Quality Assessment of an Engineering Management Program

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Abstract

An assessment process is described for LMU's Engineering and Production Management graduate program. Six quality characteristics were defined and measured. The process utilized the tools of total quality management and statistics. Improvement was benchmarked using hypothesis testing of the mean results between 1994 and 1998 using six assessment methods. Quality improvement was evaluated by plotting the results on a radar chart.

I. Introduction

In 1993, Loyola Marymount University's (LMU's) College of Science & Engineering launched a new and unique graduate program leading to an M.S. degree in Engineering and Production Engineering (EAPM). This was a practice-oriented, part-time graduate program that combines both engineering and business. It was devoted to the management of technically competitive products for the 21st Century. The program emphasized integrated product development, project management, manufacturing and total quality.

Currently the goals of the EAPM program are: (1) to teach product design, manufacturing and teamwork, (2) to provide the integrated skills that will advance the careers of our students, (3) to offer a dynamic, industry-relevant graduate program. Since our mission states that our program "will provide the highest quality education for engineers and managers in the management of technically competitive products," it is important for us to assess quality education and its improvement.

An assessment process has previously been proposed [1], which was a modified version of the ABET 2000 engineering criteria [2, 3]. Since assessment has been an evolving process, the present paper will build on the above work to assess the quality of our program. The purpose of this paper is to: (1) define a quality assessment process, (2) establish a measurement of quality, and (3) to evaluate the quality improvement by benchmarking our performance in 1998 against that in 1994. Since this work is still in progress, a sample of the results will be presented.

II. Quality Assessment

An assessment process has been identified using the principles of total quality: being focused on stakeholder needs, creating a strategic plan, establishing relationships between quality and stakeholder needs, having a strategic plan, establishing relationships between quality and outcomes assessment, and measuring improvement. The quality assessment process that has been utilized is shown in **Figure 1**, which is similar to the process that has previously been reported [1].

Figure 1. Quality Assessment Process.

The process starts with identifying the stakeholders and their needs. The stakeholders were local industry, the EAPM industrial advisory council, professional engineering societies, the university faculty and staff, and the students. The stakeholder needs were determined from private discussions with the stakeholders, surveys, and focus group discussions with our industrial advisory council. Our stakeholder needs were grouped into eight general categories [1]: (1) industry-relevant M.S. program, (2) manufacturing-oriented certificate program, (3) project management elective option, (4) career opportunities for our graduates, (5) product development team skills, (6) broad education in engineering, business and management, (7) critical EAPM student enrollment, and (8) self-initiated learning.

The stakeholder needs were translated into goals and measurable objectives of the EAPM graduate program by the EAPM industrial advisory council [1]. The advisory council was comprised of 6 executives from local industry who represented the manufacturing, aerospace and defense sectors. The goals and objectives of the EAPM program were developed from our strategic plan. The assessment process in this paper will start with the quality characteristics (which emanated from our goals and objectives) and will end with the evaluation of quality, as shown in the "shaded" boxes of **Figure 1**. The quality characteristics are correlated with the assessment methods in the box labeled QFD (quality function deployment) diagram [4, 5]. Specific performance criteria are developed along with metrics (a calibrated rating scale) for each quality characteristic in the chosen method of assessment. Then the quality characteristics are measured and analyzed during assessment. Finally, quality improvement is evaluated by benchmarking the 1998 results against those in 1994.

B. Quality Characteristics & Assessment Methods

Here quality is defined as the performance of the program. The term quality characteristics has been coined by Taguchi [6] as response variables that measure performance and characterize the success of the program. The quality characteristics were established through brainstorming discussions with the EAPM industrial advisory council. The six quality characteristics that were selected along with brief explanations were as follows: (1) flexible curriculum - providing elective options that meet industry's needs, (2) critical enrollment - having a threshold number of

students to successfully administer the curriculum, (3) industrial partnerships - having local industry endorse and support our program, (4) relevant problem solving skills - providing both the depth and breadth of knowledge to solve problems, (5) life-long learning - acquiring the knowledge and ability to implement change, and (6) career advancement - professional growth into technical management and team leadership positions.

There are six methods that have been defined to measure the above quality characteristics: (1) student surveys, (2) exit interviews, (3) focus groups, (4) industry surveys, (5) project evaluations, and (6) student data. Student surveys were conducted midway through the program to mainly assess the program's flexibility and its effect on career advancement. Exit interviews were conducted just before graduation to mainly obtain feedback on how the program contributed to life-long learning. Focus groups were held every 4 months with the EAPM advisory council to review the quality characteristics of our program. Industry surveys were sent out every 2 to 3 years to our industry partners who participate in the program. Project evaluations were obtained at the end of the students' capstone project/thesis to determine student learning, implications of the project on the student's company and on the student's career. Student data were gathered from our graduates at various periods (e.g., 2 and 4 years) after completing their degree.

C. Quality Function Deployment (QFD)

The relationship between the above quality characteristics and measurement methods were established using a QFD matrix. In this paper, a simplified version of QFD is utilized to identify

Quality Characteristics		Measurement Methods						Totals
		Student Surveys	Exit Interviews	Focus Groups	Industry Surveys	Project Evaluations	Student Data	
1	Flexible Program	9	1	3	3			16
2	Critical Enrollment			1			9	10
3	Industry Partnership			3	9	9	1	22
4	Relevant Skills	3	3	9	9		3	27
5	Life-Long Learning	3	9	1	3	3		19
6	Career Advancement	9		3	3	1	9	25
Totals		24	13	20	27	13	22	119

Figure 2. QFD Matrix of Quality Characteristics vs. Measurement Methods.

these relationships [4, 5], as shown in **Figure 2**. Here the six quality characteristics became the "what" rows, i.e., what characteristics will be assessed; and the measurement methods become the "how" columns, i.e., how it will be measured. The relationship between the rows and columns are rated on a score of 1 (weak) to 9 (strong). At the end of the rows and columns, the scores are totaled. The total row score indicates how strongly the measurement methods (columns) relate to a given quality characteristic. Likewise, the total column score indicates how strongly the quality characteristics (rows) relate to any given measurement method. If the total value of a given row is low, or if the row does not have any strong relationships, then the measurement method(s) should be re-established so that it strongly correlates with a given quality characteristic. The same holds true for the quality characteristics relating to a given measurement method.

In **Figure 2** all of the measurement methods have at least one strong relationship with the quality characteristics. In addition, all of the quality characteristics have at least one strong relationship with the measurement methods. The QFD matrix can be used to establish the weighting percentages of the measuring methods for each quality characteristic. For example, from **Figure 2**, if the critical enrollment is measured by both focus groups and student data, then these methods can be weighted by 10% and 90%, respectively, to evaluate the critical enrollment. In practice, it may be too time consuming to use all of the measurement methods for each quality characteristic. Hence, for example, if life-long learning is being assessed, it is recommended that the primary measurement method be exit interviews, because they relate the strongest to life-long learning. Also, career advancement should be measured by student surveys and student data.

D. Performance Criteria and Metrics

For each quality characteristic, performance criteria must be established that are specific, measurable, realistic and timely. The following performance criteria were established for our 6 quality characteristics: (1) flexible curriculum - number of courses that integrate engineering and business, semester-hours of elective options, establishing a graduate certificate program, and forming a joint MBA/EAPM master's degree; (2) critical enrollment - having 36 full-time students enrolled in the EAPM program; (3) industry partnership - number of class projects with private industry and company endorsements; (4) relevant skills - applying lessons learned (e.g., improved quality, reduced cost and reduced development time) to optimize products and processes, and number of courses with concurrent engineering and entrepreneurship; (5) life-long learning - number of self-initiated projects, number of technical papers and presentations, number of promotions, and number of educational units completed; and (6) career advancement - percent increase in salary, and obtaining a job promotion.

For each of the above performance criteria, actual questions would be written and measured on a 1 - 5 rating scale (where 1 = worst, and 5 = best). This rating scale is calibrated with actual metric values, which would be circled (assuming a survey format is used) [1]. For example, if life-long learning is desired, the five questions that relate to the performance criteria could be: What is the average number of projects or products per year that you initiated? What is the average number of technical talks and papers per year that you presented? With how many professional societies are you actively involved? How many promotions have you had within the last 5 years? What is the average number of post-graduate educational units per year that you completed?

If the questions are equally weighted, the mean rating can be calculated by summing the ratings for all of the questions and dividing them by 5 (number of questions). If the questions have a priority, then a weighting percentage is assigned to each question. In this case, the mean rating score is calculated by multiplying the weighting percentage times the rating for each question. Then the mean rating is determined by summing the weighted ratings for all of the questions. **Figure 3** illustrates this measurement of life-long learning. The mean rating for life-long learning was 3.6 in 1998 (on a 1 - 5 scale). Using the same methodology, the 1994 assessment rating for life-long learning was determined to be 2.5. This indicates an improvement has taken place between 1994 and 1998. The assessment rating of the five other quality characteristics (see **Figure 2**) were carried out in the same way. This process is still in progress. Hence, only an initial sample of the results will be reported.

Performance Criteria	Weighting %	Rating Scale					Total Assess't (Rating)
		Worst				Best	
		1	2	3	4	5	
Metrics							
No. of Self -Initiated Projects Per Year	20%	1	2	3	4	5	0.6
		None	One	Two	Three	• Four	
No. of Technical Presentations and Papers Per Year	20%	1	2	3	4	5	0.6
		None	One	Two	Three	• Four	
No. of Prof. Society Memberships	20%	1	2	3	4	5	0.6
		None	One	Two	Three	• Four	
No. of Promotions Per 5 Years	10%	1	2	3	4	5	0.3
		None		One		Two	
Educational Units Completed Per Year	30%	1	2	3	4	5	1.5
		One	Two	Three	Four	• Five	
Total Score	100%						3.6

Figure 3. Summary Table of 1998 Survey on Life-Long Learning.

E. Quality Assessment and Improvement

Improvement is measured by comparing the survey data of the quality characteristics from 1994 to 1998. Since this is still in progress, the methodology will be reported along with a small sampling of the results. Hypothesis testing was performed on the equality of the means for the two populations from 1994 and 1998. The assessment rating and standard deviation of the data for each quality characteristic was determined for the two assessment periods. This created two sample populations which were statistically compared. An experiment was designed using a t-test for a type I (α) error of 0.05 (caused by falsely rejecting the null hypothesis) and low type II (β) error (caused by falsely accepting the null hypothesis) [7]. Using an operating characteristic (β error) curve for a 2-sided t-test and 0.05 type I error, a low β error of $\spadesuit$ 0.10 would be expected for a sample size of 15 and "d" value (difference between the mean of the null hypothesis and the mean of the alternative hypothesis divided by the standard deviation) of 1.0

[7]. This test will ensure that the differences between the data for 1994 and 1998 are real if the alternate hypothesis is true for the given acceptance range.

The mean of the 1994 and 1998 populations are plotted on a radar chart, which is a graphical method for representing improvement [8]. The assessment ratings of the 6 quality characteristics for 1994 and 1998 are plotted in **Figure 4**. Initial sample data has been used to illustrate the use of the radar chart. The 1994 quality characteristics were connected with a dotted line. Likewise, the 1998 data were connected with a solid line. If the null hypothesis is accepted, the means of 1994 and 1998 data are considered equal. Here the data are plotted together as one data point, as shown for relevant skills (quality characteristic). If the null hypothesis is rejected, the means are considered unequal and are plotted as separate values. So long as the solid line lies outside of the dotted line, improvement takes place. With a small amount of data, our preliminary findings appear to indicate that quality improvement has taken place between 1994 and 1998.

Figure 4. Radar Chart of Quality Assessment Between 1994 and 1998.

III. Conclusions

A methodology has been suggested as a means for assessing the quality of LMU's Engineering and Production Management (EAPM) graduate program.

1. A quality assessment process was developed as a modified version of the ABET 2000 assessment process.
2. Six quality characteristics were identified from stakeholder's needs and our goals and objectives: flexible curriculum, critical enrollment, industrial partnerships, relevant skills, life-long learning, and career advancement for our students.

3. Six methods were established for measuring the quality characteristics: student surveys, exit interviews, focus groups, industry surveys, project evaluations, and student data.
4. Quality function deployment (QFD) was used to establish the relationship between the quality characteristics and the measurement methods. This enabled a weighting percentage to be determined for the measurement methods that evaluated each quality characteristic. If assessment becomes too time consuming, it is recommended to use those measurement method(s) that strongly relate to the quality characteristic.
5. Performance criteria and a rating scale were developed to quantitatively measure the mean and standard deviation of each quality characteristic between 1994 and 1998. Hypothesis testing was proposed as a technique for statistically comparing the sample means of the 1994 and 1998 data. An experiment was proposed for a sample size of 15 that yields low type I and II errors.
6. Initial data on the quality characteristics for 1994 and 1998 were plotted on a radar chart to evaluate improvement. The results appear to indicate that improvement has taken place.

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