USING QUALITY FUNCTION DEPLOYMENT IN TRAINING SYSTEMS DESIGN AND DEVELOPMENT

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INTRODUCTION

Any training systems development effort must satisfy many needs, requirements and expectations. The quality function deployment (QFD) technique offers designers, developers, managers, sponsors, and other decision makers a simple way to identify and track the accommodation of the all needs, requirements, and expectations throughout the entire development process.

Quality Function Deployment has its roots in manufacturing as a design quality tool. Yoji Akao first conceptualized it in 1966 as an approach to new product development and concurrent engineering where customer requirements were integrated into product design (Akao, 1990). John Hauser and Don Clausing of Harvard University brought QFD into the mainstream of the quality movement in the United States in 1988. Hauser and Clausing used the phrase "House of Quality" to describe the modular building process for the QFD matrix in a manner similar to adding features to a house (Hauser & Clausing, 1988). The procedure is extremely well documented in the literature. QFD remains a mainstream quality technique as evidenced by the recent article in the Quality Management Journal by Ita Richardson, Eamonn Murphy, and Kevin Ryan. These authors offer a generic QFD methodology for software process improvement (Richardson, Eamonn, & Murphy, 2002).

The Imperative

In competitive market environments, a successful product is one that is perceived by the customer as being of high quality. This quality imperative compels producers to make every effort to make their product possess the attributes desired by the customer. Quality Function Deployment (QFD) is an analytic technique used to insure that products meet customer requirements and preferences. The QFD procedure systematically matches customer requirements and preferences with production requirements, capabilities and constraints. The result is a product that can be efficiently and cost effectively produced, while fully satisfying the customer.

Training systems developers also strive to produce high quality products in their product engineering efforts. Their goal is to produce instructional products that are efficient in their implementation, cost effective, and that quickly and fully satisfy the needs of the customer or stakeholders. This means that to produce a high quality instructional product that supports high performance capabilities, training system developers must fully integrate learner and system needs as well as the needs of the learner's future work environment with instructional design requirements.

Traditional instructional design methodologies provide for the identification of training requirements, addressing the needs of the learner, and articulating strategies to achieve the required level of training. However, traditional design models tend to be sequential and do not dynamically integrate the different aspects of the training development process from the stakeholder requirement perspective. QFD offers a method that dynamically links and integrates stakeholder needs, training system requirements, and design considerations. QFD also helps designers correlate and identify tradeoffs between the different design elements, and insures that all stakeholder needs are met.

The Stakeholder as the Key to Success

The key element of producing a high-quality training product is the ability of the training systems development process to recognize and accommodate stakeholder needs. Stakeholders are described in the Baldridge Award for Education criteria as entities that benefit from quality education. These stakeholders are usually the student, the institution charged with the educational mission, and the future environment of the learner. In the military context, there are three types of stakeholders involved in any training systems development effort.

The first stakeholder is the individual who acquires the skills and capabilities to perform his or her job within the operational system and environment. This stakeholder expects a "doable" and effective training environment, accomplished in a reasonable time frame that equips him or her with skills necessary to achieve success in the "real world." The individual may be concerned with issues beyond the immediate training goals such as his or her ability to perform in the pressures of a real environment, ability to perform with others, and preparation for further skill acquisition and advancement.

The second stakeholder is the future employer or command who relies on the training system to develop the requisite level of competency in the learner to enable the learner to perform his or her jobs. The needs of this stakeholder can be far ranging and can include skills throughout the environmental spectrum from the individual through various organizational levels to the social context (ISPI, 2002).

The third stakeholder is the training agent of the service. This is the organization charged with the training mission and who is responsible for the efficient and cost effective operation of the training system. Competency requirements, time to train, training effectiveness, overhead or infrastructure costs, technology, and other considerations are issues of concern for this stakeholder.

Each of these stakeholders has a unique set of needs and expectations that must be addressed in the training systems design effort. The following description of the QFD process will demonstrate how stakeholder needs can be identified, integrated into the design process, and tracked through the development process.

THE QFD PROCESS

The Quality Function Deployment technique is a graphic-based process based on one or more matrices that show the relationships between stakeholder requirements and various design elements. One advantage of the QFD technique is that there is no specific form that must be followed, although the matrix approach is most common. Also, the QFD process is flexible and encourages innovative thinking to tackle the many problems encountered with designing an instructional product that satisfies all the stakeholders. This makes the process adaptable and easy to use for any situation.

Step 1: Identifying Stakeholder Requirements and Instructional Imperatives

The starting point for the QFD process is the identification of the customer or stakeholder needs and requirements. These requirements are stated as simply as possible and represent the stakeholders' desired attributes of the instructional product. The next task is to identify instructional imperatives (such as strategies, technologies, delivery methods, constraints, or other design considerations) that accommodate the stakeholder requirement.

The stakeholder requirements and instructional imperatives are generated by brainstorming or some similar approach. It is important to maintain a stakeholder focus throughout the process.

The initial matrix will consist of the stakeholder requirements listed down the left hand side as row labels, and the instructional imperatives listed across the top as column headings. The cells in the body of the matrix formed by the rows and columns will be used later for a relational analysis in Step 2.

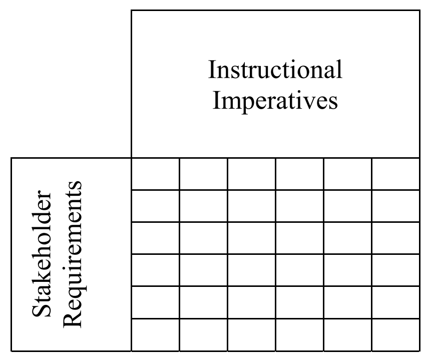


Figure 1. Basic Starting QFD Matrix

There are some general rules for this step:

1. For each listed requirement, there should be at least one corresponding instructional imperative that will satisfy the requirement.

2. There can be more than one imperative to accommodate a requirement and a single imperative may accommodate more than one requirement.

3. There should not be any requirement that is not accommodated by at least one imperative.

4. An instructional imperative may stand alone as a needed design consideration not related to a specific requirement.

A detailed analysis of the relationships between the stakeholder requirements and instructional imperatives is conducted in step 2.

Figure 1 depicts the most basic initial matrix. The row and column categories can be further broken down in order to better represent the different needs and requirements for the different stakeholders. For the military training environment, each of the three stakeholders previously mentioned can be represented individually by decomposing the general stakeholder requirements and listing the respective requirements according to the category (figure 2). This helps the designer organize and track the specific considerations throughout the design process.

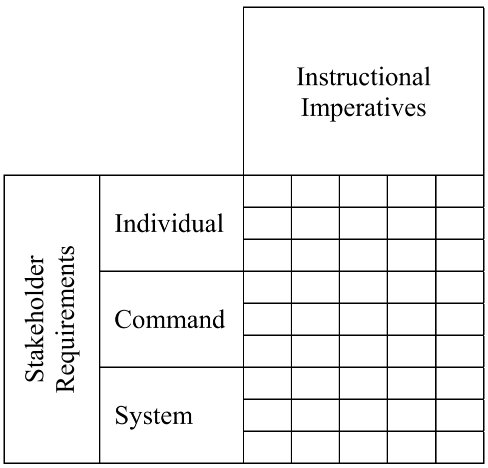


Figure 2. Decomposed Stakeholder Requirements

In a similar manner, the instructional imperatives can be further classified (figure 3). Since the instructional imperatives are identified in order to accommodate stakeholder requirements, they can be organized according to types of instructional considerations such as instructional strategies, technologies, system capabilities, etc.

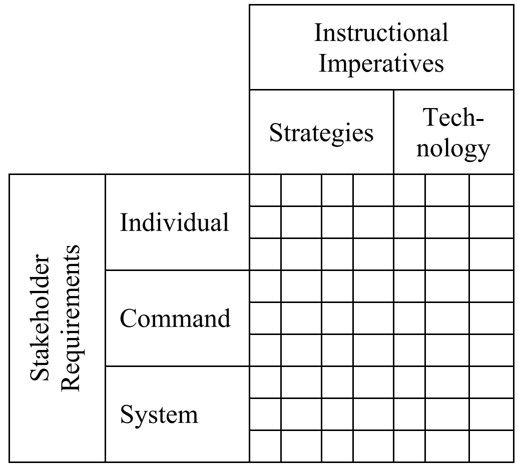


Figure 3. Decomposed Instructional Imperatives

The organization shown here is for the purpose of demonstration only. Each circumstance will require a unique organization suited to the situation at hand. Clearly, these matrices can become extensive and cumbersome. When this occurs, individual starting matrices can be constructed for each stakeholder category.

A Simple Example. Assume a training center is reengineering an electronics repair course. A learner analysis has been conducted and the top three needs identified by the learners are computer facilitated lessons, practical exercises with actual equipment, and a short course duration. The commands that will employ the course graduates want skilled technicians that are familiar with the equipment used in the field. Finally, the training center wants to automate the course as much as possible to reduce cost, minimize time to train, and attain higher achieved competency levels. This information might yield the initial matrix below (figure 4).

The use of technology is a clear imperative in this case. Instructional strategies designed to provide realistic training, teach team trouble shooting and problem solving, and reduce training time are also indicated. Training consistency is also needed to provide a standard training product.

			Instructional Imperatives				
			Strategies			Tech-nology	
		Requirements	Practical Exercises	Team skills	Fast paced	Current equipment	CBT System
Stakeholder Requirements	Individual	Computer-based					
		Practical training					
		Short course time					
	Command	High competency					
		Currency					
	System	Automation					
		Short time to train					
		Increase competency level					

Figure 4. Sample Matrix

STEP 2: Assessing Relationships Between Stakeholder Requirements and Instructional Imperatives

Once the stakeholder requirements and instructional imperatives are identified, the designer needs to assess the nature and strength of relationships between all requirements and instructional imperatives. The purpose of this step is to identify the specific links between the stakeholder requirements and instructional imperatives and to determine the importance of each instructional imperative to the different requirements. The result of this assessment is useful for prioritizing the instructional imperatives and conducting trade-off analyses later.

This assessment is accomplished by assigning a measure of correlation to each cell formed by the column-row intersection of the stakeholder requirements and instructional imperatives. In the simplest form, the measure of correlation can be indicated by symbols such as a "+" for a positive relationship where the imperative is needed for the requirement, a "0" for no relationship between an imperative and a particular requirement, and a "-" for a negative relationship where an imperative may interfere with satisfying a requirement. There can be any scheme for this assessment. When quantitative data are available, actual correlation values can be calculated and inserted into the cells.

Example Continued. Working through the previous matrix (figure 4) might yield the result shown in the matrix below (figure 5).

			Instructional Imperatives				
			Strategies			Tech-nology	
		Requirements	Practical Exercises	Team skills	Fast paced	Current equipment	CBT System
Stakeholder Requirements	Individual	Computer-based	-	-	+	0	+
		Practical training	+	+	-	+	-
		Short course time	0	-	+	0	+
	Command	High competency	+	+	-	+	+
		Currency	+	0	0	+	+
	System	Automation	-	-	+	+	+
		Short time to train	-	-	+	0	+
		Increase competency level	+	+	-	+	+

Figure 5. QFD Matrix with correlations

The relationship indicators in the matrix cells reveals that there appear to be some imperatives that are needed for some stakeholder requirements, not for others, and might be detrimental for some. Every requirement is supported by at least two imperatives (indicated by the "+"), but every requirement also has at least one imperative that might interfere (the "-" indications). Other observations might include that the use of a CBT system as an instructional imperative appears to support the most requirements, teaching team skills might be most problematic in accommodating other requirements, and using current equipment will not negatively effect any requirement. Such a relational analysis helps the designer "see" the big picture, identify conflicts and problems, and point to critical instructional imperatives.

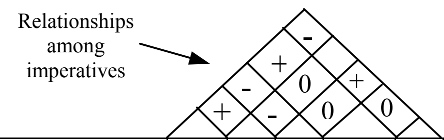
Step 3. Examining Relationships Among Instructional Imperatives.

This step and the remaining steps can be accomplished in any order and are included only if needed. Some applications of the QFD involve steps or aspects not addressed here. Additional steps are analytical and employed to achieve specific purposes depending on the situation.

Once instructional imperatives are identified, it is often helpful to examine the relationships, if any, among the imperatives. There are several reasons such an analysis may be of benefit, but two are noteworthy. First, the relationships between the instructional imperatives need to be understood in order to understand the impact of the imperatives on each other. While all imperatives are necessary, they may be related to one another in different ways. For instance, some imperatives may not be able to exist on their own and require another to work (e.g., CBT and requirements for a network-based system). In some cases imperatives may not fit together wel or may detract from one another (e.g., CBT and paper-based instructional objects). Finally, some imperatives may not be related at all (e.g., CBT and experienced instructors). Second, knowledge of the relationships among the identified instructional objectives can be important in decision-making. In the later stages of a project, cost constraints may compel designers to look for imperatives to eliminate. These decisions can be best made when all the relationships between the imperatives are understood. This can preclude eliminating an imperative that is needed to support another imperative or overlooking an imperative that is redundant because another imperative "covers" the associated requirement.

Example Continued. The partial matrix shown below (figure 6) provides an example of one approach to a relational analysis among instructional imperatives. The "roof" of the house of quality matrix shows where the designer evaluated the relationships between each pair of imperatives and used the simple method of indicating a positive relationship with a "+", no relationship with a "0" and a negative relationship with a "-." Again, more sophisticated methods, such as scales or other statistical techniques can be developed to describe the relationships in order to meet the needs of the situation.

In this example, team skills and practical exercises are seen as related by the designer. If a decision is made to eliminate practical exercises, then team skills will likely suffer in this situation. The minus sign in the intersection of the "practical exercises" column and the "fast-paced instruction" column in the "roof" area of the matrix suggests that the designer has identified a negative relationship between practical exercises and fast paced instruction. This might mean that the designer feels the two imperatives might interfere with each other in this situation. Perhaps the designer believes that if practical exercises are reduced or eliminated, the instruction could be faster paced. Conversely, if the pace of instruction is slowed down, practical exercises may be more easily integrated into the training product. Whatever the explanation of the negative relationship in the eyes of the designer, the point is that the relationship has been evaluated and such evaluation can be helpful in future trade-off analyses.



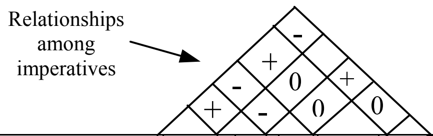
Stakeholder Requirements	Instructional Imperatives	Practical Exercises	Team skills	Fast paced	Current equipment	CBT System
	Computer-based	-	-	+	0	+
	Practical training	+	+	-	+	-
	Short course time	0	-	+	0	+
	High competency	+	+	-	+	+
	Currency	+	0	0	+	+
	Automation	-	-	+	+	+
	Short time to train	-	-	+	0	+
	Increase competency level	+	+	-	+	+

Figure 6. Partial QFD Matrix Showing Relationships Between Imperatives

At this point, the QFD matrix helps the designer track the accommodation of the stakeholder requirements with various instructional approaches and shows potential trade-off implications in setting the optimal mix of instructional imperatives.

Step 4. Evaluating Stakeholder Needs and Requirements

The fourth step normally involves evaluating how the existing system is accommodating the stakeholder requirements and possibly how competing designs may accommodate the requirements. In terms of the matrix, the designer can create a "porch" that can be used to register a rating scheme that evaluates the existing system or compares the existing system to other alternatives does this. The matrix below demonstrates this capability (figure 7).



Imperatives / Requirements	Practical Exercises	Team skills	Fast paced	Current equipment	CBT System	Rating (X – Current, A – Alt. A, B – Alt. B; Better →)
Computer-based	-	-	+	0	+	X A B
Practical training	+	+	-	+	-	B A X
Short course time	0	-	+	0	+	X A B
High competency	+	+	-	+	+	A X B
Currency	+	0	0	+	+	A X B
Automation	-	-	+	+	+	X A B
Short time to train	-	-	+	0	+	X A B
Increase competency level	+	+	-	+	+	X A B

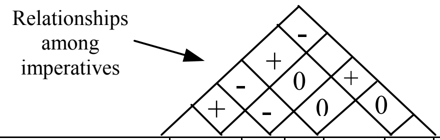
Figure 7. QFD Matrix with Stakeholder Requirements Evaluation Section

In this example, the designer has found a way to evaluate how well each of three alternatives satisfies each requirement. A simple rank-order method is used here to rank each alternative in relation to the others. For each stakeholder requirement, The three alternatives are ranked according to the degree the alternative satisfies the requirement. "Better" is to the right in this example, which means an alternative listed to the right of another is the better of the two in satisfying the requirement.

These comparative evaluations can be very sophisticated based on the nature and extent of data collected for the evaluation. Numerical scales like Likert scales or "snake" diagrams can be used as well if the rating data can be quantified. In this case, it appears that option B best accommodates all the requirements but one. Such evaluations allow decision-makers to compare alternative systems at a glance.

Step 5. Value Analysis of Instructional Imperatives

Each instructional imperative that is included in the training product has a value such as cost, return on investment, time to train impact, etc. A cost figure or some other value or factor representation can be calculated for each imperative. This valuation is normally displayed in the "basement" of the house of quality as shown in the matrix below (figure 8).



Imperatives / Requirements	Practical Exercises	Team skills	Fast paced	Current equipment	CBT System	Rating (X – Current, A – Alt. A, B – Alt. B; Better →)
Computer-based	-	-	+	0	+	X A B
Practical training	+	+	-	+	-	B A X
Short course time	0	-	+	0	+	X A B
High competency	+	+	-	+	+	A X B
Currency	+	0	0	+	+	A X B
Automation	-	-	+	+	+	X A B
Short time to train	-	-	+	0	+	X A B
Increase competency level	+	+	-	+	+	X A B
Value Analysis ($100,000)	4	2	5	3	9	Total: 23

Figure 8. QFD Matrix with Value Analysis for Instructional Imperatives

Example Continued. In this example, the designer has developed a dollar figure for the implementation of each instructional imperative for the given situation. The relative cost of each imperative can be easily seen. The value analysis indicates that if all imperatives are implemented the total cost would be $2,300,000. This figure becomes the baseline for efforts to reduce costs while accommodating the stakeholder requirements.

Expanding the Matrix

The QFD Matrix can be tailored to address any variety of analytical needs. For more complex situations, a separate matrix can be developed for the different elements being considered in order to keep the matrices manageable. In complex systems a single category of stakeholder requirements may generate a matrix with hundreds of requirement-imperative combinations. Separate matrices can be initiated for each category of stakeholder. Likewise, a separate matrix can be created for each category of instructional imperative. For example, technology issues are usually complex and may be best handled by creating a technology matrix to develop the optimal application of technology characteristics that best accommodates stakeholder requirements related to technology.

Follow-on Matrices

So far, the matrix representing the relationship between stakeholder requirements and instructional imperatives have been examined. Once the instructional imperatives have been selected, a new matrix can be created with the instructional imperatives listed as the rows and specific instructional strategies listed as the columns (figure 10).

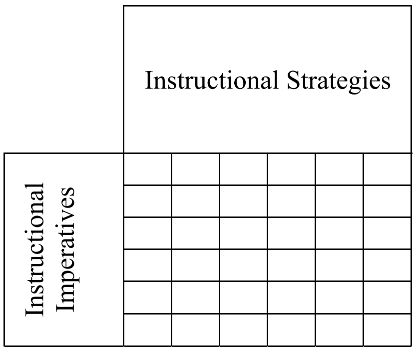


Figure 9. Instructional Imperative – Strategies Matrix

If needed another matrix can be created with the specific instructional strategies listed as the rows, and the requisite instructional tools and design elements listed as columns. Yet another matrix might be a set up for examining the relationships between instructional strategies and learner strategies suc as the case in figure 10. Each follow-on matrix will be constructed in the form needed to support the analytic goals

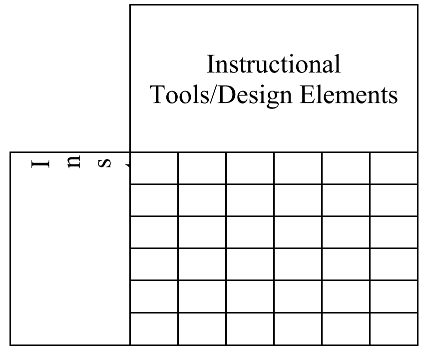


Figure 10. Instructional Strategies – Tools Matrix

A Final Example.

The matrix below (figure 11) demonstrates yet another variation of the QFD matrix. This matrix is designed to evaluate tradeoffs among technology considerations in the context of comparing three competing systems. The ultimate outcome is a quantified cost factor for each alternative weighted by the importance of the learner requirement and the relative quality score for each alternative.

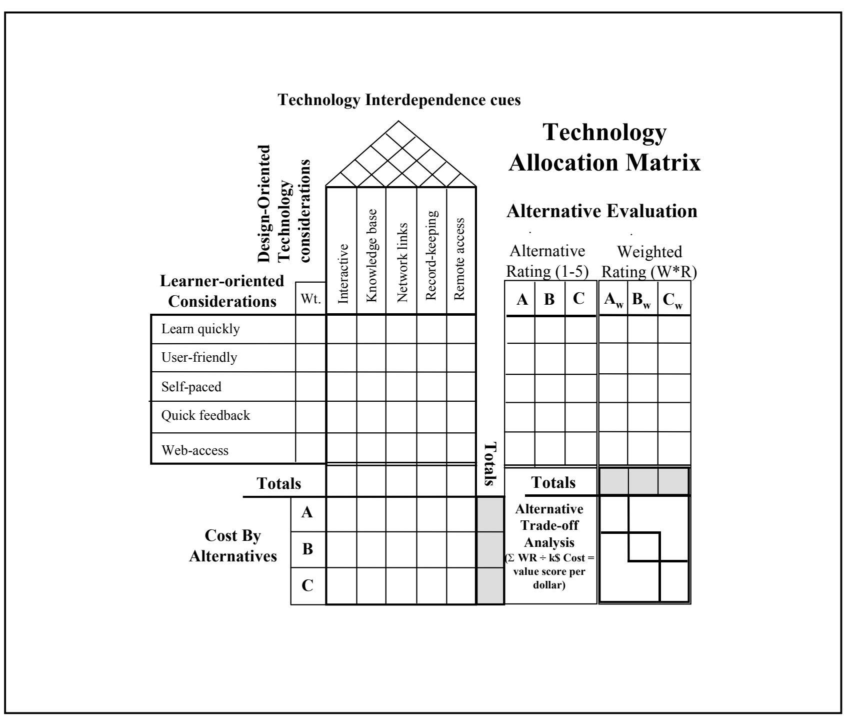


Figure 11. Trade-off QFD Matrix

CONCLUSION

One of the complaints with instructional products today is the tendency for design to drive the product rather than the stakeholder needs and requirements. Only by starting with the stakeholder needs and requirements, basing the design on these needs and requirements, and tracking the needs and requirements all the way through the design process, will the instructional product succeed. Quality Function Deployment is a simple, flexible, and easy to manage procedure that will allow everyone involved in the project to instantly see the design structure and track the accommodation of the stakeholders' needs and requirements through the entire course of the project.

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