Quality Function Deployment (QFD) is a product development process that assures the needs and desires of the customer are heard and heeded during the design, development and production of a product. Though it has been used successfully in other industries, only a few companies in the U.S. Engineering and Construction Industry have used QFD. The purpose of this project was to demonstrate that QFD can be used to assure that the voice of the owner is heard and heeded in the planning and conceptual design of a construction project. QFD methods were used in the conceptual design of a large capacity state-of-the-art, college classroom. Two classroom concepts and a list of related teaching-aid equipment were produced. These demonstrate that using QFD renders conceptual designs that respond to the voice of the customer.
I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.
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DEDICATION

To Dr. Becky
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Quality Function Deployment (QFD) is a product development process that aims specifically at identifying customer requirements and heeding those requirements throughout the design, development and production of new products. It focuses on delivering value by seeking out both spoken and unspoken needs, translating these into design parameters and communicating these throughout an organization (Mazur 1995; Nakui 1992; Wasserman 1993). QFD helps create products that please the customer not just the engineer (Hauser & Clausing 1988). The project described in this paper demonstrates the use of QFD in hearing the voice of the customers and heeding that voice throughout the conceptual design of a large capacity, state-of-the-art college classroom.

The concept of QFD was developed in 1972 as part of the Total Quality Management (TQM) system at the Mitsubishi Shipyard in Kobe, Japan. Toyota further developed the concept in the late 1970's. Since then, it has been used in many Japanese industries.

QFD is not a group of brand new ideas. It involves procedures that most people either already do, do some time, or know about. It uses goal setting,
customer research, prioritization, benchmarking against known standards, technical measurements, value engineering and many other tools depending on the application (Dika 1991). It also involves a lot of plain common sense. It replaces erratic, intuitive decision-making processes with a structured methodology that puts things down on paper and helps to make sense of it all so that everyone is working in the same direction. (Burrows 1991).

What is new about QFD is the way these ideas and procedures are integrated into a system that structures the work as a whole. It provides a series of steps that cross-functional teams can follow to get a job done more effectively (Dika 1991).

QFD in the United States

The QFD concept was brought to the United States in the early 1980s by Ford Motor Company and Xerox. These companies were encouraged by the claims that QFD resulted in 60% reduction in design costs and 40% reduction in design time (Griffin 1993). Lawrence P. Sullivan (1986) reported that Toyota Autobody started using QFD in 1977. "Between January 1977 and April 1984, Toyota Autobody introduced four new van-type vehicles. Using 1977 as a base, Toyota reported a 20% reduction in start-up costs on the launch of the new van in October 1979; a 38% reduction at November 1982; and a cumulative 61% reduction at April 1984. During this period the product development cycle (time to market) was reduced by one third with corresponding improvements in quality because of a reduction in the number of engineering changes". Today, many
industries in the United States are using QFD successfully. These include industries such as the automotive, electronics, banking, insurance, hospitals, power companies, food processing industries and others.

**QFD in Engineering and Construction**

Even though in other industries, interest in QFD is strong and growing in the mid-1990s, it has been used by very few companies in the construction industry. Recent efforts by some engineering and construction companies have been made to apply the total quality management (TQM) concepts that have transformed other industries (QFD is part of TQM). Owners that have re-engineered their production processes, focusing on improving quality, are demanding that construction projects be done with a focus on quality. Even so, statistically nearly 40% of the members of the Construction Industry Institute (an organization of owners, designers and contractors) had no TQM program in place in 1994. Less than 50% of the members of Associated General Contractors (an association of union contractors) are using quality teams (Schriener 1995).

There are several possible reasons why the Engineering and Construction Industry has not used Quality Function Deployment:

- Ignorance of its existence. QFD is not widely known in the construction industry.
- The need for dedicated commitment of top management in implementing QFD (Kinni 1993)
The daunting amount of effort needed to implement QFD

Complacence. Decision makers in the E&C industry are comfortable with the status quo. This suppresses the desire to seek out and try new approaches.

People have a natural tendency to resist change. QFD entails some changes from familiar approaches. However, for those forward looking companies willing to apply concepts that have transformed other industries, QFD has many advantages to offer.

In manufacturing, QFD has forced companies to find out what their customers want, translate that information into measurable engineering parameters, turn those parameters into part specifications, then, manufacture those parts so that they do exactly what the customer asked for in the first place (McElroy 1987). Similarly, in construction, QFD could force companies to find out what the owner wants, translate those wants into measurable engineering parameters, turn those parameters into designs and construction documents, then construct exactly what the owner asked for in the first place.

Objective of the Study

The objective of this study is to demonstrate the effective use of Quality Function Deployment tools in evoking the voice of the customer, and assuring a positive response to that voice through the conceptual design phase of an engineering project. The project is a large capacity, state-of-the-art classroom
for Oregon State University. The intent of this study is to develop a design model for large classrooms that will be used in future expansions of the university.

**Scope of the Study**

The scope of the project includes:

- Identifying the needs of the classroom "customers" through the use of focus group interviews
- Organizing the focus group data using affinity diagrams and tree diagrams
- Building the first house of quality to establish measurable engineering requirements necessary to respond to the voice of the customers
- Designing layout concepts for a large classroom that respond to the voice of the customer
- Compiling a list of teaching-aid equipment that responds to the voice of the customer

The project scope goes no further than the conceptual design phase.
CHAPTER 2
METHODS

Quality Function Deployment

QFD provides a set of communication routines that focus efforts and coordinate skills within an organization from the time a project is first conceived until it is completed. It is based on the belief that products should be designed to reflect the customers' desires and tastes (Hauser 1988). Design products to satisfy the customer. That sounds like a truism, but before the advent of QFD, often it was assumed that designers knew best and that customers would be satisfied with what the designers produced.

Who are the "customers"? The answer is not always obvious. In the E&C industry, "the owner" is an obvious answer. However, this is only a partial answer. Actually, within the owner's organization, the groups that will use and maintain the completed facility -- sales, design, engineering, manufacturing, quality control, shipping, maintenance, etc. -- are also customers. Unless these groups are satisfied, the owner will not view the project as successful. Also, the designer's own management and sales staff, as well as the contractors that will build the facility are "customers". Each of these groups have valuable inputs to be considered and addressed in the design and construction of a successful facility. QFD provides methods for hearing and heeding the voices of all these customers.
The QFD Team

Because most projects require knowledge in many areas, a cross-functional team with members of varying views and backgrounds is formed. This QFD team evokes and listens to the voice of the customer (VOC). Then, it uses QFD tools and methods to translate the customer-voiced needs into measurable engineering characteristics. The QFD team members are drawn from and represent the customer, the disciplines, and the functional groups that will respond to the VOC.

Tools of Quality Function Deployment

QFD provides tools for gathering, and prioritizing customer-voiced needs and wants. The most used QFD tools are the Focus Group Interview, the Affinity Diagram, the Tree Diagram and the House Of Quality (Bossert 1991). These are the tools used in this study.

Focus Group Interviews

The focus group interview is a data collection procedure that accomplishes a specific purpose through a defined process. In this respect, it differs from other familiar group interactions where the goal is to reach a consensus, provide recommendations, or make decisions among alternatives. Brainstorming techniques resemble the freedom and spontaneity of focus groups but differ in that brainstorming is often directed to solving a particular problem. Brainstorming primarily involves people who are knowledgeable in finding potential solutions. On the other hand, focus groups pay attention to the perceptions of the users and
consumers of products and services. Focus groups have a rather narrow purpose for which they work particularly well. Their purpose is, to determine the perceptions, feelings, and manner of thinking of consumers about products, services or opportunities. They are not intended to develop consensus, to arrive at an agreeable plan, or to make decisions about which course of action to take. In a focus group, there is no pressure on the interviewer/moderator to have the group reach a consensus. However, the focus group information, when analyzed, will provide the basis for decisions with respect to the design of the product (Krueger 1988).

When QFD is used in construction projects, focus group interviews provide a way to obtain the voice of the owner from a predetermined number of people. The focus groups must be small enough for everyone to have opportunities to share insights, yet large enough to provide diversity of perceptions. The size can range from four to twelve people, but seven to ten people is recommended. See Appendix 1 for more information on focus groups (Krueger 1988).

Affinity Diagram

The affinity diagram provides a method of arranging a set of unstructured ideas in an overall hierarchical structure. Each idea voiced by the customer is written on a separate 3 X 5 card or postit. If two ideas intuitively seem similar, their postits are placed next to each other. As the postits are moved around, they are gradually formed into groups of ideas that together suggest some major topic or theme. Then, these theme groups are grouped into higher-level themes, and
so on. The goal is to achieve a hierarchy with five to ten main ideas at the top (called the primary level). The ideas at the next level down (secondary level) provide definitions for the primary level. The tertiary level defines the secondary level (Cohen 1988).

In Figure 2.1, the ideas in the smallest rectangles, i.e. Blackboard, Overhead projector and Slide projector, represent the words of the customer. Each was entered on a separate 3" x 5" postit. During the grouping and arrangement of the postits, these were all felt to be related to the general idea of aids the teacher would use in a classroom. So, they were grouped under the category of "visual aids." Likewise other postits were seen to belong to the "public address system" and the "computer system" categories. The three categories eventually were felt to suggest the grouping "teaching aids."

For QFD, the important points of the affinity diagram process are:

1. "Words of the customer" are used as the basic building blocks of the requirement hierarchy.

2. The hierarchy is developed from bottom up, with no preconceived structure.

3. Developing the hierarchy is best done by a multi-discipline team, with each person representing a different viewpoint.
Tree Diagram

Like the affinity diagram, the tree diagram is a hierarchical structure. It is a step beyond the affinity diagram. The tree diagram starts with the affinity diagram and looks for gaps and omissions at every level of the hierarchy. Instead of intuition, analytical skills are used as a guide to obtain a complete structure. Upon examining a tree diagram such as that in Figure 2.1, a QFD team would see that the topics of "Visual Aids" and "Computer systems" are not complete. So, "VCR" and "Software" would be added to the tertiary level. See Figure 2.2.

Example of a tree diagram

Figure 2.2

The important points of the tree diagram process are:

1. "Words of the customer" are expanded upon, based on the analysis of the existing structure of ideas.
2. The hierarchy is expanded at all levels, wherever necessary, in order to represent a complete structure.

**House of Quality**

The central construct of QFD is the "house of quality" (HOQ). The HOQ is very useful in arranging facts such that groups of people can see their common goals more clearly. The HOQ uses the familiar device of a matrix to display what the customer wants (the WHATs) against how a company will meet those wants (the HOWs). When fully developed, the matrix resembles a house, Figure 2.3. The WHATs are the controlling requirements and are the input to the HOQ matrix. They are the customer's wants and needs listed at the left side of the matrix.

![Figure 2.3 Diagram of the House Of Quality (HOQ)]
The HOWs are the measurable design requirements listed at the top of the matrix. These are the outputs of the HOQ that the designers use to ensure that customer's voice is answered. Accomplishing the HOWs would result in meeting the input WHATs.

The HOQ matrix provides a structure for systematically evaluating relationships between the WHATs and HOWs. See Figure 2.5. Each cell of the matrix is a question as to the relationship of the WHAT of the cell's row and the HOW of the cell's column (Cohen 1988). Symbols or numbers are placed in the cells to indicate the strength of relationship between the HOWs and the WHATs.

The HOQ is a kind of conceptual road map that gives the cross-functional QFD team a means of reaching consensus on actions to be taken that will lead to customer satisfaction (Hauser and Clausing 1988). It can be thought of as the negotiated protocol containing the record of agreement as to exactly what the design will achieve (Griffin 1992). Complex relationships are displayed in a way that people in different disciplines, from different areas of a company, can understand them and keep their focus on what the customer wants -- thus, minimizing "opinioneering" (McElroy 1987).

A series of house of quality type matrices can be constructed in order to drive the voice of the customer throughout the life of a construction project. The voice of the customer can be systematically cascaded into engineering requirements, design, component characteristics and construction documents. This is done by creating matrices in which the HOWs of one become the WHATs of the next HOQ as in Figure 2.4.
Linked houses deploy the voice of the customer through to construction

Figure 2.4 Cascading Houses Of Quality

In order to keep the HOQ manageable in size, it is necessary to be very selective in choosing the items for each matrix. The Pareto principle can be used to determine the critical items -- the HOWs that become the WHATs of the next matrix. This process continues until the objective is refined to an actionable level. QFD is flexible and adaptable. The actual number of HOQs constructed depends on the individual project.

Building the House Of Quality

The eleven steps used in building the HOQ for this study are described here and illustrated in Figure 2.5.
Step 1. - *List the customer's requirements.*

These are the qualitative wants and needs --the voice of the customer.

Also list what the customer would be delighted with even though not asked for. These are obtained from marketing inputs, customer surveys, focus group interviews, etc. and listed in the room of the House Of Quality called The Voice of the Customer.

![The House Of Quality (HOQ)](image)
Step 2. - *Prioritize the list.*

The owner's wants and needs (WHATs) are prioritized or weighted, by the QFD team, using a number that reflects how important each WHAT is to the customers. These numbers are based on the team members' direct experience with the customers and their knowledge of the customers' needs. Usually this weighting is in terms of percentage, a complete list totaling 100%. The ratings are placed in the *Customer's weighting* column of the HOQ. See Figure 2.5.

Step 3. - *Establish the measures for the VOC (the HOWs).*

The team establishes quantifiable technical counterparts to the customer's requirements. This translates the WHATs into HOWs -- more objective, measurable technical requirements (Dika 1991). The goal here is to list all the requirements that will affect the design. The entire team should participate in developing the list and it should be based on the inputs from customers. All views must be considered (Ullman 1992).

Step 4. - *Establish the units of measure for the HOWs.*

The engineering characteristics (HOWs) must be measurable and target values must be established to assure that the finished product will satisfy every customer requirement. An objective unit of measure is assigned each HOW and placed in the cell at the intersection of the How's column and the *Units of measure* row.

Step 5. - *Establish the Correlation Matrix*
The correlation matrix of the house of quality is used by the QFD team to detect conflicts between engineering characteristics and as an aid in balancing trade-offs between those conflicts. It is the triangular roof top matrix atop the HOWs in Figure 2.5. Symbols are used to indicate the degree of the relationships — (blank = no relationship, S= slight relationship, M= major relationship). Some of the relationships may be positive while others may be negative conflicts. The appropriate symbol is placed in the cell at the appropriate intersections of the correlation matrix.

Step 6 - Establish relationship between the WHATs and the HOWs.

A number (1, 3, or 9), representing the strength of relationship between each WHAT and each HOW, is placed in the cell located in the matrix at the intersection of the row and column of the related WHATs and HOWs. A 1 means a weak relationship, 3 a moderate relationship and 9 a strong relationship. The cell is left blank if there is no relationship. A WHAT row with all blank cells means the WHAT has not been addressed and design requirements that address it must be added. A HOW column with all blank cells means that HOW does not address any of the WHATS and can be eliminated.

Step 7. - Establish the relative importance of the design requirements.

Each relationship rating number of step 6 is multiplied by the respective prioritized WHAT rating of step 2. The product of these replaces the relationship rating number of step 6 in the appropriate cells of the relationship matrix. Then the numbers in each column are added and the
sum is entered in the cell at the bottom of the column. These sums, then, indicate the relative importance of the design requirements (HOWs).

Step 8. Evaluate the competition. The right hand room of the house of quality is used to assess the products that will compete with the product being designed. The rows of the customer WHATs are extended to the right and columns are added to form this matrix. The names of the competing products are placed at the head of the columns. This matrix is used to ensure that the QFD team will discuss each competing product and reach a consensus as to what degree each product addresses each customer requirement (WHAT). The assessment is indicated by a number, from 1 to 5, with 1 indicating that the customer requirement is not addressed at all, and 5 indicating that the requirement is totally satisfied. The number is placed in the cell at the intersection of the WHAT’s row and the column of the competing product. Summing each column and averaging it will indicate how well the product satisfies the customer requirements over all.

Step 9 Competition benchmarks - In manufacturing industries, companies assess their competition by evaluating competing products offered by other companies. The QFD comparison matrix enables a QFD team to evaluate competing products on each of the needs voiced by the customer. Strengths and weaknesses are revealed. The QFD team uses these and the customer importance rankings, to determine design priorities for voiced needs. When possible, actual measurements of the engineering requirements are made on the competing product of the
leading competition as determined in Step 8. These values are entered in
the appropriate cells in the Benchmarks row of the HOQ.

Step 10. - **Target values** for each of the engineering requirements (HOWs) are
determined and placed in the appropriate cells. These target values are
based on the benchmark values established through evaluating
competing products, on the needs of the customer and on assessments of
what is possible at what cost.

Step 11. - **Rating the design.** When the design, or designs, has been completed,
the QFD team will discuss each customer requirement in light of the
design or designs. When an agreement is reached as to the degree to
which the design or designs have addressed the **voice of the customer** a
rating is assigned as was done for the competition in Step 8. This
requires the team to rethink the customer’s requirements and compare
them with the design to ensure all needs have been addressed. These
ratings can then be compared with those of the strongest competition for
an indication of the potential success of the designs.

**Benefits of the House Of Quality**

The following is a partial list of the many benefits to be derived from using
QFD:

- It enables a manager to get his/her mind around the whole project and figure
  out what he/she is going to zero in on (McElroy 1989).
- Customer requirements do not get lost during the translation process from the owner through planning and on to execution.
- Voice of the customers is not misinterpreted at subsequent stages.
- Much more of the things necessary to achieve the desired outcome are understood and in place.
- Efficiency is achieved because everyone better understands the program objectives, owner's needs, and critical control points. Therefore, the need for change requests is minimized (Sullivan 1986).
Chapter 3
APPLICATION OF QFD

A Proposal

In order to cope with increasing demands and fewer resources, Oregon State University is faced with the problem of improving its teaching effectiveness. The schools of the university have been asked to increase their student-to-teacher ratio without sacrificing instruction quality. To do this, additional large-capacity classrooms are needed. This need provided an opportunity to demonstrate how QFD can be used effectively to evoke the voice of the customer, and to assure a positive response to that voice throughout the planning and conceptual design phases of a construction project.

It was proposed that QFD tools be used to obtain the "voices of the customers" of the needed large classroom. Once the voices of the customers were heard, other QFD processes would be used to ensure that the voices were heeded throughout the planning and conceptual design phases of the project. The proposal covered the project through the conceptual design phase and offered the following deliverables:

- Optimum layout of a large classroom based on the voices of the customers
- A list of teaching aid equipment for the classroom based on the voices of the customers
- Optimum location of the classroom
- Estimates of equipment cost and total project cost
- Estimate of the time required for construction

The proposal was submitted to Oregon State University. It was then processed through the OSU approval chain and approved.

The Customers

For this project, the large classroom was the "product" and the classroom stakeholders were the "customers". A stakeholder was defined as anyone, or any group, that would have any connection with the finished classroom. Thus, the customers were the teachers who would teach in the room, the students who would attend classes in the room, facilities services that would maintain the room, the campus media group who would provide and maintain the teaching aid equipment and the administration who would obtain funding for the project.

The QFD Team

A ten member QFD team was formed to address the Large Classroom Project. Each of the large-classroom stakeholder groups was asked to appoint a representative to serve on the cross-functional QFD team. It was stipulated that each representative must have decision-making authority to represent his/her group in any decisions made by the QFD team. The following is a list of the QFD team members titles and/or affiliations:

- Communication Media Center
Hearing the Voice of the Customer

The first task of the QFD team was to hear the voice of the customers — that is, to gather data on the customers' needs. To do this QFD team members held focus group interviews with representatives from the large classroom stakeholder groups: Communication Media Center, Civil Engineering faculty, 2 groups of civil engineering students, College of Business faculty, College of Business students, Facilities Services, Information Services.

The procedures used in focus group interviews are described in Appendix 1 (Krueger 1988). The focus group members were asked to think about the worst classroom and the best classroom they had ever experienced and state what features of these rooms made them the worst or best. They also
were asked to state features they would need and features they would like to have in the new large classroom. Discussion among the focus group members was encouraged. The interviewer's assistant recorded the ideas and needs of the focus group on a large tablet mounted on an easel for all to see. The focus interview data (*the voice of the customer*), in the words of the focus group participants, are listed in Appendix 2.

**Processing the Voice**

**Using the Affinity diagram**

A total of 199 customer requirements, ideas, needs and suggestions were produced in the focus group interviews. Each was copied onto a 3 X 5 postit in the exact words of the customers. In a QFD team meeting, the postits were divided among the team members. The team members read the postits, one at a time, and stuck them on the meeting room wall where all team members could see and have access to them. If the idea on a postit seemed intuitively similar to the ideas on another postit on the wall, it was stuck on the wall under the similar postit. In this way, columns of ideas were formed. This process continued until all the postits were on the wall.

Discussions of the postits, among the team members, frequently resulted in postits being moved from one column to another. As the postits were moved around, they began to coalesce and form into groups of ideas that suggested themes. The team gave each column a name that expressed the theme that the ideas on the postits seemed to suggest. Sometimes several headings together
would suggest a higher level heading. Thus, a hierarchy with primary, secondary and tertiary levels evolved. In essence, the postits on the wall formed a diagram showing the affinity of related ideas. This "affinity" diagram is shown in outline form in Appendix 3.

Using the Tree diagram

Next, the QFD team analyzed the affinity diagram and found that many of the items were redundant idea -- just expressed differently. Others items were irrelevant and frivolous, such as vending machines in the classroom for soft drinks and snacks. Some inputs from the focus groups were suggested solutions to problems not related to the large classroom project. Some suggestions were existing building code requirements and some were requirements of the American Disabilities Act (ADA). All of these were eliminated as candidates to be put through the QFD HOQ process.

The QFD team then studied and discussed the modified affinity diagram checking it for completeness. Needs that were missed by the focus groups were added. Primarily the gaps and omissions were in the areas of technical equipment and facilities. The tree diagram showing the customer needs (the WHATs) that evolved via this process is shown in Appendix 4.

Building the House Of Quality

Listing the customer's requirements (the WHATs). With the WHATs established, the team was ready to start construction of the first house of quality. It was necessary to reduce the needs (WHATs) of the tree diagram further to a
quantity that the house of quality could manage conveniently, but without
eliminating items of high relative importance. Since each QFD team member
represented a customer group, each member rated each of the WHATs on a
scale of 1 to 5, with 1 being not important and 5 being very important. The
ratings of each need then were averaged. Needs with an average rating of 4 and
above were selected to be addressed by the QFD team. A list of needs with an
average less than 4 was compiled and reviewed. Any essential item found was
moved to the 4-and-above group. The rest were held for future review in case
team views as to their importance changed during the course of the project.
The needs with ratings of 4 and up were divided into two categories:

- those needs that would be addressed in the design of the large classroom
- those needs that required only a yes or no decision as to whether to include
  them in the project -- needs such as equipment, facilities, etc.

The yes/no needs of equipment and facilities are shown in Table 3.1. For the
rest, related ideas of each category were further combined under fewer, broader
headings. This produced the hierarchical arrangements of WHATs listed in the
left room of the HOQ matrix of Figure 3.6.

Prioritizing the list of owner requirements. Next, each QFD team member
independently assigned a percentage weighting value to each WHAT listed in
the left room of the house of quality. Since the weighting was in terms of
percentage, the complete list had to total 100%. In other words, each member
had 100 percentage points to divide among the WHATs. The weightings were
<table>
<thead>
<tr>
<th>VOICED CUSTOMER NEEDS</th>
<th>Who wants it?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stationary boards</strong></td>
<td>F</td>
</tr>
<tr>
<td>White boards</td>
<td></td>
</tr>
<tr>
<td>Multiple, long boards</td>
<td>F</td>
</tr>
<tr>
<td><strong>Network access</strong></td>
<td>F</td>
</tr>
<tr>
<td>Hook-up to Kidder Hall</td>
<td></td>
</tr>
<tr>
<td>Hook-up to Bexell network</td>
<td></td>
</tr>
<tr>
<td><strong>Teacher's automated console</strong></td>
<td>F/S</td>
</tr>
<tr>
<td>Controls all systems from console</td>
<td></td>
</tr>
<tr>
<td>Remote access to console controls</td>
<td>F/S</td>
</tr>
<tr>
<td>Video monitor in console</td>
<td>F</td>
</tr>
<tr>
<td>Simultaneous use of all visual aids</td>
<td>F/S</td>
</tr>
<tr>
<td>Simple, user-friendly controls</td>
<td>F</td>
</tr>
<tr>
<td>Phone at teacher's console</td>
<td>F/S</td>
</tr>
<tr>
<td>Phone jack in console</td>
<td>F/C</td>
</tr>
<tr>
<td><strong>Screens</strong></td>
<td>F</td>
</tr>
<tr>
<td>Multiple, user-friendly screens</td>
<td></td>
</tr>
<tr>
<td>Large front screen</td>
<td>F</td>
</tr>
<tr>
<td><strong>Teacher's computer</strong></td>
<td>F</td>
</tr>
<tr>
<td>Adequate memory</td>
<td></td>
</tr>
<tr>
<td>No pauses during demonstrations</td>
<td>F</td>
</tr>
<tr>
<td>Zoom-in capability</td>
<td>F</td>
</tr>
<tr>
<td>CD ROM</td>
<td>F</td>
</tr>
<tr>
<td><strong>Slide projector</strong></td>
<td>F</td>
</tr>
<tr>
<td>For 35 mm slides</td>
<td></td>
</tr>
<tr>
<td><strong>Multi-media projector</strong></td>
<td>F/S</td>
</tr>
<tr>
<td>Computer projection system</td>
<td></td>
</tr>
<tr>
<td><strong>Overhead projectors (Back-up for Hi-tech)</strong></td>
<td>F/S</td>
</tr>
<tr>
<td>Multiples overhead projectors</td>
<td></td>
</tr>
<tr>
<td>Low noise</td>
<td>F/S</td>
</tr>
<tr>
<td>Large picture projection capability</td>
<td>F</td>
</tr>
<tr>
<td>Storage for spare parts (bulbs, etc.)</td>
<td>F</td>
</tr>
<tr>
<td><strong>Movable boards</strong></td>
<td>F</td>
</tr>
<tr>
<td>Blackboards across front wall</td>
<td></td>
</tr>
<tr>
<td>Up/down, front wall only</td>
<td>F</td>
</tr>
<tr>
<td>Motorized, up/down boards</td>
<td>F</td>
</tr>
<tr>
<td><strong>Video capability</strong></td>
<td>F</td>
</tr>
<tr>
<td>VCRs</td>
<td></td>
</tr>
<tr>
<td><strong>Video cameras</strong></td>
<td>F</td>
</tr>
<tr>
<td>Document camera</td>
<td></td>
</tr>
<tr>
<td><strong>Ancillaries</strong></td>
<td>F</td>
</tr>
<tr>
<td>Tables for assignments and displays</td>
<td></td>
</tr>
<tr>
<td>Storage for student's gear</td>
<td>S</td>
</tr>
<tr>
<td>Adequate break facilities near-by</td>
<td>F</td>
</tr>
<tr>
<td>Clock on side wall</td>
<td>F</td>
</tr>
<tr>
<td><strong>Facilities</strong></td>
<td>F</td>
</tr>
<tr>
<td>Good sound system w/ wireless mike</td>
<td>S/F</td>
</tr>
<tr>
<td>Flexible lighting with dimmers</td>
<td>S/F</td>
</tr>
<tr>
<td>Natural lighting</td>
<td>F/S</td>
</tr>
<tr>
<td>Motorized window shades</td>
<td>F</td>
</tr>
<tr>
<td>All controls below ceiling</td>
<td>F/S</td>
</tr>
<tr>
<td>Power outlets at front &amp; many</td>
<td>F</td>
</tr>
<tr>
<td>Conduits for future technology</td>
<td>F/F/S</td>
</tr>
<tr>
<td>Podium light</td>
<td>F</td>
</tr>
</tbody>
</table>

Who wants it key: S=Students  F=Faculty  C=Communication Media  IS=Cob Information Services  FS= Facility Services
### CUSTOMER BENEFITS (VOC)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Relative Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workbenches Concept</td>
<td>180 Students</td>
</tr>
<tr>
<td>Conference Table Concept</td>
<td>200 students</td>
</tr>
<tr>
<td>Strand Agriculture Hall 109 (2.33)</td>
<td>42,274</td>
</tr>
<tr>
<td>Covet 216 (2.43)</td>
<td>38/42</td>
</tr>
<tr>
<td>Dearborn 118 (2.86)</td>
<td>42/48</td>
</tr>
</tbody>
</table>

### WORKSPACE

| Temperature controlled year around | 5 |
| Comfortable height | 10 |
| Easy access to seats | 11 |
| Clearly see screen images and take notes | 12 |
| Groups and teacher see each other | 13 |
| Chairs easily arranged for group work | 14 |
| Multiple work areas | 15 |

### AESTHETICS

| Relative importance (%): 5 |
| Good acoustics | Can hear teacher in all parts of room |
| Comfortable seats | Viewings No dead viewing areas |
| Good lighting | Good acoustics Can hear teacher in all parts of room |
| Workbenches Concept | 180 Students |
| Conference Table Concept | 200 students |
| Strand Agriculture Hall 109 (2.33) | 42,274 |
| Covet 216 (2.43) | 38/42 |
| Dearborn 118 (2.86) | 42/48 |

### AMBIENT

| Figure 3.6 House Of Quality |

### DESIGN REQUIREMENTS

<table>
<thead>
<tr>
<th>SPACE</th>
<th>SEATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>For 15.1 ft</td>
<td>For 15.1 ft</td>
</tr>
<tr>
<td>2500</td>
<td>2000</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

### DESIGN REQUIREMENTS

<table>
<thead>
<tr>
<th>Sound</th>
<th>View</th>
<th>AESTHETICS</th>
<th>AMBIENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

### COMPETING ROOMS

<table>
<thead>
<tr>
<th>ROOM RATING 1 to 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

### Room design concepts

| Conference Table Concept, 200 students |
| 147/6 | 34 | 34 | 34 | 34 |
| 17 | 17 | 17 | 17 | 17 |
| 60 | 60 | 60 | 60 | 60 |
| 30 | 30 | 30 | 30 | 30 |
| 3 | 3 | 3 | 3 | 3 |

### Competing Rooms

<table>
<thead>
<tr>
<th>ROOM RATING 1 to 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

---

Figure 3.6 House Of Quality
based on the team members' own experiences with, and knowledge of, the customers.

The team then discussed the reasoning they had used in determining the ratings. This gave the team members an opportunity to explain their views to their teammates and to understand better their teammate's views. The discussions continued until a team consensus on the ratings was reached. This resulted in the team acquiring a deeper, more fully shared vision of the customers' needs. Since the QFD team members represented their respective customer groups, this consensus on the weightings represented the customers' views of the relative importance of each WHAT. These consensus ratings are shown in the "relative importance" column of the HOQ (Figure 2.6).

*Establishing the design requirements.* The QFD team held brainstorming sessions to produce engineering/design characteristics (HOWs) that were likely to affect one or more of the customer needs. Systematically, each customer need was considered. When the brainstorming ended, each idea produced was seriously discussed to determine its measurability and its appropriateness to the customer needs. Those considered to be measurable and appropriate were placed along the top of the HOQ matrix at the head of columns (Figure 2.6). This process effectively translated the customer's voice into measurable, engineering design characteristics, the HOWs.

*Establishing the units of measure of the engineering requirements (HOWs).* Each of the HOWs, had to be measurable in order to determine whether it would address a requirement (a WHAT). The team determined the
relevant units of measure for each engineering characteristic (WHAT). Practical measures were used, e.g. feet, inches, etc. These units were put in appropriate cells of the design units row at the bottom of the HOW columns. Figure 3.6.

Establishing the correlation matrix. The purpose of the roof matrix of the house of quality is to detect conflicts between engineering characteristics. On large projects, with large numbers of HOWs, it is especially useful in balancing trade-offs between conflicting characteristics. The roof top matrix was not used on this project. However, the HOWs were studied and conflicts were resolved. Example: In some layouts, the standard minimum distance from student seats to viewing-screens was slightly compromised in resolving conflicts between room size, seating capacity and cost.

Establishing the relationships between the WHATs and the HOWs. The team next discussed the relationship between each HOW and WHAT combination of the matrix. The purpose of the discussion was to determine how much each engineering characteristic would affect each customer need and to assure that all WHATs had been addressed. The goal of the discussion was for the team to reach a consensus based on the members' respective expertise, customer inputs and the tabulated data. When a consensus was reached, a number was assigned that represented the strength of the relationship. The number "1" indicated a weak relationship, "3" a moderate relationship and "9" a strong relationship. An empty cell indicated no relationship. The consensus number then was multiplied by the "customer weighting" number of the WHAT.
The product of the two was placed in the cell at the intersection of the WHAT's row and the HOW's column (Figure 2.6).

_Establishing the relative importance of the design requirements (HOWs)._ The relative importance of the HOWs, is indicated by the sum of all the relationship numbers in each HOW's column. Each HOW's sum was placed in a cell at the bottom its column. The greater the sum, the greater the importance of the HOW. The sums of all the HOW columns were totaled. Then, this total was divided into each column's sum to determine the relative importance of each HOW on a percentage basis. These relative importance percentages are seen in the HOQ just above the design targets Figure 3.6. This relative importance is useful in resolving conflicts that may arise between HOWs.

_Competition benchmarking._ To create the comparison matrix, the rows of the WHATs were extended to the right of the HOQ's comparison matrix and columns were added. This formed a matrix for evaluating competition (Figure 3.6). For this classroom project, existing classrooms on the OSU campus were considered to be the competing products.

In the focus group interviews that were held to obtain the "voice of the customer", participants were asked to name the best and the worst classrooms they had experienced at OSU. From those named, the QFD team selected both "good" and "bad" rooms to evaluate. The team toured these rooms to measure, and otherwise assess, the characteristics (HOWs) of each room. These assessment data are shown in Table 3.2.
Table 3.2
Benchmark Survey of Existing Rooms

<table>
<thead>
<tr>
<th>Building &amp; Room Number</th>
<th>ECE 102</th>
<th>COVELL 216</th>
<th>DEARB’N 118</th>
<th>GILBERT124</th>
<th>ST AG. 109</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square footage</td>
<td>1824</td>
<td>1560</td>
<td>1848</td>
<td>2286</td>
<td>1134</td>
</tr>
<tr>
<td>Type of seating</td>
<td>Tables/swivel</td>
<td>Fixed chairs</td>
<td>Fixed chairs</td>
<td>Fixed chairs</td>
<td>Movable chairs</td>
</tr>
<tr>
<td>Linear footage of chalk board</td>
<td>41</td>
<td>20</td>
<td>20</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Windows – (yes or no)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Window darkening</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Yes, but poor</td>
</tr>
<tr>
<td>Number and size of projection screens</td>
<td>One 8’X10’</td>
<td>One 6’X6’</td>
<td>One 15’X20’</td>
<td>None</td>
<td>One 8’X12’</td>
</tr>
<tr>
<td>Access to AV equipment / projectors</td>
<td>Yes</td>
<td>Mediocre</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Audio or video connections</td>
<td>Complicated</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hook ups? To what?</td>
<td>To all networks</td>
<td>Almost none</td>
<td>Decent</td>
<td>No</td>
<td>All networks</td>
</tr>
<tr>
<td>Telephones or jacks</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lighting system:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone control</td>
<td>A little</td>
<td>None</td>
<td>Some</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of zones</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Dimmers</td>
<td>Yes</td>
<td>No</td>
<td>1</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical outlets</td>
<td>Many</td>
<td>Yes</td>
<td>Very few</td>
<td>Very few</td>
<td>Very few</td>
</tr>
<tr>
<td>Tackboards</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Map hooks</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Air conditioned</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>ADA compliance</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

CUSTOMER ATTRIBUTES

| Maximum distance - teacher to student | 38’ | 45’ | 45’ | 50’ | 42’ |
| Can hear teacher in all parts of room | Yes | Yes | Yes | No  | Yes |
| Suppress room-noise                 | Not really | Not really | Wall surfaces | Yes | Yes |
| Isolated from external noise         | Yes | Somewhat | Yes | Yes | Yes |
| Tables & chairs (4-6 people per table) | No | No | No | No | No |
| Chairs easily arranged for group work | No | No | No | No | Yes |
| Groups easily view teacher           | NA | NA | NA | NA | Yes |
| No dead viewing areas                | Yes | Yes | Yes | No  | Yes |
| Good view of visual aids by all      | Yes | Yes | Yes | No  | Yes |
| Windows or sky-lights                | No | No | No | No  | Yes, windows |
| High ceilings                        | Yes | Yes | Yes | Yes | Yes |
| Green plants                         | No | No | No | No  | No |
| Cheery decor, conducive to study(1-5) | 4  | 3  | 4  | 2  | 3  |
| Desk width for text and note book    | 19” X 24” | 14” X 14” | 9.5” X 11.5” | 11” X 12” | 14 X 20 & 12 X 13 |
| Seat to desk top dimension           | 9” | 9” | 9.5” | 9” | 9.5” |
| Good ventilation                     | Yes | No | Yes | No  | No |
| Temperature controlled               | Yes | Minimal | Yes | No  | No |
| Air conditioning                     | Yes | No | Yes | No  | No |
| Ample sized seats                   | 18” X 55.5” | 18” X 16” | 16” X 16” | 16” X 15.5” | 15” X 15” |
| Good lumbar support                  | Yes | No | No | Yes | Yes |
| Foot-rest at front of seats          | No  | No | No | No  | No |
| Room for teacher to walk around      | Yes | Yes | Yes | Yes | Yes |
| Active teacher stage—not elevated    | Yes, small | Yes | Yes | Yes | Yes |
| Easy access to seats                 | Yes | No | No | No  | No |
| QFD team’s opinion 1-5 scale         | 3.3 | 2  | 3.8 | 0.75 | 3  |
When the room surveys were completed, the QFD team met to discuss the rooms. Each customer requirement was discussed, one-at-a-time, with respect to each room surveyed. By consensus, the team assigned a number indicating the degree to which each room addressed each customer requirement. The consensus ratings were placed in the appropriate cells of the HOQ's assessment matrix under the heading "Competing Rooms". See Figure 2.6.

*Competition Benchmarking.* Measured values, for both "good" and "bad" classrooms were put in the appropriate cells of the Benchmark row at the bottom of the HOQ, Figure 2.6. Some items required by the VOC were not present in the competing classrooms. For these, accepted standards were used as benchmarks. These benchmarks were used as reference in setting the target values for the engineering requirements of the classroom design.

*Target values* were set equal to, or better than, the best of the existing classrooms. In setting the target values, consideration was given to their impact on cost. An objective was to have the project answer the voice of the customer without excessive cost. In some instances, the VOC requested specific values for certain engineering requirements. One request was for the distance from the teacher's area to any student's seat be no greater then 25 feet. This requirement was compared with the benchmark values of the "good" and "bad" classrooms. In "good" rooms, this distance was greater than 25 feet with no complaints from "customers". The interviewer for the focus group, in which this request was made, remembered that the intent of the requested 25 feet was to ensure good teacher-to-student contact. The "good" rooms had no complaints of poor
teacher-to-student contact. So, the QFD team lowered the importance of this requirement and subordinated it to other, conflicting requests with higher importance ratings. Accordingly, the target value for the maximum distance from the teacher to any seat was set at 30 feet. This distance responded to the intent of the VOC request.

At this point, except for the design rating matrix, the HOQ was completed. It contained a wealth of information that was used in designing the large classroom in response to needs and ideas voiced by the customers. Also, the HOQ provided a record of the information upon which design decisions were based.

*Rating the design concepts.* This part of the HOQ was completed after the designs and equipment lists were established. See "*answering the voice of the customer*" at the end of Chapter 4.
Chapter 4
VOC GUIDED CLASSROOM DESIGN

Results Obtained

The QFD processes produced a list of attributes for the large classroom that represented the needs and wishes voiced by the room's customers who will be using and maintaining the room and its equipment. Two needs that ranked highest in relative importance were voiced by both faculty and students:

(1) Teacher / student contact. Teachers and students wanted eye contact. The teacher's wanted easy access to any student in need of help.

(2) Students needed the ability to conveniently meet in groups of six during class.

In response to the "voice of the customer", four layout designs were produced. The designs were based on two different concepts for student seating. One concept uses workbench type student desks. The other uses conference tables with six students at each conference table.

Workbench Concept

Figure 4.1 shows a classroom layout that accommodates 180 students. Features of this concept are:

(1) The student seats in the large classroom can pivot 360°.

(2) The floor is terraced with two rows of seats and workbenches per terrace. See Figure 4.1. Since the seats can pivot 360°, the students (in
groups of three) can turn and face the three students behind them on the same level to form six-member groups for group project work. Figure 4.2.

Figure 4.1 Plan view of workbench concept.

Figure 4.2 Workbench concept student station, plan view.
(3) Aisles will allow the teacher easy access to students in need of help. The arrangement shown in Figure 4.3 accommodates 108 students and permits easy teacher-access to any student group during meetings.

(4) In all of the proposed large classroom concepts, the distances between the projection screens and the front row of seats are based on recommendations for good viewing of multimedia images by Clabough (1993).

![Figure 4.3 A variation of the workbench concept.](image)

**Conference Table Concept**

In the conference table concept, students will sit at six-person conference tables. This concept is depicted in figures 4.4 and 4.5.
Figure 4.4 Plan view of conference table concept.

Figure 4.5 Conference table concept student station, plan view.
Features of the conference table concept are:

(1) Pivoting seats will enable students to face each other, face the teacher or face the visual aid screens. See Figure 4.5.

(2) Folding tablet arms, mounted on the chairs, will provide students with surfaces for note taking when they turn away from the table.

(3) Space between the seated groups is sufficient for the teacher to move freely in the room and access any student or group.

(4) To ensure good visibility for all, the floor will be terraced with one row of tables per terrace.

Figure 4.6 A variation of the conference table concept.
Features available in all the concepts:

(1) Storage space for students to temporarily store their book bags, coats, etc. during class.

(2) Room for "assignment-return table/s" is provided at the front of the room.

(3) Windows on one or more sides of the classroom if conditions of the room location permit. Windows have automatic, motorized shades that are controlled at the teacher's console.

(4) Acoustic engineering design address the problem of external and room-generated noise including that generated by multiple groups meeting simultaneously in the room.

(5) Attention to decor assures that the room will provide a pleasant, aesthetically pleasing learning environment.

(6) Ample sized, ergonometic chairs provide student seating comfort.

(7) Wireless mikes ensure good hearing as well as allow the teacher freedom of movement in the room.

(8) Zone lighting provides good contrast for projected images with enough ambient light for note taking.

(9) Air conditioning provides fresh air as well as controls the room temperature.
Teaching Aid Equipment

The VOC proved surprising in one respect. At the outset of this project, it was assumed that the classroom would be a totally "high tech" room with computers at every station. However, the VOC revealed that neither the students nor the teachers wanted computer at every station. Both the students and the teachers wanted the teacher to have a computer with video projection capability. The room's teaching aid equipment that responds to the VOC is listed in Table 3.1. The QFD team wrote descriptions of the equipment and required performance. The following description of the teacher's automated console is taken from that report.

The console will have broadband cable, computer network access and telephone jacks. The room control panel will control any piece of equipment and multiple functions can be programmed into a single touch. For instance, the user might see a screen on the panel with buttons for computer, VCR, 35 mm slide projector, and document camera. The user presses the VCR button and several things happen. The screens and window shades lower; the video projectors turn on and the motorized mounts lower them from the ceiling into position; the projectors are switched to the VCR input; the VCR is turned on; the touch panel display changes to display VCR functions like play and fast forward, as well as volume controls. The user touches play and the VCR begins to play and the lights dim to a preset level. Anything that has an on/off switch can be controlled from the panel and the panel can be programmed to do whatever the user wants. But, it merely controls other equipment, it does not make the equipment
function in a way it normally would not. An infrared remote can be used with the main system.

The voice of the customer was answered by the conceptual design for the large classroom and the teaching aid facility equipment listed in Table 3.1. When these had been established, the QFD team (who's members represented the customer groups) discussed the two design concepts. A consensus was reached as to how well each concept addressed each customer need. A rating of 1 to 5 was assigned to each WHAT. The rating depended on how well each WHAT had been addressed by each design concept (5 = very well addressed and 1 = not addressed at all). The overall average of these ratings for the workbench concept was 4.4 and it was 4.6 for the conference table concept. These compared favorably with the corresponding average of 3.67 for room ECE 102, -- the classroom that received the highest rating on campus which the QFD team had used for benchmarking. See Figure 3.6 for the individual WHAT ratings.
Summary

The QFD Team evoked the "voice of the customers" through focus group interviews with people from the large-classroom stakeholder populations -- faculty groups, student groups, Information Services, Facilities Services and Communication Media Center. The team then compiled the needs that were voiced in the focus group interviews. Duplicate needs and conflicting inputs were resolved using QFD processes. The Team responded to the voice of the customer in designing concepts and layouts for the large classroom and in determining what teaching-aid equipment should be provided in the room. Thus, the design concepts and equipment lists that were produced reflect the voice of the large classroom stakeholders / customers.

The following deliverables were produced and presented to Oregon State University:

- Conceptual layouts for the large classroom -- both conference table and workbench concepts
- A discussion of the facts that affect where the room will be located on campus
- List of teaching-aid equipment
- Descriptions of equipment features and room concepts
- Estimated cost of equipment and of total project cost
- A presentation of the factors involved in obtaining project approval
- Design and construction time line estimate

These were the deliverables offered in the proposal made to the University in the original proposal. These were well received.

This project has demonstrated that Quality Function Deployment can be used successfully in the conceptual design phase of a construction project to evoke the voice of the customer, and assure a positive response to that voice. The team's ability to do so demonstrated the value of a multi-functional QFD team who's members have decision making authority.

**Discussion**

None of the members of the QFD team for this large classroom project had ever worked with QFD. Most had never heard of QFD. Also, they had never worked together before. To the credit of the team members and QFD, the team successfully applied QFD methods in addressing this large classroom project.

The team experienced some confusion with its first efforts to process the VOC inputs from the focus groups. The affinity diagram procedures served well in sorting out the information from the focus groups. However, the need to reduce the number of WHATs presented the team with confusing challenges:

- How to choose the focus group items to be addressed with the HOQ without dropping important customer needs.
• How to determine what was, and was not, important enough to be addressed.

These issues were resolved as the QFD team discussed each focus group item and made a group decision as to whether the item was a real need, a redundancy, a solution offered to problems outside the scope of the project, or was merely frivolous and irrelevant. Those items that were determined to be real needs were prioritized as described in the methods section and addressed in the conceptual room designs and equipment list.

Though this was a small design project, the QFD methods that were used have worked well on much larger and more complicated projects in the manufacturing industry. It is reasonable to conclude that QFD will work well on large projects in the construction industry as well. When used on large construction projects, an overall house of quality would be constructed to address the total project. Some HOWs of this HOQ might be sub-projects in themselves requiring separate HOQs to address them. The same QFD procedures would be used in building these HOQs. The overall HOQ would be used to coordinate the sub-projects.

QFD and Fast Track. The fast track, design-build approach to construction has been very popular during the past two decades. Owners like it because ground clearing and construction start as soon as the design of the foundation is completed. Seeing construction actually begin gives the feeling that the project is off and running. Fast track operates on the premise that, by the time the foundation is completed, the structural documents will be ready so
procurement and construction will continue without interruption. If all goes well, all succeeding design documents will be completed and ready when needed. The project will be delivered earlier than if construction had not been allowed to start until design of the entire project had been completed.

There are risks with this approach. The lack of sufficient data gathering before design starts, the lack of time to evaluate available data, and the rush to start construction before designs are completed frequently result in design mistakes and oversights. These can cause construction delays, wasted material, quality compromises, general confusion and added cost due to redesign and rework.

The scope of the project seldom is frozen in the fast track approach. As owners remember needs and wishes they forgot to mention, they demand changes that require designs to be modified. Often, to accommodate these changes, work that is already completed must be ripped out and redone. Materials and labor are wasted and the schedule slips. Some high-tech owners are willing to accept these risks because millions of dollars of product will be produced each day when the facility is on line. The owners rationalize that the cost of rework will be more than compensated by having the facility on line earlier.

Even so, Quality Function Deployment could reduce these risks. QFD would systematically provoke the owners to think through and voice their needs and requirements before the design phase starts. This would permit early freeze of the project scope. Early scope freeze would reduce the number of disruptive
change requests from the owner after design begins. The design phase would be shortened. Designs would be of higher quality with minimum mistakes. Construction could be fast tracked. With a frozen scope, better quality designs and less rework, the project could be delivered earlier at lower cost.

**QFD as a Product.** Today, regardless of product category or size of company, American business is accepting the reality and challenge of competing in a marketplace where unlimited growth can no longer be taken for granted. Management and consumers alike are recognizing that to be a "winner" in today's environment requires leveraging all available assets. For these reasons, as business examines options for growth, introducing new products continues to be looked at as one of the most important marketing strategies for management to pursue. (Maran, 1986). Design firms would do well to introduce Quality Function Deployment to their clients as a new product / service. Those that do will have a significant advantage over those that don't. As a product, QFD offers the owner:

- Better pricing -- bids are more competitive with reduced risk of cost overrun
- More accurate schedule estimates -- fewer surprises after project starts
- Reduced risk of late project delivery
- Attention to details -- fewer oversights
- Higher quality workmanship -- fewer quality-degrading rework panics

Satisfaction -- owners get what they expect
The benefits just mentioned relate directly to the owner. The following advantages directly benefit the E&C company that uses QFD and indirectly benefit the owner:

- Improved understanding of owners needs and wishes
- A structured, step-by-step planning process
- Early freeze of project scope
- More accurate cost estimating -- few surprises after project freeze
- A methodical analysis of the interrelationships of design features and owner needs
- Improved inter-functional communication. QFD team members are forced to discuss their different views, because group agreement on the assignment of numbers is essential throughout the HOQ.
- Improved understanding and buy-in of goals and plans by all parties (customer, designers, contractor, sub-contractors, suppliers, etc.)
- Improved efficiency and productivity
- Houses of quality that serve as archives of the product planning process. Every factor leading to a tradeoff decision is recorded in the HOQ. Each decision can be revisited and questioned. The entire HOQ can be reused when it is time to plan renovations or additions (Cohen, 1988).
- Satisfied owners and a respected company reputation which begets repeat and future business.
Future Study

The scope of this project stopped at the conceptual design of the classroom. Although the ratings by the customer representatives on the QFD team indicated that QFD was successfully used in this conceptual design project, further study is needed to demonstrate its usefulness in the design, procurement, and construction phases of larger projects as well.
References


APPENDICES
Appendix 1

Focus Group Interviewing

Conducting Focus Groups Interviews

The process of conducting a focus group study consists of three phases: 1) conceptualizing the study, 2) conducting the interviews, and 3) analyzing and reporting the results of the data gathered. The conceptualization phase is critical for a successful focus group interview. In this phase, consideration is given to the purpose of the study as well as to what information is needed and how the information will be used. The interview phase includes three distinct tasks, all of which must be completed prior to the group interview. These are developing the questions, learning interviewer skills and selecting the group participants. At the conclusion of these three steps, the focus groups are conducted. When the data have been collected, the analysis and reporting phase begins. The concept for this project is described in "A Proposal for Working Plan for the COB Classroom Project" of 3/15/95. Analyzing and reporting the results of the data gathered will be explained and discussed after the data are collected. But, now let's briefly give some thought to conducting the interviews.

Developing the questions

Quality answers are directly related to quality questions. Questions are the heart of the focus group interview. The questions should appear to be spontaneous on the part of the interviewer/moderator, but must be carefully selected and phrased in advance to elicit the maximum amount of information. They should be open ended questions that allow the respondent to answer from a variety of dimensions based on his/her specific situation. For example, What do you think of the project? How do you think the large classroom could be made user friendly?

Successful focus groups begin with well-thought-out questions that are appropriately sequenced. Questions are arranged in a focused sequence that seems logical to participants. The most common procedure is to go from general to specific—that is, beginning with general overview questions that funnel into more specific questions of critical interest. Interviews are focused by providing participants with consistent and sufficient background information and by presenting the questions in context. The answers should not be implied by the way the questions are asked. In a 90 minute session, five or six questions should be sufficient—never more than ten.

Selecting the group participants

Familiarity tends to inhibit people's disclosure. Ideally the focus group is composed of strangers—people who are likely never to see each other again. This will be virtually impossible in our case, since the participants will be drawn from the
Appendix 1
Focus Group Interviews

OSU campus. Nevertheless, close friends and those who work closely together shouldn't be included in the same group if it can be avoided. The participants of a focus group should have in common their "customer's" interest in the large classroom (not necessarily all with the same viewpoint) and good knowledge of how the room will relate to, or impact, their department or work group.

Focus group rules

At the beginning, the interviewer/moderator should establish the rules for the focus group session. An example of how this might be done follows.

**Moderator says:**

In this meeting, we will be discussing what a large capacity, state-of-the-art classroom should be like. This includes all aspects of the room. The questions that I will be asking have no right or wrong answers—just different points of view. Please feel free to join in discussion and share your point of view even if it differs from what others have said.

Before we begin, let me remind you of some ground rules. Please speak up—only one person should talk at a time. We will be on a first name basis. In our report, there will be no names attached to comments. You are assured of complete confidentiality.

The session will last about an hour and a half and we will not be taking a formal break. The rest rooms are just down the hall. Feel free to quietly leave the table if you need to. Now let's begin. Let's find out more about each other by going around the room one at a time. Tell us what your job is and how you would be affected by the large classroom.

**Moderator's assistant**

The moderator will need an assistant. The moderator will be primarily concerned with directing the discussion, keeping conversation flowing and taking notes to identify future questions that need to be asked. The assistant, on the other hand, takes comprehensive notes that record the noteworthy ideas and comments of the discussion. This record is the product (the data) for which the session is being held. In addition, the assistant operates the tape recorder (if one is used—but not in lieu of notes), handles the environmental conditions and logistics (refreshments, lighting, seating, name tents, etc.) and responds to unexpected interruptions. The assistant notes the body language of the participants and assists the moderator in the post meeting analysis of the session.

(Krueger 1988)
Appendix 2

Raw Data From Focus Groups
(VOC)

College of Business Faculty
1. Think of your experiences teaching in a large classroom.
   a. What is the worst classroom you have used?
      Withycombe Hall 109
      - Cows on the walls.
      - Cat-walk under very high blackboards.
      - Bad sound system
      - No air conditioning
      - Noisy doors
      Covell Hall
      - Seats arrangement has wings with very little space between
      - No privacy for exams
      - Poor lighting
      - Poor air conditioning
      Gilbert Hall
      - Bad acoustics
      - Posts block view of some students
      - Have to stand on a platform to use overhead projector
      - Bad chemical smells
      - Bad screens
      - High level of fan noise
      - Light controls at entrance to room—not accessible to instructor during class
      - No light dimmers, lights either on bright or off with room dark
      - Can't use blackboard and over head at same time. Screen covers blackboard
      Wiegand Hall & Wilkinson Hall
      - Work benches in front are in the way
   b. What bad experiences did you have?
      Peavy Hall:
      - Light too dim for calculators.
      Gilbert Hall:
      - Can't hear students and students can't hear me well.
      - The acoustics are bad
      - Fan noise level is high
      - Strong chemical smells are a nuisance
      - Has the light switches in the back of the room, not easily accessible to the instructor during class. no dimmers. When
Appendix 2
Focus Group Raw Data

- showing video or overheads, the lights have to be off leaving the room too dark for convenient note-taking

Wiegand Hall:
- Too steep. Get dizzy when I go top of room

Withycombe Hall 109
- Has platform to stand on when using the overhead projector
- Has a catwalk under the blackboards. Distracts me. "I'm afraid I'll accidentally step off edge"

c. What is the best classroom you have used?

Gilfillan
- The best.
- Well spaced seats—minimizes cheating
- Good acoustics
- Wide aisles
- Light controls at instructor's access w/dimmers
- Computer available to instructor
- Good air conditioner

Electrical and Computer Engineering Hall 125
- Tables for students
- Attached chairs
- Light controls
- Good overhead
- Good acoustics
- Side blackboards

Peavy Hall
- Three screens
- Light controls
- Good slope
- Good seat alignment (minimizes cheating)
- Good light controls
- Handicapped accessible

2. What features do you want for a large classroom?
   1. Good acoustics in all parts of the audience
   2. Wireless mike
   3. Accessibility to seated students
   4. Multiple, user-friendly screens and blackboards
   5. All controls of lighting and equipment accessible to instructor during class
   6. Blackboards & white boards w/ motorized lifts (up & down)
   7. Break-outs for 4-6 people groups
   8. Computer with projection system
   9. TV monitors midway back
Appendix 2
Focus Group Raw Data

10. Window shade controls (motorized and controls by instructor)
11. Need for ambient light bright enough for note taking during videos
12. TV camera overhead projector
13. Test taking security
14. Remote electronic answering of exam questions (like congress voting)
15. No timed lights that turn off if no motion in room for a while
16a. Phone in room available to instructor when help with equipment is need
16b. Speaker phone and video
17. ID for roll call and for exam security
18. Laser printer
19. Aesthetics (no cows)
20. No carpets
21. Full wide desks for text and notebook
22. Cup holders on desks
23. Depth vs width of room is important (Bexell 207 is OK)
25. Equal condition for all students (viewing hearing, etc.)
26. No student computers
27. Lap top plug-ins with computer network tie-ins
28. White board with printer
29. Photo copier in room
30. VCRs
31. Adequate break facilities conveniently located, eg. rostrums, etc.
32. Test taking security
33. Numbers on front of seats
34. Comfortable seats
35. Names on seat fronts via ID card readers
36. A means for students to get instructors' attention
37. Quiet equipment
38. A means of waking up sleeping students
39. Overhead mikes for students
40. A means of handling overflow audiences (maybe pipe tv next door)
41. Quiet doors (especially quiet crash bars)
42. Tables for pick up of handouts and assignments

College of Business Students
1. How can we get a lot of people learning simultaneously?
   1. Group teaching, i.e. students teaching students
   2. Seat students at tables -- 4 or 5 students per table
   3. No corners -- curved room
   4. Short teacher-to-student distance
   5. Mount overhead screens half-way back
   6. Monitors in back, students need agenda available
Appendix 2
Focus Group Raw Data

7. Acoustics need to be good
8. Low to none background noise in room
9. Mike on professor
10. Bright lights for note taking and solar calculators
11. Need more light than ECE 102
12. Chairs should not swing
13. Furniture should be easily moved to easily reconfigure room for groups
14. Video tape the classes--so students can view when and as the wish

2. What aspects of large group learning experiences would make learning better?

15. Depends on teacher, but 150 doesn't allow instructor to assess students to determine teaching level needed
16. Remote controls for teacher to control teaching aids
17. Scantron tests (some like, some don't)
18. Multiple overheads for all to see well and for long problems
19. Center screens with side screens 1/3rd way back
20. Larger print on overheads
21. Avoid viewing "dead space"
22. Seats arranged in broad semicircle
23. Seats only five or six rows deep
24. Lots of room for professor to walk around
25. Button at each seat for student to turn on overhead mike and light to signal for professor's attention
26. ECE 102 is an example of a dark, uncomfortable room w/poor acoustics
27. Minimize the student to teacher distance
28. Good ventilation
29. Comfortable desks
30. Space to get to-and-from seats when arriving or leaving early without disturbing others
31. Enough room for books and notebook
32. Room temperature controllable by professor
33. Have seat backs provide lumbar support
34. Personal space of 30" or more (left to right)
35. Light colored walls (ECE walls are dark blue which is bad)
36. Modern decoration (outdated decor is depressing)
37. Food accommodation, eg. cup holders
38. Book holder on desk for open text during class with clips to hold it open
39. Lockers on campus
40. Coat racks and temporary storage space for extra books
Appendix 2
Focus Group Raw Data

41. Umbrella racks
42. Snack bar in corner of room
43. Front and rear exits to arrive late or leave early w/o disturbing others
44. Space between rows for people to move to seat with minimal disruption
45. Provisions for group work
46. Professors lectern off to one side
47. No computers for students
48. Audio tapes of class lectures for a fee

Civil Engineering Department Faculty
   1. Sloped floors
   2. Crescent layout of seats
   3. Light dimmers
   4. No windows
   5. Wireless mike
   6. Video camera for overheads and pictures
   7. College of Engineering at Boise State has a state of the art classroom
   8. P. A. system volume control
   9. No computers in room - have plug-ins for lap top computers
  10. Teacher stations has a computer
  11. Good computers
  12. Central controls at podium for everything
  13. Up/down blackboards on front wall (not on sides)
  14. A stage for teacher to stand on / No stage for teacher to stand on
  15. Carpets—they provide friendly atmosphere
  16. Spot lights on blackboard
  17. Wood trim in room
  18. Comfortable (cushion) chairs
  19. Fixed chairs
  20. Projector -- multi-scanner type
  21. Overhead projector
  22. A slide projector
  23. Subdue projector noise
  24. Minimize number of switches the teacher has to operate
  25. Opaque projector
  26. Computers in room for groups to use
  27. Ability to rearrange chairs
  28. Control intrusion of noise from outside and from halls
  29. Low-noise equipment
  30. Room for student's books and work space
  31. Light for note-taking when projectors are used
Appendix 2
Focus Group Raw Data

32. Ability to darken room
33. Ability to use all visual aids simultaneously
34. Students in groups to have good view of teacher and teaching aids
35. Large, high screens with large picture projection
36. Wide aisles and plentiful for student-teacher closeness
37. Stage for teacher or slope to room best?
38. Exam security (cheating) -- not a problem
39. Improved contact between professor and student
40. Improved students' feeling of personal attention
41. Apperson 212 -- example of a bad room
42. Greater space for students
43. Pharmacy 305 -- example of good room
44. Power plugs and other plugs in risers of tiers
45. Fresh air
46. Colors -- grays and blues
47. Appearance -- not sterile, not cheap
48. Decor relative to what's being taught
49. Reduce institutional look
50. Increase comfort
51. Work benches instead of chair-desks
52. Plug-ins for lap-tops at each student seat
53. Rear-screen projection
54. Light controls at podium
55. Bright room lights
56. No fluorescent lights
57. No vinyl floors
58. Big screen plus side monitors
59. Display table for exhibits
60. Lots of blackboards (conveyor type)
61. High ceilings
62. Windows
63. Square room
64. Dearborn Hall -- example of a good room

Civil Engineering Students -- Group 1
1. What was good about the best classroom you have experienced?
   - Lots of room for mobility
   - Tables for students with room for text and notebook
   - Windows with view of sky, nature not people
   - Room sloped but maintain eye contact capability teacher/student
   - Student able to clearly see teacher, overheads, blackboards
2. What was bad about the worst classroom you have experienced?
Appendix 2
Focus Group Raw Data

- No air circulation
- Swivel chairs that push you into table
- Stale air
- Dark decor (bright is good)
- Busy color designs on walls
- Flicker of fluorescent lights annoying
- Bad Acoustics
- Tiered classrooms make group-work hard

3. What features do you think a learning environment should have in order to maximize quality of learning?
   1. Movable chairs
   2. Tables with room for text and notebook
   3. Need to see teacher and have eye contact
   4. Foot rest on front of chairs
   5. Flip-up holder for text
   6. Teacher-to-student distance 25 feet or less
   7. Wrap desks around professor in an arc
   8. Reduced over-head projector hum
   9. Keep room cool to avoid students falling asleep
   10. Light for note taking during video and overheads
   11. Fresh air into room
   12. Teaching aids must be large enough to be read from back row
   13. Distance learning doesn't allow feedback to professor/questions
   14. Have green plants in room
   15. High ceilings & skylights
   16. Accommodations for group work
   17. Room for professor to move around
   18. Room to arrive late or leave early w/o disturbing other students
   19. Safe storage of book bags & umbrellas in view of students
   20. Lockers

4. Are there other issues or features that should be considered in the design of a new classroom?
   21. More back support in seats
   22. Foot rack on front of chair
   23. Carpet
   24. No food or drink in classroom

Civil Engineering Students -- Group 2
What was bad about the worst classroom you have experienced and what ideas do you have to make an ideal classroom?
   1. Milan 26 is example of bad room
   2. "Chairs are worthless"
Appendix 2
Focus Group Raw Data

3. Chairs too close together
4. Not enough personal space
5. Tables and chairs are preferred
6. Comfort is important
7. Room temperature is important
8. Fresh air is important
9. Milam Hall has poor lighting
10. Arrange seats in crescent is good -- Bexell 207 is good example
11. Tiered seats
12. ECE is example of good rooms except for group work
13. Good acoustics
14. All students have good view of screens
15. Motorized shades on windows to quickly darken room
16. Need windows
17. Use computer with power point rather than overhead projectors
18. Computers available for groups to use
19. Screens half-way back
20. Bright colors on walls (cream / white)
21. Carpets
22. Good aesthetics
23. Prefer tables with lots of room with swivel seats
24. Proper sized chairs, comfortable
25. Blackboards of white boards -- not green
26. No overhead projectors
27. Document camera
28. Seats only 5 or 6 rows deep
29. Lots of room for professor to walk around -- no desk
30. Good ventilation
31. Weigan -- example of bad room
32. Twenty-five feet = maximum distance between professor and student
33. Have specialized rooms instead of rooms for all purposed
34. Storage for book bags under tables or in riser spaces
35. Power point for overhead projectors
36. Power point training for professors

College of Business Information Services
Think about a classroom you have had to support. What are the positive/negative support issues you have encountered?
1. Need good security, tamper proof
2. Stationary, non portable equipment
3. Multi-media sound, CD rom etc.
4. Easy access to campus network
Appendix 2
Focus Group Raw Data

5. IPX and IP access
6. Adequate memory
7. A mechanism to deal with hard drives
8. Tamper proof software
9. Remote access to console
10. Open to student access during non class hours
2. What could be included in a room design to make support of equipment more effective and easier to use?
11. Standardize classroom design and layout of equipment
12. Clear of physical barriers
13. Phone in room at console
14. All controls in one place (lights, projector, video, keyboard, power, etc. – all equipment)
15. Have laminated simple, concise instructions at console
16. Have server names posted
17. All the above answers to question #1
18. Light for instructors notes
19. Projection system to allow ambient light for note-taking
20. Dual purpose modules located around the room to be used by professor for lectures and by students for projects
21. Satellite access
22. High speed network access
23. Single point of contact for help for teacher with phone numbers of specialist for support people
24. Proper staffing for VCR, laser disk, OH projector, etc.
25. Instructional support person
26. Outlets flexible enough for new technology – extra plugs, etc.
27. Port for video on side of cabinet
28. Separate consoles

Campus Media Center
1. Think About your past experiences in supporting teaching facilities: what were some of the positive/negative issues encountered?
   1. Screens not large enough
   2. Viewer's angle bad in seats to side of room
   3. Light controls poor. Should have independent controls for instructor's area, student area and screen area (lenticular or parabolic)
2. What room design features would make equipment support and maintenance more effective and efficient?
   4. Projectors should have signal handling scan rate compatible with demand of the various equipment
Appendix 2
Focus Group Raw Data

5. Instructors console appropriate size and location
6. Fixed seating makes it hard for small group-work
7. Elevator mounts for ceiling mounted projectors
8. Lots of outlets: phone, TV cable, power, network hook-up
9. Conduits to projector and teacher's desk
10. Automated instructor's console for all equipment
11. Security for equipment, ID card readers for keys
12. Equipment closet / service chases / equipment storage
13. Multiple projectors

3. What room design features would make user support more effective and efficient?
14. Phone in room
15. Pagers and/or cellular phones for support people
16. Good acoustics
17. Wireless mike
18. Good sound system
19. Instructor's monitor for video and computer
20. Video camera for taping the class lectures, etc.
21. Document camera
22. Microscope camera
23. Air conditioning
24. Writing boards
25. Hi-tech board of electronic writing tablet
26. Window shades

4. What other suggestions do you have regarding desired room features?
27. Satellite receiver dish
28. Fiber optics into the room (transmit & Receive)
29. Broad band cable TV
30. Distance learning capability
31. Computer dedicated to the room

Facilities Services
From your point of view, what features should a state-of-the-art large classroom have?

Electrical
1. Flexibility of lighting: multi-level, multi-zone lighting, central control
2. Projectors controlled at teacher's stand
3. Outlets at front of room
4. Lap top plug-ins
5. Stations vs seats
6. Reflectant lighting
Appendix 2
Focus Group Raw Data

7. IR motion sensors for lights, not ultra sound (ultra sound produces interference)

Mechanical
9. Nothing installed above ceiling
10. All in the mechanical space
11. All controls below ceiling
12. Electronic gear requirements
13. CO2 monitoring on return air

Seating
14. Theater seats
15. Benches with swivel seats
16. Terraced preferred to continuous slope
17. Seats mounted on the rises

Custodial
18. No carpets
19. No mix of carpets and tile
20. Chalk boards
21. White boards (more of a custodial problem)
22. Sound proofing on risers

ADA Requirements
23. Wheel chair accessible
24. Handicap seating per code
25. Accessible routes equivalent to number of exits
26. Exit routes uniformly dispersed in room
27. Head phones for hearing impaired
28. Visual (flashing light) fire alarm for hearing impaired

Safety Issues
29. Wide aisles
30. Sprinkled if the building is
31. Code three issues
APENDIX 3

Affinity Diagram of Focus Group Data
(VOC)

1.0 Seating

1.1 Seats

1.1.1 Comfortable seats, ample sized
1.1.2 Benches with swivel seats
1.1.3 Theater seats
1.1.4 Good lumbar / back support
1.1.5 Foot rest at front of seat
1.1.6 Name on front of desk via ID card reader

1.2 Desks

1.2.1 Comfortable desks
1.2.2 Work benches instead of desk-chairs
1.2.3 Work benches / tables with swivel chairs
1.2.4 Student's desk wide enough for text & notebook
1.2.5 Flip-up text holder at desk-edge opposite student
1.2.6 Cup holder on student desk
1.2.7 Table & chairs, 4 to 6 students per table

1.3 Room geometry

1.3.1 Good student to professor contact / eye contact
1.3.2 Improve student's feeling of personal attention
1.3.3 Equal conditions for all students in the room
1.3.4 Seats arranged in a broad semi-circle
1.3.5 Avoid dead viewing areas for students
1.3.6 Seats mounted on face of risers
1.3.7 25' maximum distance between professor & students
1.3.8 Only five or six rows of seats
1.3.9 Accommodations provided for 4 to 6 person group-work
1.3.10 Chairs/desks that are easily re-arranged
1.3.11 Chairs fixed to floor
1.3.12 Space for easy teacher/student access to seats
1.3.13 Chairs should not swing
1.3.14 Wide aisles
1.3.15 Safe storage for book bags and umbrellas
1.3.16 Numbers on front of seats
1.3.17 Square room
1.3.18 Comfortable view of professor when in groups
1.3.19 Sloped floors
1.3.20 Terraced floors
1.3.21 Tiered seats
1.3.22 Room for professor to walk around
1.3.23 Wide aisles
1.3.24 Exit routes uniformly dispersed
APPENDIX 3
Affinity diagram
VOC

1.3.25 Exits at front and rear of room
1.3.26 Room curved with no corners
1.3.27 Standardized the layout of room and equipment

2.0 Display equipment
2.1 Projectors
2.1.1 Projectors compatible with light for note-taking
2.1.2 Document camera
2.1.3 Projection system for computers
2.1.4 Projector w/single handling scan rate compatible with all equipment
2.1.5 Multiple projectors
2.1.6 Microscope camera
2.1.7 TV monitors for people in back
2.1.8 Opaque projector
2.1.9 Multi-scanner projector
2.1.10 TV camera for taping class sessions
2.2 Slide projectors
2.2.1 Rear screen projector
2.3 Overhead projectors
2.3.1 Multiple overheads
2.3.2 Overhead projectors with reduced hum
2.3.3 Large picture projection capability
2.3.4 No overhead projectors
2.3.5 Storage place for spare bulbs, chalk, pens, spare, & parts
2.3.6 Lens with very short focal length
2.4 Screens
2.4.1 Screens mounted half-way back for people in back
2.4.2 Multiple, user-friendly screens
2.4.3 Good view of screens/TV monitor throughout the room
2.4.4 Large front screen plus side monitors
2.4.5 Screens located in corners
2.5 Writing boards
2.5.1 Capability for using all visual aids simultaneously
2.5.2 High tech board or electric writing board
2.5.3 White boards
2.5.4 Chalk boards (black, not green)
2.5.5 Up/down blackboards front walls (none on sides)
2.5.6 Conveyor, or scroll type, blackboards
2.5.7 White board with printer
2.5.8 Multiple blackboards
2.5.9 Motorized black boards and white boards
APPENDIX 3
Affinity Diagram
VOC

2.6 VCRs
2.7 Hook-up to media center in Kidder

3.0 Computers and accessories
3.1 Student computers for group work
3.2 No individual student computers
3.3 Dual purpose modules around the room
3.4 Instructor's console
   3.4.1 Separate console
   3.4.2 Console to be of adequate size and located well
   3.4.3 Remote access to console
   3.4.4 IPX and IP access
   3.4.5 Photo copier
3.5 A dedicated computer in the room for the instructor
   3.5.1 Video monitor for the instructor's computer
   3.5.2 A mechanism to deal with hard drives
   3.5.3 Tamper-proof software
   3.5.4 Adequate memory
   3.5.5 Power Point for instructor's computer
   3.5.6 Group computers used by students in non-class hrs.
   3.5.7 Bandwidth wide enough to prevent pauses in demonstrations
   3.5.6 Zoom-in capability
3.6 A laser printer

4.0 Equipment infrastructure
4.1 Computer tie-ins
   4.1.1 Satellite access
   4.1.2 Satellite receiving dish
   4.1.3 Broad-band cable TV
   4.1.4 High speed network access
   4.1.5 Easy access to campus network
   4.1.6 CD ROM
   4.1.7 Access to Bexell network
4.2 Instructor's Podium
   4.2.1 Automated console
   4.2.2 Control of everything from podium, ie. all teaching aids, room lights,
       P.A. system, automatic blackboards, computer, etc,
   4.2.3 Port for video on side of cabinet
   4.2.4 Remote controls for all teaching aids
   4.2.5 Minimize control switches instructor must use
   4.2.6 Place podium off to one side
4.3 Electrical wiring
APPENDIX 3
Affinity Diagram
VOC

4.3.1 Outlets at front of room and at other convenient locations
4.3.2 Conduits from podium to projectors, etc.
4.3.3 Conduits to all student stations for possible future use
4.3.4 Plug-ins for lap-tops at each student's seat
4.3.5 Lots of outlets: phone, TV, cable, power, network hook-ups etc.
4.3.6 Outlets flexible enough for new technology
4.3.7 Power and equipment mounted in terrace risers
4.4 Fiber optics into room (transmit and receive)
4.5 Elevator mounts for ceiling mounted projectors
4.5 No controls for any system to be above ceiling

5.0 Room equipment
5.1 Good sound system
  5.1.1 Wireless mike
  5.1.2 Mike worn by instructor
  5.1.3 Overhead mike for students
  5.1.4 Mike switch at each seat for student comments & questions
5.2 Communications
  5.2.1 Phone at podium
  5.2.2 Speaker phone in room
  5.2.3 Support people to have cellular phones and pagers
  5.2.4 Light and switch at students' seats to get instructor's attention
5.3 Equipment parameters
  5.3.1 All equipment must be quiet or isolated from the room
  5.3.2 Equipment should be non portable, ie. stationary
  5.3.3 Tamper proof security for equipment
  5.3.4 ID card readers for equipment security

6.0 Lighting
6.1 Instructor
  6.1.1 Controls at instructor's podium
  6.1.2 Independent light controls for various room areas
  6.1.3 A light on podium for instructor's notes
  6.1.4 Light dimmers
  6.1.5 No timers on room lights
  6.1.6 Spot lights on the blackboards
6.2 Lighting Flexibility
6.3 IR motion detectors to avoid interference
6.4 Light brightness during projector and video operations
  6.4.1 Bright enough to take notes
  6.4.2 Bright enough to operate solar calculators
6.5 Use reflectant lighting (parabolic grids or light cans)
6.6 No fluorescent lights
APPENDIX 3
Affinity Diagram

VOC

6.7 Bright room lights

7.0 Windows
7.1 Motorized window shades controlled by instructor to darken room
7.2 Some say no windows but more say yes for windows

8.0 Good acoustics
8.1 Low noise in room
8.1.1 Sound absorbing surfaces on terrace risers
8.1.2 Room noise insulated
8.1.3 Quiet doors
8.1.4 Sound absorbing wall coverings

9.1 Walls
9.1.1 Bright colors
9.1.2 Blues and grays

9.2 Floors
9.2.1 Carpets
9.2.2 No carpets
9.2.3 No mix of tile and carpets
9.2.4 No vinyl on floor

9.3 Good aesthetics
9.3.1 No cows on the walls
9.3.2 Reduced institutional look
9.3.3 Appearance not sterile, not cheap
9.3.4 Green plants in the room
9.3.5 Wood trim
9.3.6 Modern decor
9.3.7 Decor relative to what is being taught in room

10.0 Support
10.1 Laminated, simple, concise instructions in the console
10.2 Posted server names
10.3 Single point of contact for teacher to get help

11.0 Air
11.1 Fresh air, good ventilation
11.2 High ceilings and skylights that open
11.3 Air conditioning
11.4 Carbon dioxide monitor on return air of HVAC system
11.5 Temperature
11.5.1 Maintain cool room (prevents drowsiness)
11.5.2 Temperature controlled by instructor

12.0 Test taking
12.1 Electronic test taking – like congress votes
12.2 Scantron testing
APPENDIX 3
Affinity Diagram
VOC

12.3 Test taking security
12.3.1 ID readers for roll call for exam taking
12.3.2 Seat arranged and floor sloped so as to discourage cheating

13.1 Wheel chair accessible
13.2 Accessible disabled routes equal to the number of exits
13.3 Seating for the disabled per code
13.4 Visual fire alarms (flashing lights)
13.5 Head sets for hearing impaired

14.0 Ancillary facilities
14.1 Service chase for equipment
14.2 Equipment closet
14.3 Stage for instructor
14.4 Table for pick-up and hand-out of assignments
14.5 Adequate break facilities conveniently located near the room
14.6 Means of waking up sleeping students (exciting class maybe?)
14.7 Temporary, safe storage of student's book bags, umbrellas, etc. Maybe under tables or in the terrace risers
14.8 Student lockers on campus
14.9 Clock on side wall, not front
14.10 Room close to Bexell would be nice
14.11 No elevated areas in the instructors' area
14.12 Emergency lighting in case of power failure

15.0 Miscellaneous
15.1 Distance learning capability for overflow
15.2 Sprinklers if the building has them
15.3 No controls above the ceiling
15.4 Establish specialized rooms rather than all-purpose room
15.5 Capability to video and/or audio tape each class
15.6 A display table for exhibits
APPENDIX 4

TREE DIAGRAM OF LARGE CLASSROOM PROJECT FOCUS GROUP INPUTS

SEATS:
   1.1.1 Comfortable seats, ample sized
   1.1.4 Good lumbar / back support
   1.1.5 Foot rest at front of seat
   1.2.1 Comfortable desks

ROOM LAYOUT:
   1.2.7 Table & chairs, 4 to 6 students per table
   1.3.1 Good student to professor contact / eye contact
   1.3.2 Improve student's feeling of personal attention
   1.3.3 Equal conditions for all students in the room
   1.3.5 Avoid dead viewing areas for students
   1.3.9 Accommodations provided for 4 to 6 person group-work
   1.3.10 Chairs/desks that are easily re-arranged
   1.3.11 Chairs fixed to floor
   1.3.12 Space for easy teacher/student access to seats
   1.3.14 Wide aisles
   1.3.18 Comfortable view of professor when in groups
   1.3.22 Room for professor to walk around

PROJECTORS:
   2.1.1 Projectors compatible with light for note-taking
   2.1.2 Document camera
   2.1.3 Projection system for computers
   2.1.5 Multiple projectors
   2.1.6 Microscope camera
   2.1.10 TV camera for taping class sessions
   2.2.1 Rear screen projector
   2.3.1 Multiple overheads
   2.3.2 Overhead projectors with reduced hum
   2.3.3 Large picture projection capability
   2.3.5 Storage place for spare bulbs, chalk, pens, spare, & parts
   2.3.6 Lens with very short focal length

SCREENS:
   2.1.7 TV monitors for people in back
   2.4.2 Multiple, user-friendly screens
   2.4.3 Good view of screens/TV monitor throughout the room

WRITING BOARDS:
   2.5.1 Capability for using all visual aids simultaneously
   2.5.2 High tech board or electric writing board
APPENDIX 4
Tree Diagram

2.5.3 White boards
2.5.4 Chalk boards (black, not green)
2.5.5 Up/down blackboards front walls (none on sides)
2.5.6 Conveyor, or scroll type, blackboards
2.5.8 Multiple blackboards
2.5.9 Motorized black boards and white boards

VCRs:
2.6 VCRs

HOOK-UPS:
2.7 To Kidder media center

COMPUTERS AND ACCESSORIES:
3.1 Student computers for group work
3.2 No individual student computers
3.3 Dual purpose modules around the room
3.4 Instructor's console
3.4.1 Separate console
3.4.2 Console to be of adequate size and located well
3.4.3 Remote access to console
3.4.4 IPX and IP access
3.5.1 Video monitor for the instructors computer
3.5.2 A mechanism to deal with hard drives
3.5.3 Tamper-proof software
3.5.4 Adequate memory
3.5.5 Power Point for instructor's computer
3.5.6 Group computers used by students in non-class hrs.
3.5.7 Bandwidth wide enough to prevent pauses in demonstrations
3.5.8 Zoom-in capability
4.1.6 CD ROM

EQUIPMENT INFRASTRUCTURE:
4.1.4 High speed network access
4.1.5 Easy access to campus network

INSTRUCTOR'S PODIUM:
4.2.2 Control of everything from podium, ie. all teaching aids, room lights, P.A. system, automatic blackboards, computer, etc,
4.2.4 Remote controls for all teaching aids
4.2.5 Minimize control switches instructor must use
4.2.6 Place podium off to one side

ELECTRICAL:
4.3 Electrical wiring
4.3.6 Outlets flexible enough for new technology
4.5 Elevator mounts for ceiling mounted projectors
4.5 No controls for any system to be above ceiling
APPENDIX 4
Tree Diagram

EQUIPMENT:
1.1.6 Name on front of desk via ID card reader

EQUIPMENT PARAMETERS:
5.3.1 All equipment must be quiet or isolated from the room
5.3.3 Tamper proof security for equipment
15.1 Distance learning capability for overflow
15.5 Capability to video and/or audio tape each class
15.6 A display table for exhibits

COMMUNICATIONS:
5.2.1 Phone a console
5.2.2 Speaker phone in room for tele-conference

Lighting:
6.1.2 Independent light controls for various room areas
6.1.3 A light on podium for instructor's notes
6.1.6 Spot lights on the blackboards
6.2 Lighting Flexibility
6.3 IR motion detectors to avoid interference
6.4.1 Bright enough to take notes
6.4.2 Bright enough to operate solar calculators

WINDOWS:
7.1 Motorized window shades controlled by instructor to darken room

8.1 LOW NOISE IN ROOM:

Aesthetics:

AIR:
11.1 Fresh air, good ventilation
11.2 High ceilings and skylights that open
11.3 Air conditioning
11.5 Temperature

TEST TAKING:
12.1 Electronic test taking – like congress votes
12.3 Test taking security

ADA / CODE:
1.3.24 Exit routes uniformly dispersed
1.3.25 Exits at front and rear of room
13.1 Wheel chair accessible
13.2 Accessible disabled routes equal to the number of exits
13.3 Seating for the disabled per code
13.5 Head sets for hearing impaired
14.12 Emergency lighting in case of power failure
15.2 Sprinklers if the building has them
APPENDIX 4
Tree Diagram

ANCILLARY FACILITIES:
14.1 Service chase for equipment
14.2 Equipment closet
14.3 Active stage for instructor (Not necessarily elevated)
14.4 Table for pick-up and hand-out of assignments
14.5 Adequate break facilities conveniently located near the room
14.7 Temporary, safe storage of student’s book bags, umbrellas, etc. Maybe under tables or in the terrace risers
14.9 Clock on side wall, not front

SOLUTIONS:
1.1.3 Theater seats
1.1.2 Benches with swivel seats
1.1.6 Numbers on front of seats
1.2.2 Work benches instead of desk-chairs
1.2.3 Work benches / tables with swivel chairs
1.2.4 Student’s desk wide enough for text & notebook
1.2.5 Flip-up text holder at desk-edge opposite student
1.2.6 Cup holder on student desk
1.3.4 Seats arranged in a broad semi-circle
1.3.6 Seats mounted on face of risers
1.3.7 25’ maximum distance between professor & students
1.3.8 Only five or six rows of seats
1.3.13 Chairs should not swing
1.3.17 Square room
1.3.19 Sloped floors
1.3.20 Terraced floors
1.3.21 Tiered seats
1.3.26 Room curved with no corners
1.3.27 Standardized the layout of room and equipment
2.1.9 Multi-scanner projector
2.4.1 Screens mounted half-way back for people in back
2.4.4 Large front screen plus side monitors
2.4.5 Screens located in corners
4.2.1 Automated console
4.3.1 Outlets at front of room and at other convenient locations
4.3.2 Conduits from podium to projectors, etc.
4.3.3 Conduits to all student stations for possible future use
4.3.4 Plug-ins for lap-tops at each student’s seat
4.3.5 Lots of outlets: phone, TV, cable, power, network hook-ups etc.
4.3.7 Power and equipment mounted in terrace risers
4.4 Fiber optics into room (transmit and receive)
5.1.1 Wireless mike
APPENDIX 4

Tree Diagram

5.1.3 Overhead mike for students
   5.1.4 Mike switch at each seat for student comments & questions
   5.2.4 Light and switch at students' seats to get instructor's attention
   5.3.2 Equipment should be non portable, ie. stationary
   5.3.4 ID card readers for equipment security
   6.5 Use reflectant lighting (parabolic grids or light cans)
   6.6 No fluorescent lights
   6.1.4 Light dimmers
   6.1.5 No timers on room lights
   8.1.1 Sound absorbing surfaces on terrace risers
   8.1.2 Room noise insulated
   8.1.3 Quiet doors
   8.1.4 Sound absorbing wall coverings
   9.1.1 Bright colors
   9.1.2 Blues and grays
   9.2.1 Carpets
   9.2.2 No carpets
   9.2.3 No mix of tile and carpets
   9.2.4 No vinyl on floor
   9.3.2 Reduced institutional look
   9.3.3 Appearance not sterile, not cheap
   9.3.4 Green plants in the room
   9.3.5 Wood trim
   9.3.6 Modern decor
   9.3.7 Decor relative to what is being taught in room
   11.4 Carbon dioxide monitor on return air of HVAC system
   11.5.1 Maintain cool room (prevents drowsiness)
   11.5.2 Temperature controlled by instructor
   12.3.1 ID readers for roll call for exam taking
   12.3.2 Seat arranged and floor sloped so as to discourage cheating
   13.4 Visual fire alarms (flashing lights)
   14.11 No elevated areas in the instructors' area
   15.3 No controls above the ceiling

REDUNDANT, IRRELEVANT AND FRIVOLOUS:
   1.3.23 Wide aisles
   2.1.4 Projector w/single handling scan rate compatible with all equipment
   2.3.4 No overhead projectors
   2.5.7 White board with printer
   3.4.5 Photo copier
   3.6 A laser printer
   4.1.1 Satellite access
   4.1.2 Satellite receiving dish
APPENDIX 4
Tree Diagram

4.1.4 High speed network access
4.1.7 Access to Bexell network
4.2.3 Port for video on side of cabinet
5.1.2 Mike worn by instructor
5.2.3 Support people to have cellular phones and pagers
6.1.1 Controls at instructor's podium
6.7 Bright room lights
7.2 Some say no windows but more say yes for windows
9.3.1 No cows on the walls
10.1 Laminated, simple, concise instructions in the console
10.2 Posted server names
10.3 Single point of contact for teacher to get help
12.2 Scantron testing
14.6 Means of waking up sleeping students
14.8 Student lockers on campus
14.10 Room close to Bexell would be nice
15.4 Establish specialized rooms rather than all-purpose room

MISCELLANEOUS:
2.1.8 Opaque projector
1.3.15 Safe storage for book bags and umbrellas