Assessment and Quality Improvement Process in Engineering and Engineering Education

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Abstract *- Embedding quality improvement methods into the teaching of engineering processes is not new to engineering education. Engineering graduates are expected to be able to develop and design products and processes that meet the needs of customers within given constraints and follow known procedures to ensure quality results. Quality function deployment (QFD) is an internationally accepted planning technique that is used to ensure that quality is designed into a product by incorporating customers needs. The QFD matrix, or "house of quality," (HoQ) depicts the components of this process for determining engineering characteristics, parts characteristics, key process characteristics, and production requirements. The QFD process will be used as a tool for understanding the assessment of academic programs and meeting the continuous improvement requirements embedded in Engineering Criteria 2000.[1]*

The authors will compare the QFD process with the development of an assessment planning process and outline considerations needed in developing an assessment tool (both content and process). Necessary components of quality assessment will be outlined and an example provided from EC2000 learning outcomes.

Introduction

This paper depicts the similarity between QFD and the development of an assessment process. A step by step approach is outlined for developing an assessment process by using a QFD approach. This approach details the components of quality assessment and contrasts these components with the development of QFD. In QFD, the focus is on designing quality in a product or process; in quality assessment, the focus is on assuring quality in the educational process. QFD stresses knowing your customers and meeting their needs; quality assessment stresses meeting the information needs of all constituents. QFD emphasizes the enterprise functioning as a whole; quality assessment emphasizes all aspects of the educational environment. QFD requires multi-disciplinary teams; quality involves representatives from all constituents of the academic community. Both approaches stress outcomes definitions and development of strategies for assessment and continuous improvement of the final product/outcome.

QFD is an internationally accepted planning technique that is used to determine engineering characteristics, parts characteristics, key process characteristics, and production requirements. QFD originated in 1972 at Mitsubishi's Kobe shipyard site and was introduced in the US at Ford in 1984. [2] There are four "houses" suggested to insure that the customer's needs are carried through to manufacturing. These houses are shown in Figure 1.

Development of Assessment QFD

The first house is concerned with translating the needs of the customer into engineering characteristics (ECs.) ECs are a list of technical descriptors that characterize the product or process. Weight or length, for example, might be appropriate ECs for a product. Developing the first HoQ identifies the key design specifications that will most satisfy the customer. The HoQ team then selects target values for these ECs. The ECs become input to the second house. The development of the second house determines the key part characteristics necessary to meet the target values for the ECs. These part characteristics become the input to the third house that determines the key process operations necessary to insure that the key parts characteristics are met. Finally, the key process operation leads to the development of production requirements as shown in the fourth house.

Customer Requirements

The HoQ identifies customer requirements drawn from market evaluations and benchmarking against competitors. "Customers" for the education process must also be defined. What do these customers need to know? A simplified HoQ for an assessment process at Rose-Hulman is shown in Figure 2. For this HoQ the "customers" consisted of recruiters, alumni, industrial advisors, faculty, students, and administrative staff who are key stakeholders in the educational experiences of Rose-Hulman students. One of the characteristics desired was for Rose-Hulman graduates to be effective team members. The customer attributes in the HoQ are the WHATs that the customer wants. In this case,

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the WHAT is developing an effective team member. The HOWs or ECs are specific measurable performance criteria - metrics by which success can be evaluated. In this case, the planning team identified six metrics for determining if a student is an effective team member.

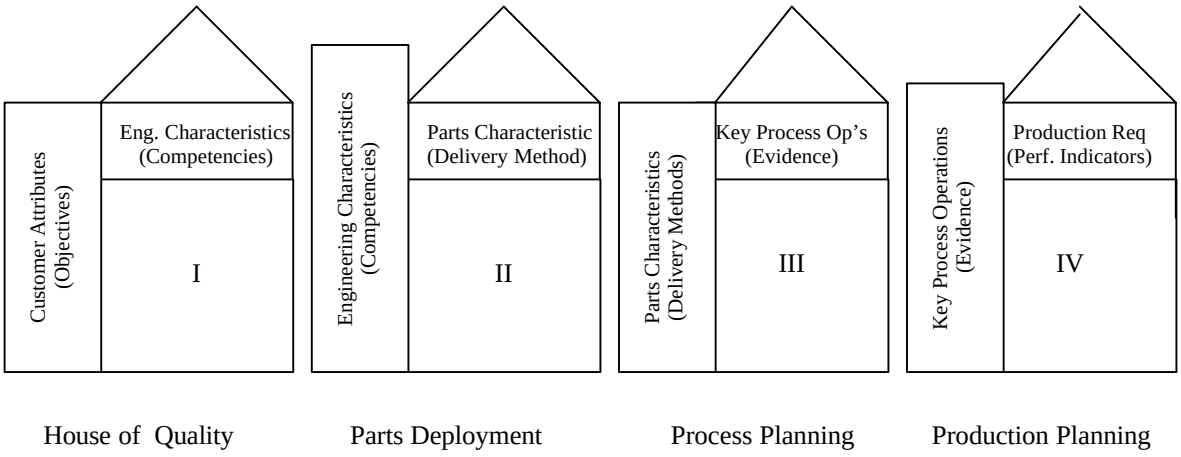

Figure 1: Linked Houses Conveying the Customer's Voice Through to Manufacturing
(Adapted from Hauser and Clausing 1988)

	Share responsibilities and duties	Take on different roles when applicable	Analyze ideas objectively	Discern feasible solutions	Develop a strategy for action	Arrive at a consensus	
Effective Team Member							
Communication Skills							

Figure 2: Partial HoQ for Rose-Hulman Assessment Process

Parts Deployment

In the next stage, the parts deployment house is formed as shown in Figure 3. The ECs are the driving forces that determine the parts characteristics. In the assessment example, the question becomes, "What strategies should we use to provide students with an opportunity to gain the knowledge and/or practice the skills necessary to become effective team members?" This involves identifying where in the curriculum students are getting an opportunity to gain the knowledge, skills and other attributes necessary to meet performance criteria. In Figure 3 the skills necessary to "Analyze Ideas Objectively" might be acquired by learning to use decision matrices and/or the Pugh concept selection technique. [3] The parts identified must be formed into a cohesive pattern.

Process Planning

The third house, the process planning house identifies means for determining whether or not a criterion has been achieved. The process planning house is shown in Figure 4. The parts characteristics identified in the parts deployment house must be tied to key process operations. The instruments that will be used for assessment are identified. For example, a design report might contain a Pugh concept selection chart that illustrates a team's ability to analyze ideas objectively. Students have a variety of methods for demonstrating that they have met the teaming performance criteria. After students have completed documenting their attainment of the performance criteria, there must be a mechanism for evaluating individual students, individual departments, and the institution as a whole. This process is detailed in the fourth house that is shown in Figure 5.

	Team training	Decision matrices	Pugh concept selection	Gantt charts	
Develop a strategy for action					
Arrive at a consensus					
Discern feasible solutions					
Analyze ideas objectively					
Take on different roles when applicable					
Share responsibilities and duties					

Figure 3: Partial Parts Deployment House

Production Planning

The production planning house relates key process operations to production requirements. Figure 5 indicates that assessment is both formative and summative. Course assessment and program assessment are both utilized. Strengths and weaknesses can be identified for individuals, courses, and programs. Assessment results are evaluated and reported to constituents thus closing the continuous improvement loop. At each stage in the process the constituents desire for an effective team member drives the tools and processes utilized.

The QFD technique parallels the requirements for developing an educational assessment program. In QFD, customer attributes are used to identify ECs; in quality assessment, performance criteria are developed to define the customers' objectives. In QFD, the ECs drive the development of parts characteristics. In quality assessment, strategies are identified to achieve the desired performance. In QFD, the parts characteristics determine the key process operators. In quality assessment the strategies identified

determine that portion of the curriculum designed to achieve the desired student learning outcome. In QFD, the key process operations lead to production requirements. In quality assessment the curriculum is assessed and evaluated providing information for feedback and correction completing the continuous improvement cycle.

Team training						
Decision matrices						
Pugh concept selection						
Gantt charts						

Figure 4: Partial Process Planning House

Design Reports					
Engineering Log Books					
Peer Evaluation					
Peer Assessment					
Self Assessment					
Portfolio					

Figure 5: Partial Production Planning House

Process Characteristics

Teamwork, ambiguity, iteration and integration characterize the development of both a quality assessment process and the QFD process.[4] The planning and implementation teams generally represent a microcosm of the organization. Team members with varying expertise, experience and perspectives are vital to quality processes. The team grows, changes and must be nurtured over time. The core team membership generally remains the same, but the team size and membership varies as the processes move through the development, production, and continuous improvement cycle. The team must be able to deal with ambiguity. As in any design process, there are usually several "good" answers. However, not all answers are equally good and some are definitely wrong. The team must be capable of compromise and evaluation of alternatives. The design of quality processes is not linear. It is characterized by a series of loops where what is learned in one step of the process is used to improve the next. Components must be integrated to optimize the results. Multiple processes are utilized but they are all interrelated in the continuous quality improvement cycle.

Summary

A wise man once said, "All models are wrong, but some are useful." The Quality Function Deployment model provides a useful tool for understanding the processes required to meet the letter and spirit of Engineering Criteria 2000. As engineering faculty work to develop continuous improvement processes related to engineering program outcomes, they are encouraged to look at quality models that have been developed and tested in the business setting and are presented to students in the engineering curricula. This approach will provide faculty with a familiar language and framework for assessment planning and "demystify" the assessment process.

References

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