Case Study: Using Quality Function Deployment to Meet ABET 2000 Requirements for Outcomes Assessment

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I. Introduction

During the 1997-98 Academic Year the Industrial and Manufacturing Engineering Department Faculty formed an ABET Outcomes and Assessment Team to address issues related to program objectives, outcomes, and assessment in preparation for our accreditation visit scheduled for Fall 1999. The following options for approaching the ABET 2000 criteria and process were considered:

Strategic Planning – Classical strategic planning is not far off from being a model that could be used for outcomes assessment. Kaufman, in his book <u>Educational Planning: Strategic, Tactical, and Operational</u>, proposes "mega-strategic planning" for educational institutions[1]. In this framework constituencies are asked to help define specific "skill, knowledge, attitude, and ability requirements" (called SKAA's) which drive sequencing and curriculum requirements.

Malcolm Baldrige National Quality Award Criteria – The MBNQA criteria has been adapted for educational institutions and could be adapted and used for educational assessment and planning. Core values in the MBNQA process are very compatible with outcomes assessment The advantage of the adopting this methodology is the future potential for external auditor assessment and comparing to best practices of other institutions.

Total Quality Management (TQM) - In 1992 the IME Department used a combinations of several of the tools to develop a new manufacturing engineering curriculum. "Voice of the customer" from QFD, affinity diagrams, and interrelationship charts were used with excellent results[2]. Kaufman also proposes a more comprehensive approach to TQM for educational planners called QM+[1].

Quality Function Deployment (QFD) – QFD is an excellent, efficient approach for identifying the "voice of the customer" and designing an efficient system around their requirements. QFD has been widely adapted ever since for use in government, education, and the non-profit sector at large. The originator of QFD, Prof. Yoji Akao, has even proposed some developments along these lines[3].

The common denominators among these methodologies that make them good candidates for use for ABET assessment are: Sensitivity to the “Voice of the Customer”, stakeholders are identified and needs considered, “Outcomes” are based on stakeholder expectations, process orientation, and participation from all levels of the organization.

The team decided to propose QFD as the primary methodology[4]. This recommendation was enthusiastically supported by the full IME faculty. Adaptations and enhancements were made using features from some of the other methodologies where it made sense to do so. A QFD team was formed and included representatives from IME Department Industrial Advisory Council and the College of Engineering. The team met regularly for five quarters to work through the QFD process and present findings. ABET assessment updates were on the Industrial Advisory Council Agenda and discussed at department meetings. QFD practitioners will notice that a modified version of QFD was used to simplify the process. Not all rating and ranking algorithms were employed.

The project was divided up into phases:

Phase I - The Voice of the Customer - The IME Department recognized a number of constituencies or “customers” that need to be considered in all curriculum, scheduling, and program related decisions. This process identified eighteen customers.

Phase II - Program Objectives and Outcomes - Program outcomes were developed in line with program objectives and stakeholder requirements. Twenty-four areas of skill, knowledge, attitude and ability (SKAA’s) were developed.

Phase III – QFD Implementation - Five QFD Matrices were decided upon: (1) Stakeholder vs. SKAA, (2) SKAA vs. Core Course (for each major), (3) SKAA vs. Methodology, (4) SKAA vs. Assessment Tool, and (5) Assessment Tools vs. Core Courses (for each major). Changes were made to many courses by adding components to bolster SKAA’s and removing material that was not customer oriented. Department strategy was developed for implementing department-wide feedback, developing department-supported teaching methodologies, and for reviewing the process itself on a regularly scheduled basis.

Phase IV - Action Planning - A schedule was produced for planning and tracking the process.

The purpose of this paper is to give a step-by-step explanation of the process that was followed and examples that clearly illustrate the results. As other institutions over the next six years embark on their journey to address the same issues, this paper could become a helpful reference.

II. IME Department QFD Project

Phase I – The Voice of the Customer - The Industrial and Manufacturing Engineering Department recognizes a number of constituencies or “customers” that need to be considered in all curriculum, scheduling, and program related decisions. Also, within each constituency below there may be sub-groups in various ways. For purposes of planning and program development, some constituencies are more important than others. The IME ABET Outcomes and Assessment Team has broadly defined stakeholders (constituencies) to be:

1. Those we serve;
2. Those who use our graduates; and
3. Those who regulate us.

Kaufman has a very similar list of constituents for educational institutions[5]:

1. Citizens, taxpayers, residents, and members of the society and community.
2. The school or school system itself
3. Individuals or small groups – internal clients (teachers, learners, lobbyists, unions)

This process identified eighteen customers. Each customer was subjectively rated based on importance using a 9-3-1-0 scale (9 being "most important"). The results are as follows:

Customers	Importance rating
Students (& Alumni)	9
University Administration/CSU	9
Manufacturing sector companies	9
ABET (accrediting agency)	9
State Govt	9
Other faculty/depts	3
Parents of students	3
Service Companies	3
Professional Engineer (Registration)	3
ASQ (Certification)	3
SME (Certification)	3
Grad schools	1
General Public	1
Granting agencies	1
Public sector employers	1
Information sector companies	1
WASC	1
APICS	1

Note, for instance, the high ranking of ABET (Accreditation Board for Engineering and Technology) on the list. Without ABET accreditation, our program would not be marketable to incoming students and would not be officially recognized by graduate schools and many employers. Without ABET accreditation the IME program would be a candidate for elimination by the campus administration.

Phase II - Program Objectives and Outcomes - The current IME Department Mission Statement was developed in 1994 during participation in campus-wide strategic planning. :

1. To serve the university, the community, and our alumni by offering ABET accredited degree programs and courses that prepare students for study at both the undergraduate and graduate level.

2. To teach sound engineering principles, ethics and theory supported with significant classroom, laboratory and industrial experiences to a diverse student population. Our goal is to prepare students for immediate and productive entry into today's workplace or the best graduate schools.

3. To continuously improve the curriculum, faculty, scheduling, advising, teaching methods, facilities, and student services while maintaining safety of students, faculty, and staff as a top priority.

4. To educate the general public about the exciting fields of industrial and manufacturing engineering and the opportunities available at Cal Poly Pomona.

5. To develop and expand the industrial base in the Southern California area.

The mission statement is at the heart of the IME Department's Program Objectives. For the general public and other stakeholders who refer to the Cal Poly Pomona Catalog, the objectives are published as follows:

1. Prepare the student to function and provide leadership in today's highly technical environment;

2. Enhance the student's ability to communicate by oral, graphic, written and electronic means to describe engineering challenges and their solutions;

3. Prepare students to solve unstructured problems through analytical means and to synthesize, analyze, and critically evaluate their solutions;

4. Develop a knowledge of and appreciation for the solution of engineering problems through the use of teams;

5. Instill the habit of life-long learning and professional growth in engineering practice;

6. Develop the competence in the chosen discipline to assure that the graduate possesses the methodological and computational skills necessary to succeed in that field; and

7. Assure that the graduate appreciates the moral, ethical and legal implications of engineering decisions.

Kaufman looks at program objectives in the strategic planning sense as "needs" or, if at the process level, "quasi-needs" and defines various levels of needs (objectives)[6]. Below are the IME Department's program objectives from above categorized by these levels for internal use (detailed descriptions are omitted):

1. **Mega/Societal Level –** Do you care about and commit to deliver the success of learners after they leave your educational system and are citizens? (Mission Statement #2 & #5, Objectives #1, #2, #3, #4, #5, #6, #7).

   Employer satisfaction
   Lifelong learning and professionalism
   Graduate Satisfaction
   Community Involvement

2. **Macro/Organizational –** Do you care about and commit to deliver the quality—competence—of the completers when they leave your educational institution? (Mission Statement #1).

   Number of Graduates
   EIT Exam/Certification
   Job Placement.

3. **Micro/Individual Level -** Do you care about and commit to deliver the specific skills, knowledge, attitudes, and abilities of the learners as they move from course to course, and level to level? (Mission Statement #1, & #2, Objectives #2, #3, #4, #5 & #6).

   SKAA's – The IME Department has identified 24 "Skill, Knowledge, Attitude, and Ability" outcomes using Quality Function Deployment. These are also "Program Outcomes" for purposes of outcomes assessment and accreditation.

4. **Operational/Process –** Do you care about and commit to deliver the efficiency of your educational programs, activities, and methods? (Mission Statement #3).

   Course Offerings
   Reduce Student Attrition

5. **Inputs/Resources -** Do you care about and commit to deliver the quality and availability of your educational resources, including human, capital, financial, and learning? (Mission Statement #1 & #3).

   Laboratory Revitalization Program.
   Industrial Advisory Council (IAC)

6. **Evaluation/Continuous Improvement –** Do you care about the worth and value of your methods, means, and resources? Do you care about the extent to which you have reached your educational objectives? (Mission Statement #3).

   Assessment Surveys
   Curriculum Review

Using these categories to organize the IME Program Objectives, efforts were made to integrate these levels as much as possible so that the lower level objectives ultimately support the upper level objectives. The following section explains the methodology employed for this effort.

Program Outcomes - The next step was the development of program outcomes in line with program objectives and stakeholder requirements. To start with, a list of skill, knowledge, attitude, and ability requirements was developed using the following sources:

1. The IME Department adopted ABET outcomes known as "a – k" paraphrased below:

    a. Ability to apply knowledge
    b. Ability to design and conduct experiments and interpret data
    c. Ability to design a system
    d. Ability to function on an interdisciplinary team
    e. Ability to solve engineering problems
    f. Understanding of professional and ethical responsibility
    g. Ability to communicate effectively
    h. Understand global and societal impact of engineering solutions
    i. Lifelong learning
    j. Knowledge of contemporary issues
    k. Ability to use the techniques, skills, and modern engineering tools

2. **The Manufacturing Engineering Plan published in 1996 by the Society of Manufacturing Engineers -** Fourteen "Competency Gaps" were identified by SME. Six of the competency gaps corresponded to the "a-k" outcomes: communication skills, teamwork, personal attributes, manufacturing principles, statistics and probability, and lifelong learning. Eight competency gaps were not duplicates and were adopted by the IME Department and placed on the outcomes list:

    l. Project management
    m. Business skills
    n. Change management
    o. Materials and their properties
    p. Product and process reliability
    q. Manufacturing processes
    r. Quality principles
    s. Ergonomics

3. **Other Sources –** After looking at program specific criteria, work done with curriculum development in 1992, and the IME Department and university mission statements, the following additional outcomes were added to the list:

    t. Operations Research
    u. Knowledge of manufacturing systems
    v. Working knowledge of basic and engineering sciences
    w. Employability

x. Attitude of Social Responsibility

This list was considered to be appropriate for both Industrial and Manufacturing Engineers with the expectation that differences would appear in emphasis and degree of importance within each discipline.

Phase III – QFD Implementation

QFD Matrices – After researching various sources, the following five QFD Matrices were decided upon[7]:

Matrix 1: Stakeholder vs. SKAA – An 18x24 matrix was used to evaluate the importance of each SKAA for each stakeholder. This process identified which SKAAs are the most important overall. The result is a ranking that include the importance weighting for each stakeholder.

Matrix 2: SKAA vs. Core Course (for each major) – Using SKAA's ranked from most important to least important, all core courses in each major was evaluated to see what the current SKAA coverage was for each. Column totals reveal how much each individual course covers SKAA's. Each row total shows how much each SKAA is covered in the curriculum. The rankings of SKAA row totals compared to stakeholder ranking reveals both areas of strength and potential weakness in the curriculum.

Matrix 3: SKAA vs. Methodology – The IME faculty developed a complete list of current, and potential teaching methodologies. Each methodology was evaluated against each SKAA for "potential" effectiveness and assessment capability. The resulting rankings indicate which methodologies have the most *potential* benefit in achieving and evaluating desired outcomes. Some methodologies are easily implemented by individual faculty members on a discretionary basis. However, the main benefit of the results of this assessment are to identify methodologies that require department support and standardization. These methodologies need to be considered in future planning. The faculty used these findings to identify department supported educational methods and practices.

Matrix 4: SKAA vs. Assessment Tool – The IME Assessment Team put together a list of existing and potential assessment tools. This list was presented to the faculty and modified. Each assessment tool was rated for its potential effectiveness in assessing the degree to which each SKAA has been effectively taught. Individual and department assessment tools were included. These results are important to decide which assessment tools should be supported at the department level and planned for in advance.

Matrix 5: Assessment Tools vs. Core Courses (for each major) - Using the list of assessment tools decided as being the most appropriate and effective, each core course was rated as for the potential effectiveness of the tool. This matrix gives each faculty member a more complete list of assessment options for the courses taught.

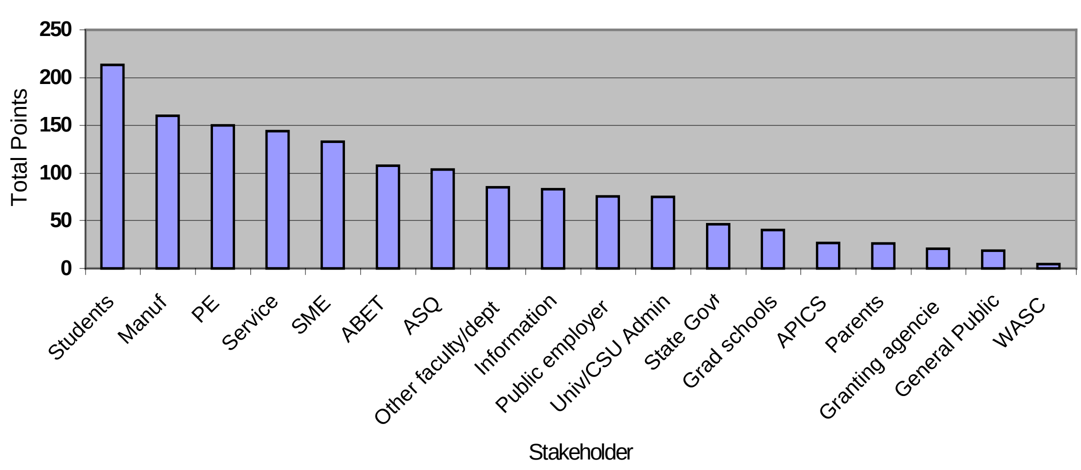
Prior Assessment– The results of the previous alumni and industry surveys was used to generate some of the requirements for the matrices and weights used. Comments as well as ranked data were considered. The overwhelming thrust of previous surveys was a mandate to continue the "hands-on" polytechnic strategy toward education and to increase the use of teams. Another major theme was communication skills.

Faculty Assessment Project –With the QFD outcomes, it would become known which SKAA's would have to be developed for the curriculum and which action items would be identified. Faculty professional growth, for example, could then be pointed in the directions of greatest mutual benefit.

Results – EXCEL was used to create and total the matrices. Only Matrix 2 is shown in its entirety here. Probably the most exciting results came as a result of completing the first two matrices.

Matrix 1 - Stakeholders vs. SKAA's – Figure 1 below is a graph of the row totals from Matrix 1. The row totals are not weighted and reflect the degree to which the program satisfies each stakeholder. First of all, the table shows that the program favors the student as the primary stakeholder. Following was a second group of stakeholders that also ranked very high: Manufacturing employers, PE (registration requirements), Service Industry Employers, SME, ABET, and ASQ. Results were discussed by the faculty and the general conclusion was that the results are consistent with stated mission, purposes, and goals. The relatively high ranking of "stakeholders who evaluate us" (PE, SME, ABET, ASQ) was considered a positive and strengthens the department's resolve to remain viable in producing graduates who meet

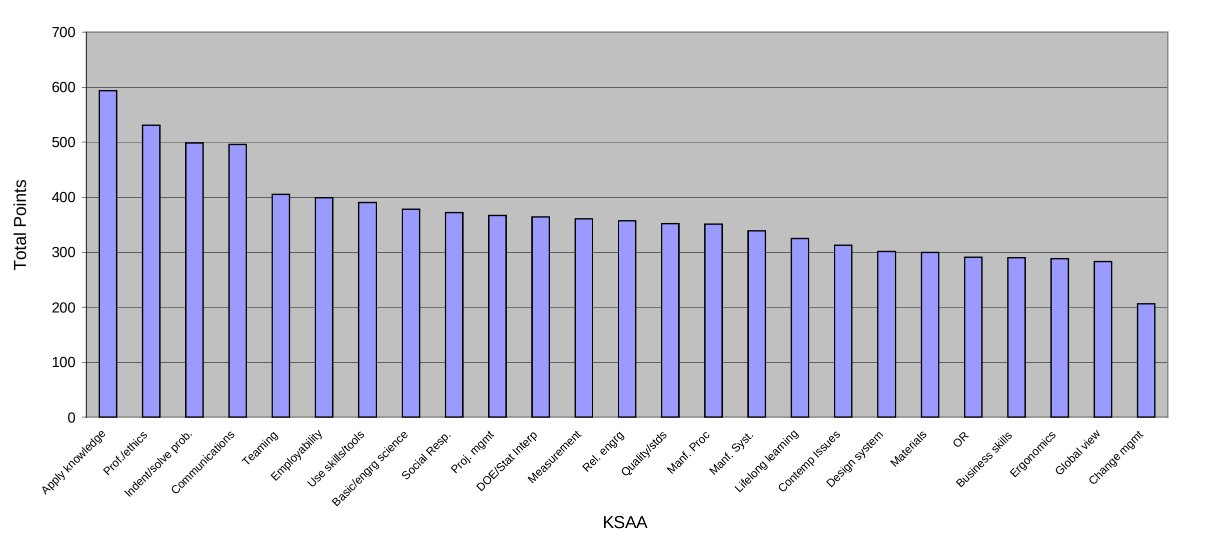
Figure 1 - Stakeholder Totals



professional standards.

This matrix also allowed ranking of SKAA's as well. Figure 2 shows the ranked results of the column totals.

Figure 2 - KSAA Importance



In addition to being useful, the results were very illuminating and, in a few cases, surprising. The “ability to apply knowledge” is very much in line with the polytechnic philosophy of “learn by doing”. The large number of laboratory assignments and projects assigned to students throughout the curriculum is a major contributor to this result.

“Knowledge of Ethical and Professional Standards” ranked number 2. At first glance this was a surprising result to the IME faculty. It was not expected to rank above communications, teamwork, and other very important areas. However, in today’s working world there is a more deliberate emphasis and demand for the ability to make ethical and moral decisions than in the past. This topic is specifically addressed in the next section where each SKAA was assessed across the curriculum.

Problem solving, communications, and teaming were the next highest categories. These results are not surprising and further emphasized the need to adopt teaching methodologies that would promote student growth in these areas.

The results of Matrix 1 were used to prioritize, weight and rank other features and design characteristics of the program as reflected in the rest of the matrices. This approach was useful, if not essential, in attempting to use scarce resources in a manner that best serves stakeholders.

Matrix 2 - SKAA vs. Core Course (for each major) – Matrices 2a (IE) and 2b (MFE) were used to analyze the core courses in the curriculum relative to their coverage of SKAAs. This was probably the most dramatic matrix in the whole assessment process because it revealed for the first time the direct impact of each course on the overall stakeholder outcomes. The discussion below is extensive but not exhaustive. Examples of the results and how the matrices were used are given throughout the discussion to illustrate the power of this approach.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	Matrix 2a - SKAA vs. IE Core Courses			IME112	IME113/L	IME224	IME239	IME301	IME312	IME326	IME331/L	IME415	IME460	IME461/2	MFE126/L	IE225/L	IE311	IE327/L	IE416	IE417	IE429	IE436/L	MFE126/L	MFE201/L	MFE450/L	ECE114	EGR402	EGR403	Total
2	Apply knowledge	594			9	9	9	9	9	3	9	3	3	9	3	3	9	9	9	9	9	9	3	3	9	3	3	9	162
3	Prof./ethics	531		3		3	3				3	1	1			9		3	1	1		1					9		38
4	Indent/solve prob.	498		3	9	9	9	9	9	3	9	9		9			9	9	3	3	9	9			9	1		9	139
5	Communications	496		3	1	3					3		9	9	3	3		9	3	3	3	3	3				3	3	64
6	Teaming	405		3	1	1					9	1						9	3	3	3	9			3				45
7	Employability	399			3	3	3				3	1	1	1		1			3	3	3				3				28
8	Use skills/tools	390			9	3	9	9	9	3	9			3	9	3	9	9	9	9	9	9	9	3	9	9		9	159
9	Basic/engrg science	378		0	1	1		1	1			1		1		3	1	3	9	9	3	1		1	9				45
10	Social Resp.	372		1			3				1					3		3									9		20
11	Proj. mgmt	367								9	9			3	1			9	1	1		3	1						37
12	DOE/Stat Interp	364				1		9	9	3		9		1		1		1	1	1	3	3			3				45
13	Measurement	360				9		3		1		1			1	9		3			3		1	1	1				33
14	Rel. engrg	357							3																				3
15	Quality/stds	352						3				9			1								1	1					15
16	Manf. Proc	351		3						1					1								1	9	9				24
17	Manf. Syst.	339								1	3										3	1		1	9	1			19
18	Lifelong learning	325		1			1				1								1	1									5
19	Contemp Issues	313		3	3	3					3	1						9	1	1	9				9				42
20	Design system	301			9	9					9					3		9	1	1	9			1	9				60
21	Materials	300																						3					3
22	OR	291						1	1	3		3					1	1	9	9		3							31
23	Business skills	290					9			9	3	1						3				3						9	37
24	Ergonomics	288								1	3					9								1					14
25	Global view	283														1		3									3		7
26	Change mgmt	207								3	3	1									9				1				17
27	Total points			20	45	54	46	44	41	40	80	41	14	36	19	48	29	92	54	54	75	54	19	24	83	14	27	39	
28	rank			21	11	5	*10*	*12*	*13*	*15*	*3*	*14*	*24*	*17*	*22*	*9*	*18*	*1*	*6*	*7*	*4*	*8*	*23*	*20*	*2*	*25*	*19*	*16*	
29	Categorized by total		0-24	20									*14*		*19*								*19*	*24*		*14*			
30			25-49		45		*46*	*44*	*41*	*40*		*41*		*36*		*48*	*29*										*27*	*39*	
31			50-74			54													*54*	*54*		*54*							
32			75+								*80*							*92*			*75*				*83*				
33																													

Row Totals and Row Rankings - Faculty members evaluated the degree to which each SKAA was covered in each course they teach. These inputs were summarized in one matrix for each major. Unweighted row totals were computed and ranked. These rankings were compared to the rankings of the SKAAs. Our approach was that if a higher order SKAA had a low row total, then possibly that SKAA was not being given enough coverage in the curriculum. A possible exception to that approach was that in some cases an entire course was dedicated to a SKAA and therefore the coverage was underestimated in the row total. Examples of this situation are Professionalism and Ethics (EGR 402), Experimental Design and Statistical Interpretation (IME 301, IME312), Manufacturing Processes (MFE 201 or MFE 217/221/230), and Ergonomics (IE 225).

“Apply Knowledge” was ranked 1 and 2 on the MFE and IE matrices respectively. This was a desired result. Other high ranking SKAA’s that had appropriately high rankings (MFE, IE rankings in parentheses) were “Identify and Solve Problems” (2,3) “Communications” (4,4), “Use Skills/Tools” (3, 1), and Basic/Engineering Science (11, 6). These results confirmed to some degree the result of the polytechnic philosophy of education in these areas. Some of the lower level stakeholder outcomes also had high rankings: “Design System” (7, 5), and “Business Skills” (14, 8). This result is probably a reflection of the faculty bias. Many IME faculty members have years of industrial experience and know first-hand the importance of these two topics to practicing engineers. This experience and wisdom may be manifested here.

The situations where the row total rankings were much lower than the stakeholder rankings indicates areas that may not be getting enough coverage in the curriculum. The most glaring example may be “Professionalism and Ethics”. This SKAA was number 2 based on stakeholder expectations, yet was ranked 17 and 7 on the MFE and IE matrices respectively. An entire course is devoted to this topic as part of the upper division general education curriculum (EGR 402). However the results still beg the question of whether or not one “stand alone course” is enough coverage.

Other areas were weaknesses in coverage were indicated were “Teaming” (6, 9), “Employability” (10, 15), “Social Responsibility” (20, 16), “Reliability Engineering” (21, 24), and “Quality/Standards” (18, 19). Just as with “Professionalism and Ethics”, it was agreed that these topics would be bolstered wherever opportunities were present. If major changes were needed, then they would be considered as well. The column totals were used to identify courses that may be the primary candidates for upgrading and enhancement. These courses are discussed next.

Column Totals – Columns show the “SKAA inventory” for each course. Column totals were both ranked and divided into four categories for ease of analysis. While weighted totals were possible, they were not used at this time. A look at the courses that were in the 75+ range show the common trait of all being upper-division major courses with team design projects and major written reports and presentations (e.g. IME 331 Facilities Design, MFE 450 CIM, IE 429 Simulation, and IE 327 Systems Engineering). This observation prompted the faculty to ask why more of our upper division “capstone” type courses did not score higher and what would it take to upgrade them?

<u>Case study - IME 415:</u> An example of how one course was upgraded to meet this challenge was IME 415 Quality Control by Statistical Methods. The column total for IME 415 was initially 41 points. The instructor looked at how to upgrade the curriculum and course requirements to improve the course for stakeholders in the most efficient way. The areas where improvement was sought were those areas identified as weaknesses in the analysis of row rankings. The following changes were made in IME 415 (estimated increase in the number of points is also given):

1. **Professionalism/Ethics & Social Responsibility** – Included discussion of the impact of quality on society and Dr. Taguchi’s definition of quality as “loss to society”. Discussed the trends for reporting and documenting non-conforming products and processes. (+8)

2. **Teaming –** Changed from individual research projects to team projects with a PowerPoint presentation. Continued use of teams for the practical exercise.(+8)

3. **Employability –** Added substantial component on Six-Sigma Quality. (+2)

4. **Use skills/tools –** Increased use of web to find quality related information. Earlier introduction of the use of control charts to improve proficiency. (+3)

5. **Reliability Engineering –** Added introduction to Reliability Engineering (+3)

6. **Quality Standards –** Added significant component on ISO/QS 9000.(no change)

These changes added 24 points to the column making a new total of 75 points. Additional enhancements will be made in the future. This approach was followed in a variety of other classes. Time does not permit including all the work that has been done as a result of this approach. Now faculty have a roadmap for planning change that will truly benefit stakeholders.

Matrix 3 - SKAA vs. Methodology - Thirty-eight different teaching methodologies (not shown) were identified by the IME faculty for assessment of their potential effectiveness in meeting stakeholder needs

Matrix 3 was developed for initial assessment of the potential value of each methodology vs. all SKAA's. A major issue here is the difference between those methodologies that can be implemented by individual instructors (e.g., lecture, homework, term papers) and those that require department support or department-wide adoption in order to be effective (e.g., Team senior projects, presentations, coop program, design competitions).

Members of the assessment team completed the matrix and circulated it for review by the faculty. Column totals were weighted by the point score for each SKAA. The weighted column totals were then analyzed based on whether they were individual or department-wide implementations. The department-wide initiatives were ranked among themselves and the following interesting patterns emerged:

Enrichment Activities – Design competitions, colloquium speaker series, workshops, club activities, and conferences ranked very high. These activities contributed a lot to the areas of applying knowledge, identifying and solving problems, and using skills and tools. They also contributed by expanding on contemporary issues and global viewpoints.

Work Experience – Coop/internship, On-the-job training, and tutoring/mentoring ranked very high. The potential for meeting stakeholder needs through good work experience is unsurpassed by any other method. This finding confirmed what many faculty members have been espousing all along.

Computer Programming and Use of Software – Writing a computer program and use of a software package ranked very strong. The ability to write and use software assumes an underlying understanding of the theory and science of the material. A lot is gained by converting the concepts, formulas, and relationships into a working program.

Matrix 3a was developed by eliminating methodologies that scored low on the initial assessment. Subsequently new row totals were computed and analyzed to see which SKAA's were low. This information will be used to further analyze courses by the instructors in charge.

These results were presented to the IME Department faculty at a special meeting and discussed. The faculty agreed to review the level of support of enrichment activities and see how we could more concretely support them. As an immediate result one faculty member was assigned to be in charge of the next student competition project for WESTEC in March 2000. Other faculty club advisors were encouraged to propose ways the department could assist their organizations. With respect to coop/internships, the faculty agreed to turn to the IME Department's Industrial Advisory Council for assistance in planning for a more formal program. For presentations, the department feels that new video projections systems should be acquired for use in student presentations, computer labs, competitions, and student practice.

Matrix 4 - SKAA vs. Assessment Tool – Matrix 4 was developed to determine the overall value of potential assessment tools with respect to each SKAA. Especially important was the value of various assessment tools that require department support and resources to administer and evaluate. In a department meeting, the IME faculty brainstormed a list of thirty assessment tools or techniques (not shown), many of which are already being used. Matrix 4 was used to evaluate the "potential value" of each of the tools for each SKAA Note that some assessment tools are also on the methodology list. This is possible because some methodologies are potentially useful as both teaching and assessment methods.

Results - Column totals (weighted by SKAA importance) for each assessment tool showed that many of the traditional assessment techniques were still very valuable. The top ranked assessment methodologies individually administered by faculty were: Research papers, senior projects, tests, project reports, lab reports, presentations, term papers, and homework.

The top ranked results for assessment methodologies requiring department-wide administration or support were: Employer surveys, PE Exam, CMfgT Exam, employer interviews, EIT Exam, alumni survey, and portfolios.

These results were presented to the IME Faculty at a special meeting and discussed. The point total for **Employer Survey** was 338 points and was 121 points ahead of the next highest total (PE Exam at 217 points). This is a significant result. After some discussion it was decided to take the following approach: (1) Develop survey instruments for interns and graduate students tailored around the SKAA's. (2) Adopt a two or three year cycle of assessment and curriculum development. Administer the survey instrument and evaluate the results in alternating years. Also use the year(s) in-between to implement changes to the curriculum. (3) Ask our Industrial Advisory Council to assist in developing the survey instrument and test it for validity and reliability. The IAC could also help administer the survey if deemed appropriate.

The PE, CMfgT, and EIT exams ranked very high in their ability to assess SKAA's. This result is part of the rationale for the goals mentioned in "Macro/Organizational" program objectives. Using the results of EIT and CMfgT the IME Department has been able to identify some of the weaknesses in student knowledge and ability. This information is considered along with other results of the assessment process.

Matrix 5 - Assessment Tools vs. Core Courses (for each major) - Using the list of assessment tools decided as being the most appropriate and effective, each core course was rated as for the potential effectiveness of the tool. This matrix gives each faculty member a more complete list of assessment options for the courses taught.

Results - The results for the IE Curriculum are shown and are representative of both majors. The decision on which assessment tools to use that require department support will apply to both IE and MFE core courses out of a moderate need for efficiency. It was found that the traditional assessment techniques were the most highly rated probably because of their applicability to so many courses. The top rated assessment tools are:

1. Tests
2. Quizzes
3. Homework
4. **Lab reports**
5. **Presentations**
6. Project reports
7. **Employer survey**
8. **Alumni survey**
9. Term/Research paper
10. **CMfgT Exam (MFE only)**
11. **PE Exam**
12. **EIT Exam**

The first six assessment tools are fairly traditional and rank very high because they apply to almost every course taught. Employer and alumni surveys rank very high as do the certification and professional engineering exams. These results were discussed with the IME faculty at a special department meeting and it was agreed that we would conduct an employer and alumni survey every two or three years. The years in-between will be used to analyze the results, make changes to the curriculum, and implement the changes.

The column totals show how well these assessment tools assess the courses. The lowest totals were for introductory and seminar courses. Most of the lower scores were in lower division courses. This phenomenon is due to the lessened requirements for projects, project reports, and presentations compared to upper division courses. This observation was not considered alarming.

In summary, the careful use of surveys and professional certification and registration exam scores for assessing the curriculum is very promising. To many it just confirmed what they already believed. Now these methods will be supported as department initiatives.

Phase IV – Action Planning – The following table was developed for tracking, follow up, and implementation of future assessment steps.

	Objectives	**1a**	**1b**	**1c**	**1d**	**2a**	**2b**	**2c**	**3a**	**4a**	**4b**	**5a**	**5b**	**6a**	**6b**
Activities	**Frequency/ Status**														
QFD Phase I	Completed								x						
QFD Phase II	Completed								x						
QFD Phase III	Completed								x						x
Employer Survey	99-00, 02-03	x												x	

Alumni Survey	99-00, 02-03		x	x	x			x						x	
Ind. Advisory Council	quarterly				x								x		
Major Curriculum Review	Completed 98-99, 00-01, 03-04								x						x
EIT/CMfgT/PE Exam results	Annually						x		x						
Student Recruiting, Retention, and Development	On-going					x				x	x				
Lab Revitalization	On-going								x			x			
Senior Project Presentations	Quarterly since Winter 98								x						
Colloquium	Winter quarters since 1996								x						
Team Projects	On-going								x						
Design Competitions	WESTEC, AFS Conf., IIE Conf								x						
Coop/intern program	Target Fall 00	x					x		x						
Industry Councils	Attend 2 so far.				x										
Adopt Software package for stats/OR	99-00	x							x						
Faculty Assessment Project	Major project for 99-00		x	x					x						

EAC Visit Results - The IME Department was visited in Fall 1999. The results were very positive. However, the visitors did provide some valuable feedback regarding measures. As a result, the following additional elements were added to the IME Department plan.

Measures for Knowledge, Skill, Attitude, and Ability Areas - Several new feedback mechanisms were developed that would give feedback sooner than the alumni surveys would. This proved to be a valuable addition to the project.

Senior Project/Coop/Work Experience Survey - This survey will become an integral part of every individual and team project and/or assignment involving industry partnership. In addition, it will be administered for students who are working part-time or full-time in engineering or junior engineering positions during their school years. These surveys will be administered during the educational process to close the feedback loop much sooner in the process and address the knowledge/skill areas directly. This feedback will allow us to assess our progress in advancing our students in the knowledge, skill, attitude, and ability areas from a demonstrated work vantage point DURING their educational program.

Student Instructional Assessment - The IME Department already conducts instructional assessment with a student survey. At present there are 10 questions. Seven questions questions will be added that represent the most important of the 24 knowledge, skill, attitude, and ability areas based on our customer requirements. It was also felt that these seven areas were within reason of what we could put on a general survey and still receive meaningful results.

Student Focus Group - A student focus group will be formed and the assessment plans presented for evaluation and feedback. This qualitative information will be used to make any adjustments or improvements deemed appropriate. The focus group will also be asked prepare a proposal on how the department should conduct and assess "exit interviews" from graduating students.

III. Summary

The modified QFD approach delivered the desired results in an organized manner. The faculty was enthusiastic and supportive. The results were accepted because everyone's input was considered. The fact that the faculty started the project approximately 1.5 years before the visit was very fortunate since implementation asks for incremental feedback along the way. The visiting team was very concerned that full participation was evident, and it was. Anyone who has any questions about this paper or the results is welcomed to contact the author.

Bibliography

[1] Kaufman, R., Herman, J., Watters, K. (1996). Educational planning: Strategic, tactical operational. Lancaster, PA: Technomic Publishing.
[2] Rosenkrantz, P. (1996). Using TQM techniques for curriculum development: Developing the Manufacturing Engineering curriculum at Cal Poly Pomona. In ASQC 50th Annual Quality Congress Proceedings (pp. 29-37). Milwaukee: ASQ.
[3] Akao, Y. (1996). QFD Concept for improving higher education. In ASQC 50th Annual Quality Congress Proceedings (pp. 12-20). Milwaukee: ASQ.
[4] ReVelle, J., Moran, J., Cox, C. (1998). The QFD handbook. New York: Wiley & Sons.
[5] Ibid (p.22)
[6] Kaufman, R., Herman, J., Watters, K. (1996). Educational planning: Strategic, tactical operational. Lancaster, PA: Technomic Publishing.(p. 195)
[7] ReVelle, J., Moran, J., Cox, C. (1998). The QFD handbook. New York: Wiley & Sons.

Biography

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