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A QFD Decision Model for Selecting Service, Teaching, and Research Opportunities

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Abstract

New faculty are confronted with a barrage of information reiterating the importance of performance in the “big three” areas: teaching, service, and research / publications. From the provost to the department head, an untenured faculty member faces strong and sometimes conflicting pressures to become involved in activities ranging from committee assignments to participation in department or university research programs. Often these opportunities come with little guidance, advice, or obvious linkage to long term success in the three pillar areas and ultimately tenure. New faculty are confronted with a complex decision problem for which there is unstructured information available to develop a solution.

This paper presents a strategic and structured decision process for choosing service, teaching, and research opportunities to achieve results for the tenure process. First, this paper discusses the use of strategic planning methods to develop a focused, personal statement of research and teaching interests. In the framework of this strategic research and teaching statement, a Quality Function Deployment (QFD) approach is then developed to rate and identify opportunities that have the highest impact on tenure objectives. The paper promotes a structured career planning process that minimizes non-focused effort, and provides a foundation for future success.

I. Introduction

New engineering educators are presented with a bewildering array of opportunities as they ponder the paths to tenure through teaching, research and service. The contribution to tenure success made by specific activities is not clear, yet new faculty must make decisions as to how to allocate their time. Service options may include multiple university and department committees that can absorb time and effort. Involvement in research centers and industry related projects may lead to research funding and publications but their contribution toward achieving tenure is not clear. Teaching is an important activity that must be performed well but may have limited potential to support research and publication efforts. To aggravate the situation, the priority of the three tenure areas is often unclear. Although it is obvious that the university expects exemplary performance in teaching, research, and service, it is not clear how to select and prioritize the activities that lead to tenure.

This paper describes a decision model that applies Quality Function Deployment (QFD) methods to the problem of planning a successful academic career. Based on the strength of QFD to establish relationships, the model identifies the most important activities by quantifying their impact on teaching, research, and service related objectives. The QFD decision model is based on identification of a well – defined, strategic career context that is discussed in the next section.

II. Strategic Context for Activity Selection

An essential first step in career planning is development of a strategically oriented statement of teaching and research interests. This statement must recognize that time is an issue since tenure planning involves a 3-5 year horizon. An excellent approach for developing this statement is to employ a standard strategic planning tool: SWOT analysis:

Strengths: Examine realistically the strengths you possess and those of the department and university. For example, what is the department known for or what laboratories or facilities are useful to you?

Weaknesses: Consider the issues that will be detrimental and may negatively impact your plans. For example, NSF may be a possible source of research funding but this may not be realistic unless your department has an on-going relationship with NSF.

Opportunities: Examine unexplored areas that may be exploited for your benefit. Areas such as local economic development activities and synergy with current faculty research should be considered.

Threats: Identify competitive issues that may impact your plans. For example, other universities may have programs or research plans that compete with your ideas.

Once the SWOT analysis is completed, important department-related factors should be identified to provide a more comprehensive perspective. First, understand the general goals of the department and the near term plans of the department head. The goals and plans of new faculty should have a symbiotic relationship to the department objectives to assure funding and support in critical areas such as graduate students, conferences, and equipment. Second, it is important to know where the previous sources of research funding have originated and where the untapped sources may be identified. For example, a local industrial firm may have been overlooked and may have need for your expertise.

These departmental factors can be integrated with the SWOT analysis to develop a "statement of research and teaching interests" that summarizes and focuses the professional development plan. This statement provides a context for tenure portfolio activities and integrates directly with the QFD model. The importance of activity alternatives is measured based on the impact in achieving the thrust of this strategic statement. The next section develops the QFD model and assumes that this first strategic step has occurred to provide a focus for the QFD ratings.

III. Quality Function Deployment Decision Model

Quality Function Deployment (QFD) originated as a tool to quantify customer needs and reflect these needs as technical requirements through the product design and manufacturing process. Historical information and detailed applications of QFD in a product development framework are found in [1] and [2]. In product design, QFD relates the product performance requirements of the customer with technical design characteristics through a matrix generally known as the "house of quality." This "house of quality" maps "whats" (product / customer specifications) to "hows" (technological features) and develops a quantitative measure of priority for each technical characteristic based on its impact on the customer requirements. Based on this ability to identify relationships, QFD is an attractive decision tool for application to the problem of career development. Exhibit 1 contrasts the traditional product development orientation of QFD with the career development example that is discussed in the following sections. The specific information used in this example generally reflects the authors' experiences but has been simplified to emphasize the method and to highlight basic model concepts.

Exhibit 1 Comparison of QFD Applications

Product Development Application of Quality Function Deployment			
Whats: Customer or Product Requirement	**Hows:** Technical characteristics that impact customer product requirements	→	**Product Development Data**
Characteristics desired by customer.	Mapping of interrelationships of customer product requirements and the impact of major technical features.		Importance ranking of technical features in meeting customer requirements

Career Management Application of Quality Function Deployment			
Whats: Tenure Requirements	**Hows:** Activities that achieve the tenure requirements.	→	**Career Management Data**
Factors required for organizational success.	Mapping of the interrelationships of teaching, research, and service activities to tenure requirements.		Importance ranking of activities in meeting tenure requirements.

IV. Impact of Activities on Tenure Objectives

Exhibit 2 describes the starting point for the model and lists tenure objectives with their estimated importance (weights). This data should be developed from review of the historical objectives and weight assigned by the various university and department tenure committees.

Exhibit 2 Tenure Objectives and Description

Tenure Objective	Importance (Weight)	Description
Teaching Effectiveness	25%	Ratings and feedback from courses taught
Research –Journal Publications	25%	Publications in refereed journals
Research - Funding	25%	Annual average of funded research and grants
Research – Conference papers	15%	Refereed conference papers, presentations, and technical reports
Service - University	5 %	Service to the department and the university
Service- Professional	5 %	Service to professional organizations

The QFD model identifies two levels for the potential activities to impact the tenure objectives. The first level evaluates the direct effect of the activity on the tenure objective. Since activities may also influence each other, the second impact level measures the interaction (indirect) effect of the activities on each other. From these two impact levels, the cumulative effect of an activity on tenure objectives can be developed. Consider the case in which a faculty member has to prioritize the five activities listed below.

1. Participate in a university task force to develop guidelines for experiential learning course credit.
2. Represent the department on the College of Engineering library committee.
3. Become a member of a team focusing on supply chain programs for local industry through the College of Engineering Modeling and Simulation Center.
4. Teach a professional development class on project management.
5. Work on an industry project through the university Technology Applications Center.

Exhibit 3 describes the results of scoring the activities based on their impact on the strategic goal statement and the tenure objectives. It employs a traditional (9,3,1) QFD method: nine indicates high impact of an activity on an objective, three indicates medium, one indicates small, and zero indicates no impact. Additional information on scoring methods can be found in [3] and [4].

Exhibit 3 Activity Impact on Tenure Objectives

Tenure Objective	Weight	Activity Options				
		Experiential Learning Task Force	Library Committee	Modeling and Simulation Center	Teach Professional Development Course in Project Management	Technology Application Center Project
Teaching Effectiveness	25%	0	1	3	3	3
Research – Journal Publications	25%	0	1	9	1	3
Research - Funding	25%	1	1	9	3	3
Research – Conference papers	15%	0	3	3	9	3
Service - University	5 %	3	3	3	3	3
Service-Professional	5 %	0	0	3	3	1

Measurement of activity interaction is an important attribute for a decision model. The general QFD approach to this issue employs the concept of correlation between the technical characteristics (hows) and describes interaction in terms of a fractional value between zero and one [5]. The interaction between a given pair of activities is a fractional value between ± 1. Using the (9,3,1) rating scale as a basis, a set of interaction scores can be defined:

- High, positive or negative interaction between two activities is assigned a ± score of 9 / (9+3+1) = 9/13 = 0.69;
- Medium interaction is a ± score of (3 / 13) = 0.23;
- Low interaction is a ± value of (1 / 13) = 0.077
- No interaction results in a zero score.

Exhibit 4 uses this approach to develop an interaction matrix that is symmetrical about the main diagonal. Consistent with the concept of correlation, the matrix assumes that the interaction of activities is reciprocal. For example, participation on the library committee is judged to have a strong interaction with participation in the modeling and simulation center. Conversely, participation in the experiential learning task force has no impact on either the Modeling and Simulation Center or the Technology Application Center project.

Exhibit 4 Interaction Matrix for Work Packages

	Experiential Learning Task Force	Library Committee	Modeling and Simulation Center	Professional Development Course	Technology Application Center Project
Experiential Learning Task Force	1	0.077	0	0.077	0
Library Committee	0.077	1	0.23	0.077	0.077
Modeling and Simulation Center	0	0.23	1	0.23	0.23
Professional Development Course	0.077	0.077	0.23	1	0.23
Technology Application Center Project	0	0.077	0.23	0.23	1

V. Career Management Information

Using the data in Exhibits 2, 3, and 4, QFD can develop a range of useful career management information. The following questions provide an analytical framework to illustrate this capability:

1. Activity impact: How can the interactions of the activities in Exhibit 4 be combined with the direct impact information in Exhibit 3 to evaluate the total impact of the activities on the tenure objectives?
2. Proportional activity impact: Do the activities impact the tenure objectives in a manner proportional to the importance (weights) of the objectives? For instance, activities may have been selected that ignore a high priority objective.
3. Importance of the activities to the tenure objectives: Which activities are most important to achieve the success of specific tenure objective and to overall success?

1. Evaluating Activity Impact

Defining the activity impact on objectives requires integration of the data in Exhibits 3 and 4 to develop a combined measure of the direct and interaction impact. The QFD methodology develops this information using matrix multiplication. In the general case, the direct impact data of Exhibit 3 is a matrix **A** (bold, capital letter denotes a matrix) of m rows representing objectives and n columns representing activities. The elements of this matrix may be described as a_{ij} (i = 1, 2,…, m and j = 1, 2,…,n). Similarly, the interaction data in Exhibit 4 is an n x n matrix **B** with elements b_{ij} (i, j = 1,2,…, n). The combined impact (including interactions) of activities on objectives may be defined by the m x n matrix **C** that is the result of the matrix product (**A x B** = **C**). The elements of **C** (c_{ij}) describe the complete impact of $(\text{activity})_j$ on $(\text{objective})_i$.

$$c_{ij} = \sum_{j=1}^{n} a_{ij} b_{jk} \qquad (1)$$

The upper half of Exhibit 5 contains the **C** matrix that provides a quantitative measure of both direct and interaction impact of the activities on the tenure objectives. For example, the impact of the Experiential Learning Task Force on the Teaching Effectiveness objective is:

$$c_{11} = 0*1+1*0.077+3*0+3*0.077+3*0=0.3 \quad (2)$$

In addition to **C**, the upper portion of Exhibit 5 contains two additional columns: the row total and the normalized row total. The row total elements are defined by the sum of the row impact values. For instance the row total for Teaching Effectiveness is:

$$\sum_{j=1}^{5} c_{ij} = 0.3 + 2.2 + 4.6 + 4.5 + 4.5 = 16 \quad (3)$$

Dividing the row total by the grand sum of all the C matrix elements and expressing this value as a decimal or percentage value develops the normalized row total:

$$\frac{\sum_{j=1}^{n} c_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}} = \frac{16}{128.6} = 0.12\,(12\%) \quad (4)$$

These columns (row total and normalized row total) will be used to answer questions in the next section.

2. Assessment of Proportional Work Package Impact

The second question asks whether the impact of the activities on the tenure objectives is consistent with the objective importance (weight). The normalized row totals (last column) of Exhibit 5 provide the basis to analyze this issue. By comparing the importance of an objective with the normalized row total value, we determine if the impact of the identified activities is proportional to (consistent with) the original importance of the objective.

This comparison identifies several issues in the example. Teaching Effectiveness is 25% of tenure importance, yet it receives only 12% of the activity impact. On the other side, the University Service objective is only 5% of tenure importance and receives 17% of the impact of the analyzed activities. This type of analysis indicates that there may be a need to redefine the activities or identify new ones to assure appropriate (proportional) objective impact.

Exhibit 5 Total Impact of Activities on Tenure Objectives

Tenure Objectives	Objective Importance (Weight)	Activities						
		Experiential Learning Task Force	Library Committee	Modeling and Simulation Center	Professional Development Course	Technology Application Center Project	Row Total	Normalized Row Total
Teaching Effectiveness	**25%**	0.3	2.2	4.6	4.5	4.5	16.0	**12%**
Research –Journal Publications	**25%**	0.2	3.4	10.2	3.8	5.4	22.9	**18%**
Research - Funding	**25%**	1.3	3.6	10.6	5.9	5.8	27.3	**21%**
Research – Conference papers	**15%**	0.9	4.6	6.5	10.6	6.0	28.6	**22%**
Service - University	**5 %**	3.5	4.4	5.1	4.8	4.6	22.4	**17%**
Service-Professional	**5 %**	0.2	1.0	3.9	3.9	2.4	11.4	**9%**
					Impact Sum		**128.6**	
		Normalized Impact Values						
Teaching Effectiveness	25%	2%	13%	29%	28%	28%		
Research – Refereed Journal Publications	25%	1%	15%	44%	17%	23%		
Research - Funding	25%	5%	13%	39%	22%	21%		
Research – Conference papers	15%	3%	16%	23%	37%	21%		
Service - University	5 %	15%	20%	23%	22%	21%		
Service-Professional	5 %	2%	9%	34%	34%	21%		
Activity Importance to Tenure		**3%**	**14%**	**34%**	**25%**	**23%**		

3. Assessment of Work Package Importance

The final question addresses the importance of a work package both to an individual objective and to the overall program. To examine these issues, the upper portion (**C** matrix) of Exhibit 5 is restated in the lower portion in terms of normalized impact values ($\mathbf{C}^{\mathbf{N}}$ matrix). The elements of the $\mathbf{C}^{\mathbf{N}}$ matrix (c_{ij}^{N}) are:

$$c_{ij}^{N} = \frac{c_{ij}}{\sum_{j=1}^{m} c_{ij}} \quad (5)$$

The elements of $\mathbf{C^N}$ provide direct insight into the importance of an activity for a specific tenure objective. For instance, the normalized impact of the Modeling and Simulation Center on Refereed Journal Publications is:

$$c_{23}^{N} = \frac{c_{23}}{\sum_{j=1}^{5} c_{2j}} = \frac{10.2}{22.9} = 0.44(44\%) \qquad (6)$$

This value indicates that the Modeling and Simulation activity produces 44% of the impact on the Refereed Journal Objective. It is clear that the Modeling and Simulation Center and the Technology Applications Project are the most important activities for the Refereed Journal objective and contribute 67% of the total impact toward attainment of this objective (44% + 23% = 67%).

The last part of the third question addresses the relative importance of the activities to the tenure goal and $\mathbf{C^N}$ also provides the key to this information. Consider the Library Committee activity and its value to achieving tenure. This impact can be quantified by multiplying the relative importance of each objective by the impact of the Library Committee on that objective and summing these values. Expressing this in matrix notation, the objective importance can be considered a 6x1 column vector **W** (weight). If **W** is transposed ($\mathbf{W^T}$) and used with the normalized impact matrix $\mathbf{C^N}$ to develop the product ($\mathbf{W^T}$ **x** $\mathbf{C^N}$), the result is a 1 x 5 row vector, **T**, that expresses the total importance of each activity to tenure success. For example, the element of **T** that expresses the importance of the Library Committee to the tenure objectives (14%) is:

$$t_{11}=0.25 * 0.13 + 0.25*0.15+ 0.25*0.13+... + 0.05 * 0.09 =0.14\ (14\%) \qquad (7)$$

Similar calculations produce the remaining entries of $\mathbf{W^T}$ in the row "Activity Importance to Tenure" in Exhibit 5. The values in this row identify the Modeling and Simulation Center and Teaching the Professional Development Course as the most important activities for tenure. It is also clear that the Experiential Learning Task Force is probably a waste of time.

VI. Summary

Successfully navigating the path to tenure can be enhanced by using basic decision science tools to organize and prioritize activities. This paper has presented a QFD model that can help to achieve this goal. The model is capable of highlighting key decision factors by:

- Developing a framework for integrating strategic and tactical selections in career planning.
- Identifying relationships between activities and tenure objectives.
- Providing a quantitative measure for identifying productive and non-productive activities.

The model provides new insight for understanding relationships between potential activities and the attainment of tenure. However, decision models are only one factor to consider in this complex decision. The final direction must integrate many other issues such as intellectual curiosity and personal satisfaction which are critical in the long run but very difficult to model.

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