A QFD Framework for Curriculum Planning

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Abstract
This paper proposes a three-phase QFD framework for curriculum planning in academia and illustrates its application via a case study of planning an integrated *Engineering for Business* curriculum. A Course Planning Matrix which prioritizes the teaching methodologies best suited to deliver critical competencies is integrated with a Course Design Matrix which identifies and prioritizes the engineering tools and techniques to be incorporated into the curriculum. A Course Implementation Matrix is introduced in the final phase of this curriculum planning methodology to assign the engineering tools and techniques to specific *Engineering for Business* courses. The robustness of the Course Implementation phase of this planning methodology is confirmed via sensitivity analysis and extensions of this structured, collaborative approach to planning are suggested.

1. Introduction

Continuous improvement (CI) is vitally important in academia to maintain a high quality of service to "customers" - the students, faculty, and industry stakeholders. Proposals for curriculum enhancements should be examined and teaching methodologies carefully scrutinized to ensure that they are well suited to deliver the critical competencies and course content needed by students. Relevant analytical tools and techniques must be identified and incorporated into the curriculum. Appropriate courses must be developed to deliver the desired curriculum. Quality Function Deployment (QFD) [1], a planning and design tool traditionally employed to facilitate integrated product development, can be modified to provide a flexible, integrated planning framework for curriculum planning. In this paper, we propose a framework using QFD to provide a systematic approach to curriculum planning in academia and describe a case study from Florida A & M University to illustrate the application of this approach.

2. Quality Function Deployment

Quality Function Deployment (QFD) [1] first developed and applied by the Japanese in the early 1970's helps multi-functional teams identify and prioritize customer requirements and relate these needs to corresponding product or service characteristics. Over the years, QFD has attracted attention from a wide range of progressive industrial organizations in the USA including Ford Motor Company, General Motors, Rockwell International, AT&T, DEC, Hewlett-Packard, and Polaroid [6] and has been used mainly in the area of product development and improvement. Recently, QFD has been used to facilitate planning in areas such as planning process improvement projects [2], planning for technology transfer on information technology projects [3], business planning in small companies [4], manufacturing strategic planning [5], and strategic planning for service improvement projects [6]. QFD is best implemented as a multi-phase process as this approach offers the greatest potential for realizing significant benefits. Here a series of matrices link relationships and provide a graphical summary of the process. However, several QFD projects limit implementation to the first two phases thus limiting the positive impact of this technique.

Recently, we have seen several attempts to utilize QFD to provide a structured approach for planning in academia in areas such as developing laboratories for CIM [10], revising mechanical engineering curriculum [11], research planning [12], course design [13], planning enhancements to computer laboratories [14], and improving the quality of teaching [15]. These applications all confirm the potential of QFD to facilitate effective communication, timely information transformation, and efficient resource utilization. In the following section, we describe a case study in which QFD provides a framework for integrating engineering concepts into a business curriculum.

<u>3. A Case Study</u>

<u>3.1 The Course Planning Process</u>

The School of Business and Industry (SBI) at Florida A & M University (FAMU) is developing a suite of *Engineering for Business* courses for integration into its business curriculum. Among the benefits envisaged to be reaped by the students are an increased awareness of engineering and technology fundamentals, improved teamwork skills, and enhanced analytical and logical thinking. To realize these benefits, careful attention must be given to curriculum planning to maintain the quality and effectiveness of this very innovative program. We propose that planning for this curriculum development proceed in the following phases:

- *Phase #1: Course Planning* - which prioritizes the teaching methodologies best suited to deliver critical competencies;

- *Phase #2: Course Design* - which identifies and prioritizes the engineering tools and techniques to be incorporated into the curriculum;

- *Phase #3: Course Implementation* - which assigns the preferred engineering tools and techniques to specific *Engineering for Business* courses.

In this paper we describe Phase #3: *Course Implementation*, the final phase of the integrated three-phase QFD methodology proposed for curriculum planning in academia.

<u>3.2. Course Implementation</u>

The steps adopted in this phase of the QFD process for curriculum planning were as follows:
<u>Step #1</u>- Define the customer: In this case, the customers were the students enrolled in SBI's innovative program.

<u>Step #2</u>-Identify the relevant Engineering Tools and Techniques for incorporation in the program and establish the relative importance of these tools and techniques - the WHATs: These engineering tools and techniques were determined via faculty collaboration in the previous phase of the QFD process, the *Course Design* phase, and weights derived to reflect their relative importance.

Step #3- Identify Engineering for Business courses that are candidates for implementation – *the HOWs.* Following a brainstorming session among our Engineering faculty, the following four courses were proposed:

- Fundamental Engineering Concepts
- Management Engineering I
- Management Engineering II
- Managemernt of Technology

<u>Step #4</u>- Map the HOWs into the WHATs

The planning team mapped the HOWs into the WHATs by assigning ratings on a 1-3-9 scale (1 – weak; 3 – medium; 9 – strong;) to indicate the relationship between each *HOW* and *WHAT*. Several heuristics were employed to facilitate aggregation of the mappings of individual team members while enabling a balanced allocation of tools and techniques to proposed courses.

<u>Step #5</u> - Develop a House of Quality

Our team constructed a spreadsheet-based model to facilitate computation of the row and column totals and the ranking of the courses under consideration. The QFD chart is shown as Figure 1.

<u>3.2 Analysis Of Results</u>

Examination of the results summarized in the QFD chart in Figure 1 reveals the following:

Engineering Tools and Techniques
The weights assigned to the Engineering Tools and Techniques approximated a symmetrical distribution with 5 of the 17 tools (29.4%) receiving the median weight of 3 on a five-point weighting scale. The results indicated that the greatest importance should be assigned to those engineering tools and techniques which have a strong team orientation. e.g. Project Management and Quality Function Deployment. These received a weight of 5 on a five-point weighting scale. The least importance was accorded those which required considerable mathematical manipulation (e.g. Risk Analysis, Value Engineering, and Mathematical Programming). These received a weight of 1.

Engineering for Business Courses
The scores obtained by the four courses examined ranged from a low of 22.75% to a high of 25.9 %. This narrow range suggests that all four courses were of approximately equal significance in satisfying the School's curriculum objectives. These results can in part be attributed to the consensus-building heuristics used for aggregating individual preferences during the mapping process. Equal contributions could therefore be expected from faculty charged with the responsibility for delivering these courses. This would afford curriculum planners considerable flexibility in developing an integrated *Engineering for Business* curriculum.

3.3 Sensitivity Analysis
Sensitivity tests were conducted to ascertain the impact of variations in the weights assigned to the *Engineering Tools and Techniques (the WHATS)* and the rating scale used to map the *HOWs* into the *WHATs* on the relative importance of the *HOWs*, the *Engineering for Business Courses*. Four scenarios were investigated. Scenario 1 used the weights obtained from the *Course Design* phase and a rating scale of 1-3-9 to map *the HOWs* into *the WHATs*. In Scenario 2, all *WHATs* were assigned a weight of three (average importance) on a five point scale. In Scenario 3, all weights adopted in Scenario 1 were reduced by 30%. In the final case, Scenario 4, the weights of the WHATs were similar to those obtained in Scenario 1. However, a 1-3-5 rating scale was used (1 - *weak*; 3 - *medium*; 5 - *strong*;)

The results of the sensitivity analysis are summarized in Table 1. These show the relative importance of each of the proposed courses in achieving the overall curricular objectives. These results suggest that the proposed planning framework is very robust. Significant changes in the input planning data have little impact on the relative scores of the HOWs. However, there is some minor shifting in the ranking of the HOWs. Scenario #2 which assigns equal weights to the WHATs and Scenario #4 which uses a 1-3-5 rating scale both produce significant changes in the ranking of the HOWs.

4. Conclusion
QFD has proven to be an effective tool in managing product/service development in manufacturing industry, in software development, in service industries, and in academia. It can provide a powerful framework for enhancing effective communication, defining clear and accurate tasks, and achieving effective resource utilization. This makes the technique attractive for adoption as a planning tool to enhance any group decision-making process. In this application in academia, QFD provided a flexible framework to support an integrated, robust curriculum planning process. Its effectiveness can be enhanced through the use of groupware to facilitate consensus building and timely decision-making. The QFD process can also be expanded to provide a structured approach for assessing the outcomes of these curriculum changes.

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Factor Number	Description	***Scenario #1*** Base Case Original Data — Relative Importance (%)	Rank	***Scenario #2*** Equal Weights of 3 — Relative Importance %	Rank	***Scenario #3*** Weights Decreased by 20% — Relative Importance %	Rank	***Scenario #4*** Rating Scale *(1-3-5)* — Relative Importance %	Rank
1	Fundamental Engineering Concepts	25.90	1=	25.37	1=	37.00	1=	84.00	2
2	Management Engineering I	25.42	3	23.88	4	36.31	3	94.00	1
3	Management Engineering II	25.90	1=	25.37	1=	37.00	1=	72.00	4
4	Management of Technology	22.78	4	25.37	1=	32.55	4	75.00	3

Table 1: Summary Results of Sensitivity Analysis

	The WHATs — ***Engineering Tools And Techniques***	**The HOWs: Proposed Courses** — ***Fundamental Engineering Concepts***	***Management Engineering I***	***Management Engineering II***	***Management of Technology***	***Importance 1-little; 5-great;***	**Row Total**
1	Computer Aided Design	*3*	*1*		*1*	***2***	***10***
2	Facilities Planning	*1*	*9*		*3*	***3***	***39***
3	Value Engineering			*3*		***1***	***3***
4	Quality Control	*3*			*3*	***3***	***18***
5	Ergonomics	*3*				***4***	***12***
6	Simulation Modeling	*9*	*3*	*1*		***3***	***39***
7	Multi-Criteria Decision Models	*3*	*9*	*3*	*3*	***3***	***54***
8	Mathematical Programming			*3*		***1***	***3***
9	Scheduling			*3*	*3*	***2***	***12***
10	Network Analysis			*9*		***4***	***36***
11	Expert Systems		*1*			***2***	***2***
12	Artificial Neural Networks				*9*	***4***	***36***
13	Fuzzy Logic					***2***	***0***
14	Quality Function Deployment	*3*	*3*			***5***	***30***
15	Project Management		*3*	*9*	*3*	***5***	***75***
16	Risk Analysis			*3*	*9*	***1***	***12***
17	Computer Programming	*9*	*3*			***3***	***36***
	Absolute Score	***108***	***106***	***108***	***95***		***417***
	Percentage	***25.90***	***25.42***	***25.90***	***22.78***		***100***
	Rank	***1=***	***3***	***1=***	***4***		

Rating Scale: ***1 - Weak*** ***3 - Medium*** ***9 - Strong***

Figure 1: QFD Chart for Course Implementation

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