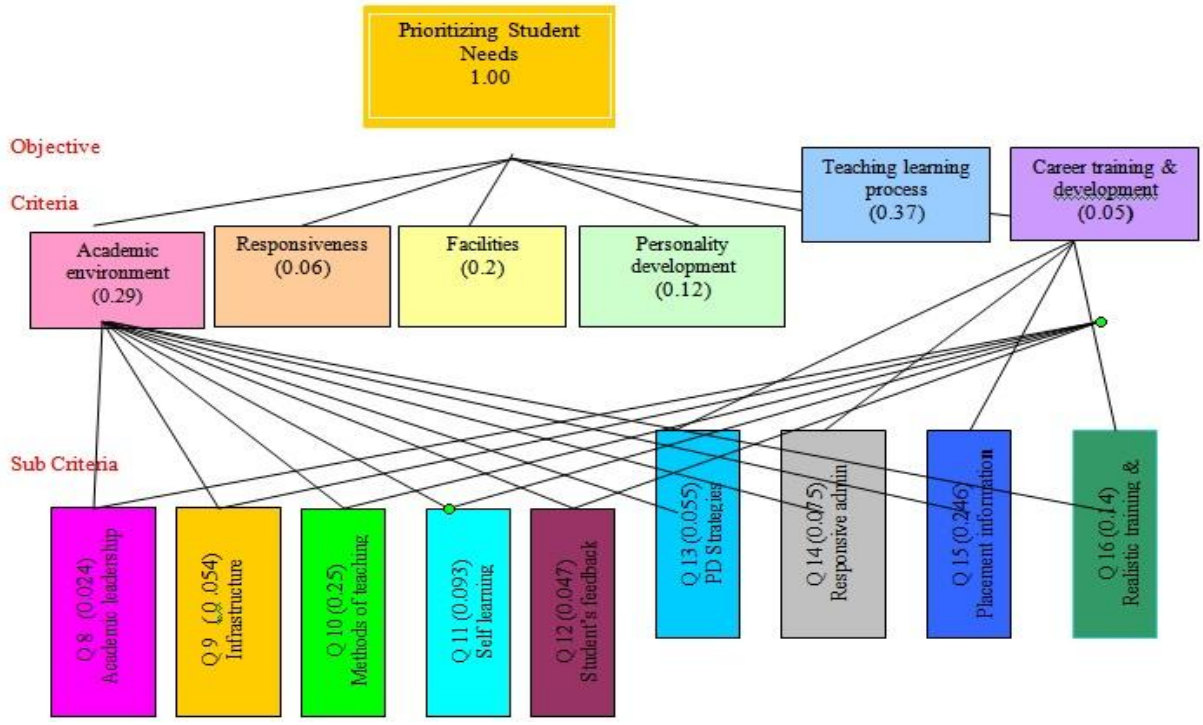


Fig 5 Analytical Hierarchy Process (AHP) (Only two relationships has been shown between criteria and sub criteria to avoid congestion)

In the context of this study, as the first step in the AHP, prioritizing student needs, the overall goal, was modeled as a *hierarchy*. In doing this, six dimensions of education were taken as the criteria for needs, and responses to the nine survey questions were formed as sub criteria Fig 5.

The hierarchy was analyzed through a series of *pair wise comparisons*. The criteria were pair wise compared against the goal for importance. The sub criteria were also pair wise compared against each of the criteria for preference. The comparisons were processed mathematically, and *priorities* were derived for each node. *Priorities* are numbers associated with the nodes of hierarchy. Like probabilities, priorities are absolute numbers between zero and one, without units or dimensions. For example a node with priority .200 is twice more importance than the one with priority .100, ten times the weight of one with priority .020, and so forth. Priorities are distributed over a hierarchy according to its architecture. Priorities of the Goal, the Criteria, and the Sub criteria are intimately related but need to be considered separately.

By definition, the priority of the Goal is 1.000. The priorities of the criteria or sub criteria always add up to 1.0. Since the responses to the survey questionnaire were obtained from both faculty and the students separate pair wise comparisons were conducted. The procedure was followed as given by Geoff Coyle [2004] Four matrices (two each for faculty and student responses) were constructed for six dimensions and nine responses to the need questionnaire i.e. two 6x6 and two 9x9 square matrices. Two elements were compared at a time with respect to each higher node based on the relative importance ranking derived from the responses and the judgment based on experience using a nine-point scale [Saaty,1980. For example consider the first row at Table 4, if the ranking of two elements A and D are 9 and 7 it was given a relative rating of 3 in the square AD. In the first row relative rating is 9 for 9-1 (AC), 7 for 9-3(AF), 5 for 9-5 (AB) and 3 for 9-7 (AD)

To calculate Eigenvector multiply together the entries in each row of the matrix and then take nth root of product. The nth roots are summed and that sum is used to normalize the eigenvector elements to add to 1.0. In the matrix at Table: 4, the 6th root of the product in the first row is 2.9 and that divided by the sum, 8.68 gives eigenvector as 0.33. Other values were calculated similarly.

Table: 4 Pair wise Comparison Matrix: Ranking of Needs by the Students

Initial Ranking	Attributes	9	5	1	7	9	3	nth root of product values	Eigen vector	Ranking	New vector	Eigen value λ max
Quality Dimensions		A	B	C	D	E	F					
Academic environment	A	1	5	9	3	1	7	2.9	0.33	9	2.14	6.49
Responsiveness	B	1/5	1	5	1/3	1/5	3	.77	0.088	5	.54	6.17
Facilities	C	1/9	1/5	1	1/7	1/9	1/3	.23	0.026	1	.15	6
Personality Development	D	1/3	3	7	1	1/3	5	1.47	0.16	7	1.05	6.6
Teaching Learning Process	E	1	5	9	3	1	7	2.9	0.33	9	2.14	6.4
Career Training & Development	F	1/7	1/3	3	1/5	1/7	1	.41	0.047	3	.28	6
								8.68			λ max=6.2	

The next stage is to calculate λ max (Eigen value) so as to further calculate Consistency Index (CI) CI and Consistency Ratio(CR). To do this we first multiply the matrix of judgments by their corresponding eigenvector, obtaining a new vector. New vector divided by the Eigen vector gives the Eigen value. For the first row it is:- 0.33+5x0.088+9x0.026+3x.0.16+0.33+7x0.047 = 2.143 (new vector) /0.33 (Eigen vector) =λ max= 6.49

The six new vectors (2.14,0 .54,0 .15, 1.05, 2.14, 0.28) in the matrix at Table:4 give n (6 in our context above) estimates of λ max (Eigen values). If any of the λ max is < n (6 in this case), it indicates error in calculation. In our case all values are within limits.

For the set of judgments the Consistency Index (CI) is = (λ max – n) / (n - 1) and the Consistency Ratio (CR) is calculated by dividing CI by an index given in table below (from Saaty's book).

n →	1	2	6	7	8	9	10

Index	0	0	1.24	1.32	1.41	1.45	1.49

Table: 5 Final weighted rating of Student Needs

Saaty [1980] argues that a CR > 0.1 indicates that the judgments are inconsistent and CR as high as 0.9 would mean

that the pair wise judgments are completely untrustworthy. Only one matrix of the pair wise comparisons has been shown here, however in all the four pair wise comparisons the Consistency Ratio was found well within the limit.

The values of Eigen vectors calculated for the faculty and the students responses are the importance ratings, which were weighted, in the ratio of 40:60 (faculty: student) after pair wise comparisons, to calculate the final rating. Refer Table 5 and Fig5 - AHP diagram. The final ratings of the student needs were used in construction of VOS matrix of the HOQ.

Needs/Attributes	Rating after pair wise comparison (EV)		Weighted Rating (EV)		Final Rating (EV)
	Faculty	Students	Faculty 40%	Students 60%	
Q8 Academic Leadership	.014	.03	.0056	.018	0.024
Q9 Infrastructure	.09	.03	.036	.018	0.054
Q10 Methods of Teaching	.21	.27	.084	.162	0.25
Q11 Self Learning	.21	.016	.084	.009	0.093
Q12 Student's Feedback	.02	.065	.008	.039	0.047
Q13 PD Strategies	.04	.065	.016	.039	0.055
Q14 Responsive Administration	.09	.065	.036	.039	0.075
Q15 Placement Information	.21	.27	.084	.162	0.246
Q16 Realistic Training and Development	.09	.173	.036	.1	0.14

IV. THE HOUSE OF QUALITY

Construction of the matrices of the HOQ is the most cumbersome process of calculations and iterations. Thanks to MS Excel 97 tool that it makes it easier than the time consuming manual process. Steps given in QFD process were followed for construction of the four HOQ 1 to 4. Note that *how's* of the first HOQ become *what's* for the next HOQ and Raw weights of TR in each house is used as importance ratings for the next HOQ.

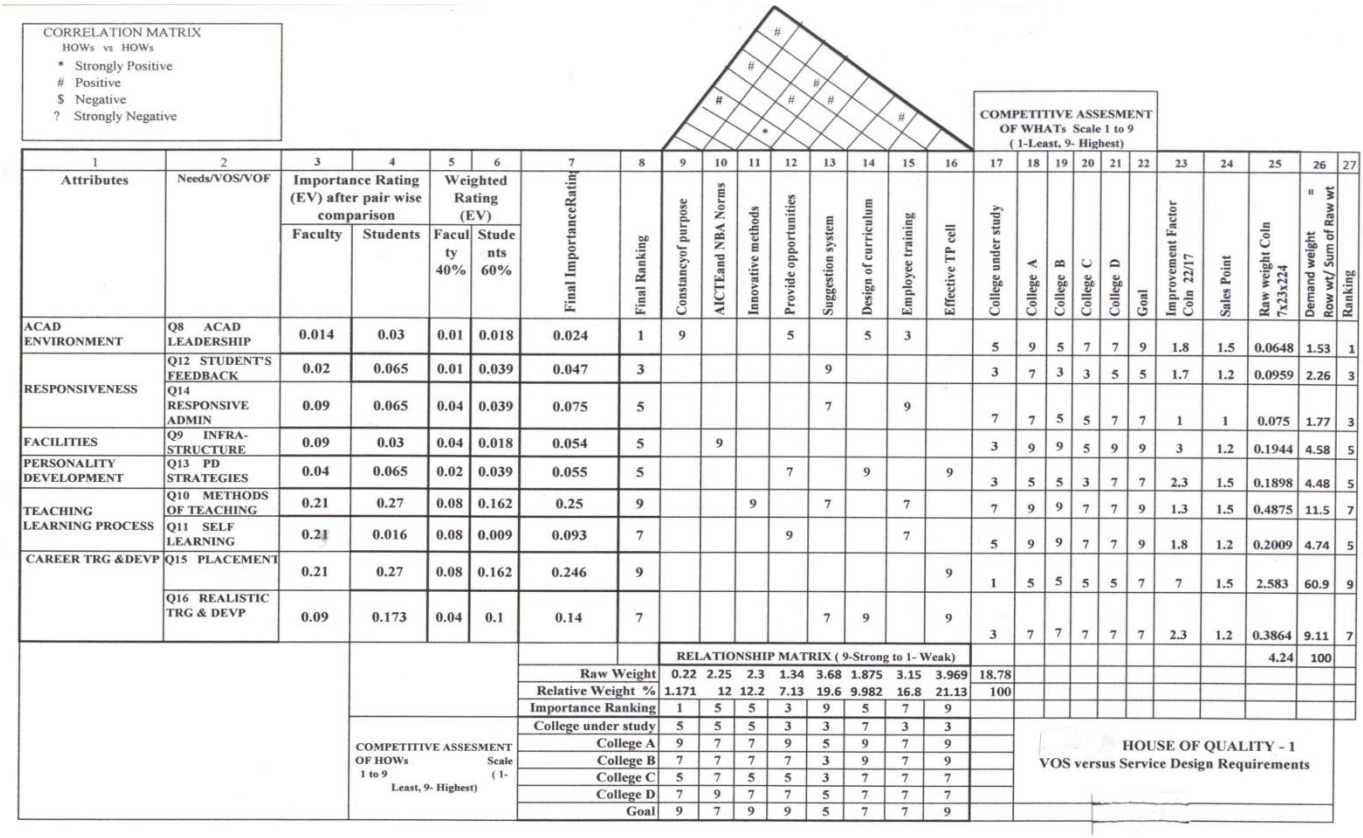
A .Outcomes of the Study

One of the major gains of this study was in generating and bringing together large amounts of useful data which could be organized in a structured and logical way. The word quality has been so extensively used every where in education from top to bottom that its appeal has diminished. What most experts strongly focus is on the 'designed quality' i.e. the curriculum, standards and norms, infrastructure, facilities, and grandeur of the buildings while the main purpose the teaching – learning process and the student's character building continues to suffer. Myron Tribus [11] is no wrong when he says 'what students actually expect is knowledge, know-how, wisdom and character'. It is so heartening that the outcomes of this study support his concept. The students have clearly mandated teaching- learning process, academic environment and the personality development on top of their expectations from the college. Students, like any customers in the commercial world, exactly know what they want from the education. Their responses to the questionnaire have been indeed very wise and mature.

The Voice of Students (VOS) has been identified explicitly as a result of structured analysis and prioritization of needs. Application of AHP and pair wise comparison provides good measure of consistency as CR were well within the limits, proving that the judgment ratings given by the students and the faculty were quite valid.

The study has highlighted the areas which need to be addressed on priority to attain a competitive advantage as well as the requirement of continuous assessment of the competitors and continuous improvement to delight the customers. The following needs of the students must be addressed on priority :

1. Career guidance and placement information must be continuously communicated to students from the 1st year onwards.(Importance ranking 9)
2. Ensure effectiveness of TP Cell (ranking 9).
3. TP Cell should interact with HOD and faculty on regular basis. Organize industry visits, training and career counseling for students.(ranking 9).
4. Plan and conduct GD/seminars/presentations/ language labs /sports and other activities on regular basis (ranking 9).
5. Conduct at least one FDP/staff development programs and encourage initiatives (ranking 9).
6. Training and development classes should be part of the time table and be realistic (ranking 7).



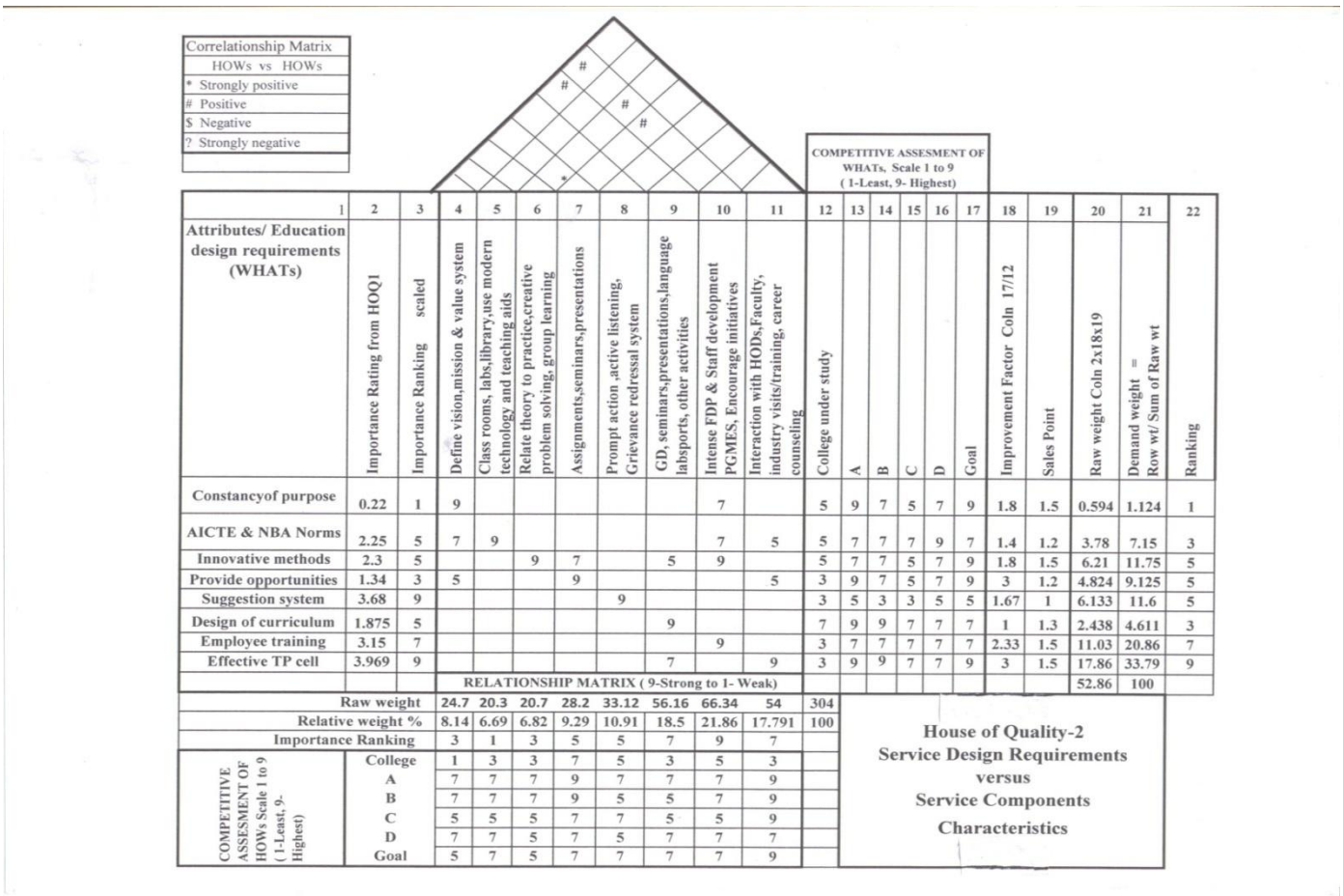
CORRELATION MATRIX
HOWs vs HOWs
* Strongly Positive
\# Positive
$ Negative
? Strongly Negative

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Attributes	Needs/VOS/VOF	Importance Rating (EV) after pair wise comparison		Weighted Rating (EV)		Final ImportanceRatin	Final Ranking	Constancyof purpose	AICTEand NBA Norms	Innovative methods	Provide opportunities	Suggestion system	Design of curriculum	Employee training	Effective TP cell	College under study	College A	College B	College C	College D	Goal	Improvement Factor Coln 22/17	Sales Point	Raw weight Coln 7x23x224	= Demand weight Row wt/ Sum of Raw wt	Ranking
		Faculty	Students	Faculty 40%	Students 60%																					
ACAD ENVIRONMENT	Q8 ACAD LEADERSHIP	0.014	0.03	0.01	0.018	0.024	1	9			5		5	3		5	9	5	7	7	9	1.8	1.5	0.0648	1.53	1
RESPONSIVENESS	Q12 STUDENT'S FEEDBACK	0.02	0.065	0.01	0.039	0.047	3					9				3	7	3	3	5	5	1.7	1.2	0.0959	2.26	3
	Q14 RESPONSIVE ADMIN	0.09	0.065	0.04	0.039	0.075	5					7		9		7	7	5	5	7	7	1	1	0.075	1.77	3
FACILITIES	Q9 INFRA-STRUCTURE	0.09	0.03	0.04	0.018	0.054	5		9							3	9	9	5	9	9	3	1.2	0.1944	4.58	5
PERSONALITY DEVELOPMENT	Q13 PD STRATEGIES	0.04	0.065	0.02	0.039	0.055	5				7		9		9	3	5	5	3	7	7	2.3	1.5	0.1898	4.48	5
TEACHING LEARNING PROCESS	Q10 METHODS OF TEACHING	0.21	0.27	0.08	0.162	0.25	9			9		7		7		7	9	9	7	7	9	1.3	1.5	0.4875	11.5	7
	Q11 SELF LEARNING	0.21	0.016	0.08	0.009	0.093	7				9			7		5	9	9	7	7	9	1.8	1.2	0.2009	4.74	5
CAREER TRG &DEVP	Q15 PLACEMENT	0.21	0.27	0.08	0.162	0.246	9								9	1	5	5	5	5	7	7	1.5	2.583	60.9	9
	Q16 REALISTIC TRG & DEVP	0.09	0.173	0.04	0.1	0.14	7					7	9		9	3	7	7	7	7	7	2.3	1.2	0.3864	9.11	7
								RELATIONSHIP MATRIX (9-Strong to 1- Weak)																4.24	100	
						Raw Weight		0.22	2.25	2.3	1.34	3.68	1.875	3.15	3.969	18.78										
						Relative Weight %		1.171	12	12.2	7.13	19.6	9.982	16.8	21.13	100										
						Importance Ranking		1	5	5	3	9	5	7	9											
						College under study		5	5	5	3	3	7	3	3											
						College A		9	7	7	9	5	9	7	9											
						College B		7	7	7	7	3	9	7	9											
						College C		5	7	5	5	3	7	7	7											
						College D		7	9	7	7	5	7	7	7											
						Goal		9	7	9	9	5	7	7	9											

COMPETITIVE ASSESMENT OF HOWs Scale 1 to 9 (1-Least, 9- Highest)

COMPETITIVE ASSESMENT OF WHATs Scale 1 to 9 (1-Least, 9- Highest)

HOUSE OF QUALITY - 1
VOS versus Service Design Requirements



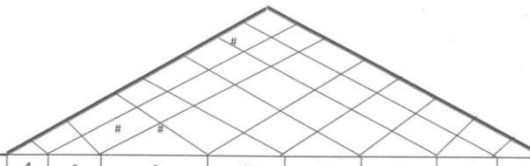
Correlationship Matrix
HOWs vs HOWs
* Strongly positive
\# Positive
$ Negative
? Strongly negative

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Attributes/ Education design requirements (WHATs)	Importance Rating from HOQ1	Importance Ranking scaled	Define vision,mission & value system	Class rooms, labs,library,use modern technology and teaching aids	Relate theory to practice,creative problem solving, group learning	Assignments,seminars,presentations	Prompt action ,active listening, Grievance redressal system	GD, seminars,presentations,language labsports, other activities	Intense FDP & Staff development PGMES, Encourage initiatives	Interaction with HODs,Faculty, industry visits/training, career counseling	College under study	A	B	C	D	Goal	Improvement Factor Coln 17/12	Sales Point	Raw weight Coln 2x18x19	Demand weight = Row wt/ Sum of Raw wt	Ranking
Constancyof purpose	0.22	1	9						7		5	9	7	5	7	9	1.8	1.5	0.594	1.124	1
AICTE & NBA Norms	2.25	5	7	9					7	5	5	7	7	7	9	7	1.4	1.2	3.78	7.15	3
Innovative methods	2.3	5			9	7		5	9		5	7	7	5	7	9	1.8	1.5	6.21	11.75	5
Provide opportunities	1.34	3	5			9				5	3	9	7	5	7	9	3	1.2	4.824	9.125	5
Suggestion system	3.68	9					9				3	5	3	3	5	5	1.67	1	6.133	11.6	5
Design of curriculum	1.875	5						9			7	9	9	7	7	7	1	1.3	2.438	4.611	3
Employee training	3.15	7							9		3	7	7	7	7	7	2.33	1.5	11.03	20.86	7
Effective TP cell	3.969	9						7		9	3	9	9	7	7	9	3	1.5	17.86	33.79	9
			RELATIONSHIP MATRIX (9-Strong to 1- Weak)																52.86	100	
Raw weight			24.7	20.3	20.7	28.2	33.12	56.16	66.34	54	304										
Relative weight %			8.14	6.69	6.82	9.29	10.91	18.5	21.86	17.791	100										
Importance Ranking			3	1	3	5	5	7	9	7											
COMPETITIVE ASSESMENT OF HOWs Scale 1 to 9 (1-Least, 9- Highest)	College		1	3	3	7	5	3	5	3											
	A		7	7	7	9	7	7	7	9											
	B		7	7	7	9	5	5	7	9											
	C		5	5	5	7	7	5	5	9											
	D		7	7	5	7	5	7	7	7											
	Goal		5	7	5	7	7	7	7	9											

COMPETITIVE ASSESMENT OF WHATs, Scale 1 to 9 (1-Least, 9- Highest)

House of Quality-2
Service Design Requirements
versus
Service Components
Characteristics

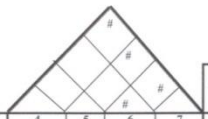
CORRELATIONSHIP MATRIX
HOWs vs HOWs
* Strongly positive
# Positive
$ Negative
? Strongly negative



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Attributes/ Education component characteristics (WHATs)	**Importance Rating from HOQ 2**	**Importance Ranking**	**Brainstorm with core team, align with NPE/NBA**	**Upkeep,maintenance of CR, labs, audiovisual aids, virtual CR facilities**	**Identify practical examples/ case studies, form groups,incorporate students' experience, observations of others, personal ideas and feelings**	**Give challenging assignments,make students to organize seminars, presentations**	**SOP on students feedback,support open exchange, sharing of opinions, and problem-solving strategies**	**Include these activities in time table from 1st yr onwards & ensure implementation**	**Atleast one FDP/Sem/Department, recognition & reward**	**Organize formal meetings with HODs/Faculty, comn to all includig students of 1st yr**	**College under study**	**A**	**B**	**C**	**D**	**Goal**	**Improvement Factor Coln 17/12**	**Sales Point**	**Raw weight Coln 2x18x19**	**Demand weight = Row wt/ Sum of Raw wt**	**Importance Ranking**
Define vision,mission & value system	24.7	3	9						5		1	7	7	5	7	5	5	1.2	148.2	16.035	7
Class rooms, labs,library,use modern technology and teaching aids	20.3	1		9	5						3	7	7	5	7	7	2.33	1.3	61.58	6.6624	5
Relate theory to practice,creative problem solving, group learning	20.7	3			9		5				3	7	7	5	5	5	1.67	1.5	51.75	5.5992	3
Assignments,seminars,presentations	28.2	5				9					7	9	9	7	7	7	1	1	28.2	3.0511	1
Prompt action ,active listening, Grievance redressal system	33.12	5					9				5	7	5	7	7	7	1.4	1.2	55.64	6.0202	5
GD, seminars,presentations,language lab sports, other activities	56.16	7						9			3	7	5	5	7	7	2.33	1.5	196.6	21.267	9
Intense FDP & Staff development programs, Encourage initiatives	66.34	9							9		5	7	7	5	7	7	1.4	1.5	139.3	15.073	7
Interaction with HODs,Faculty, industry visits/training, career counseling	54	7								9	3	9	9	9	9	9	3	1.5	243	26.292	9
			RELATIONSHIP MATRIX (9-Strong to 1- Weak)																924.2	100	
Raw weight			2.22	1.82	2.87	2.53	4.01	5.05	7.2	4.86	30.56										
Relative weight %			7.264	5.95	9.39	8.27	13.12	16.52	23.5	15.9	99.91										
Importance Ranking			3	1	5	3	5	7	9	7											
COMPETITIVE ASSESMENT OF HOWs Scale 1 to 9 (1-Least, 9- Highest)	**Own College**		3	5	5	7	7	7	5	5											
	College A		7	7	7	9	7	5	7	7											
	College B		7	7	7	7	7	7	5	7											
	College C		5	5	5	7	5	7	7	7											
	College D		7	7	5	7	5	7	7	7											
	Goal		7	7	7	7	7	9	9	7											

House of Quality 3
Service Components Characteristics *versus* Process Parameters

CORRELATION MATRIX
HOWs vs HOWs
* Strongly positive
# Positive
$ Negative
? Strongly negative



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Attributes/ Education Process Parameters (WHATs)	**Importance Rating from HOQ 3**	**Importance Ranking**	**Continuous monitoring , take periodic survey & feedback by the top mgt**	**Continuous monitoring and checks**	**Academic monitoring committee, identify gaps & revise training needs**	**Under direct control of the Director, periodic reporting**	**College under study**	**A**	**B**	**C**	**D**	**Goal**	**Improvement Factor12/8**	**Sales Point**	**Raw Weight**	**Demand Weight**	**Importance Ranking**
Brainstorm with core team, align with NPE/NBA	2.22	3	9				3	7	7	5	7	7	2.33	1.2	6.216	10.7	5
Upkeep,maintenance of CR, labs, audiovisual aids, virtual CR facilities	1.827	1		9			5	7	7	5	7	7	1.4	1	2.558	4.4	1
Identify practical examples/ case studies, form groups,incorporate students' experience, observations of others, personal ideas and feelings	2.87	5			9		5	7	7	5	5	7	1.4	1.5	6.027	10.4	5
Give challenging assignments,make students to organize seminars, presentations	2.53	3			9		7	9	7	7	7	7	1	1.2	3.036	5.22	3
SOP on students feedback,support open exchange, sharing of opinions, and problem-solving strategies	4.01	5			9		7	7	7	5	5	7	1	1.2	4.812	8.27	3
Include PD activities in time table from 1st yr onwards & ensure implementation	5.05	7			9		7	5	7	7	7	9	1.29	1.5	9.739	16.7	7
Atleast one FDP/Sem/Department, recognition & reward	7.21	9			9		5	7	5	7	7	9	1.8	1.2	15.57	26.8	9
Organize formal meetings with HODs/Faculty, comn to all includig students of 1st yr	4.86	7				9	5	7	7	7	7	7	1.4	1.5	10.21	17.5	7
			RELATIONSHIP MATRIX (9-Strong to 1- Weak) WHAT vs HOW												58.17	100	
	Raw Weight		19.98	16.44	185.76	43.74	266										
	Relative weight		7.51	6.182	69.8556	16.4486	100										
	Ranking		3	1	9	7											
COMPETITIVE ASSESMENT OF HOWs Scale 1 to 9 (1-Least, 9- Highest)	**Own College**		3	5	5	7											
	A		7	7	7	9											
	B		7	7	7	7											
	C		5	5	5	7											
	D		7	7	5	7											
	Goal		7	7	7	7											

House of Quality 4
Process Parameters versus Process Delivery & control characteristics

7. Faculty should develop innovative methods to relate theory with practice and create interest of students in the subject. (ranking 7).
8. Employee training (ranking 7).
9. Define vision, mission and value system of the college (ranking 7).
10. Achieve these actionable goals through delegation and continuous monitoring and establishing control points.

V. CONCLUSION

QFD is a customer driven approach to quality planning and development. It can be applied to both to the product development and the services. QFD can be used to improve all university and college level education activities from course design to delivery of the teaching. The study has demonstrated that the concepts of QFD can be well applied to the services and in particular to engineering education to plan, design, deliver and control various parameters to enhance satisfaction, delight the students and gain competitive advantage. The student's need analysis and HOQ developed can help a college set priorities for subsequent improvement. QFD considers both tangible and intangible aspects and results can be utilized for academic reforms in any educational institute

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