TOTAL QUALITY
IN SCHOOLS OF BUSINESS
AND OF ENGINEERING

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INTRODUCTION

Total quality management has been proven successful in many different enterprises around the world. Applications in engineering, and in business management, have also been clearly advantageous in commerce, especially in the design and manufacture of automobiles and consumer products. The interest in Total Quality is now worldwide. In North and South America, in England and Europe, in Australia and Asia, conferences and seminars on total quality occur, almost daily, with large attendance and testimonials to its success.

As we all know, although educators are among the first to write about new ideas, they are almost always the last to apply them to their own activities. Schools of Business are not famous for being well managed. Schools of Engineering do not apply engineering methods to their own operations. Thus it has happened that the quality movement has been active in the USA, for over a decade, and yet it has been only in the last year or two that we have heard of schools making a definite attempt to apply total quality to their own activities.

In presenting this paper, I begin by assuming that the readers already know what TOTAL QUALITY is. They are presumed to have read books, such as Deming's Out of the Crisis,[1] and other related works. My objective is to discuss how to apply total quality to education, especially higher education, in schools of engineering and schools of business administration. However, because, to my knowledge, there are no examples of schools which have done this, my examples will be taken from isolated instances of work done in education by myself and others, in an environment in which total quality has not been established for the institution as a whole.

WHAT IS THE PRODUCT?

To begin, let us agree that *the student is not a product.* The product is *the education of the student.* In the "manufacture" of this product, as with any other product, it is essential that the "worker" (student) be an active participant in the design and creation of the product. The student, who is the person who stays with the learning process longest, should learn to become the "co-manager" of his or her education. This means, according to the tenets of total quality, that the student should be involved, consciously and with skill, in the continuous improvement of the processes which create the product.

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[1] Deming, W. Edwards, Out of the Crisis, Center for Advanced Engineering Study, MIT, Cambridge, MA 1982

Who are the Customers for the Product?

The customers for the education of the student are several. They are, in order of importance:

1. **The Student**, who must live with the product for the rest of his or her life. The student must become the co-manager of the production of the education, and having such a personal stake it, must be considered first when attempting to define what it means to have quality in education.

2. **The Student's parents and immediate family**, who, in most instances are paying for the product, and must also live with the results for the rest of their lives.

3. **Potential employers**, who will rely upon the education of the student, after graduation, to achieve the purposes of their enterprises.

4. **Society at large,** which pays a substantial proportion of the cost of the education and requires the future participation of the student as a citizen, in the operation of government, as a contributor to the general welfare of society and as a taxpayer who will support the education of future generations of students.

Within the educational enterprise, at the K-12 level, we have recognized the existence of a number of supplier-customer relations, as pictured in the table below[2]. I have not yet seen a similar table for schools or engineering or management. That is a challenge I leave to you.

CUSTOMER	SUPPLIER	SERVICES
Students	Teachers	System Management Curriculum Design Counseling Leadership Materials and Equipment
	Administrators	Systems Development and Analysis Materials and Equipment
	School Boards	Policy
Teachers	Administrators	Materials and Equipment
Parents	School System	Knowledge, Wisdom, Know-How and Character of their children
Industry[3]	School System	Knowledge, Wisdom, Know-How and Character of graduates.

[2] This table was supplied by David Langford and his students in Mt. Edgecumbe High School, Sitka, Alaska.

[3] The last entry was added by the students in Theresa Hick's class of second graders!

WHAT SHOULD WE EXPECT FROM EDUCATION?

I propose that we examine any educational offering by analyzing its content in four categories:

1. **Knowledge**, which enables us to understand what we learn in relation to what we already know. Knowledge is both practical and theoretical. Theoretical knowledge provides us with the ability to generalize from unique instances. With theoretical knowledge, we can accumulate 30 years of experience. Otherwise, with only practical knowledge, we will have only one year repeated 30 times.

2. **Know-how**, which enables us to do. Know-how takes us past merely understanding. Know-how enables us to put knowledge to work. Know-how differs significantly from knowledge. Knowledge can be organized into intellectually tight compartments and these compartments may be taught as a subject unto themselves. Know-how, on the other hand, requires the purposeful organization of knowledge from many different areas of learning. As know-how is extended to higher and higher levels of accomplishment, it requires extension to more and more areas of knowledge. When teaching know-how, it is impossible to put bounds on the areas of knowledge which will be encompassed.

3. **Wisdom** is the ability to distinguish what is important from what is not. Wisdom enables us to set priorities on how to use our resources of time, energy and emotion.

4. **Character**, as Stephen Covey[4] has said, is a combination of knowledge, know-how and wisdom, coupled with motivation. We often recognize the development of character by certain character traits, among which we might list:

Honesty	Initiative	Curiosity
Truthfulness	Integrity	Cooperativeness
Ability to work alone	Ability to work in groups	Initiative
		Self esteem

It is up each educational enterprise to identify what to include in each of the above four categories. It appears that in higher education, attention is given only to the first of the four categories, with the last two not even given lip service.

Professors often believe, as I once did, that, at the level of the university, their sole duty is to develop knowledge and pass it on to the next generation. The development of the student's character is none of their business. President Sproul used to say to the students, "The University sets a bountiful table, but it guarantees neither the appetite nor the digestion." Only the football coach seems to care about the development of character.

The typical Professor in the University would consider it beneath a Professor's calling to actually teach people to apply their knowledge in a practical way. I recall my Professor of Mathematics, when asked "Sir, what good is the hypergeometric equation?" replying, in all seriousness: "Some people may use it to put two cars in every garage or two chickens in every pot. I for one do not give a damn!"

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[4] Covey, Stephen R. The 7 Habits of Highly Effective People, Simon and Schuster, New York, 1989

Professional schools, such as schools of business and schools of engineering, usually attempt to provide more than knowledge and understanding. They claim to provide the competence to actually do something, but because they are imbedded in a University setting, they find themselves struggling to maintain status while they depart from the norms of the University. The result is that while they may often move to include the second category, e.g., teaching effective presentation skills or the ability to design, they are often on the defensive, trying to justify these objectives to other faculties.

The faculties seldom make an overt effort to include the third and fourth categories. Indeed, I have had more than one professor say to me, "How could I possibly teach wisdom, when I have so little of it myself?"

What Do Future Employers Want From Education?

The list of knowledge which students are expected to acquire is usually a composite of what is required for accreditation and what the school decides itself. The list of know-hows is usually less specific, except for vocational schools. In general the accrediting authorities pay no attention to the development of either wisdom or character. For example, the US Department of Education, in laying out the goals for Education in the year 2000, is silent on these matters. On the other hand, when the Secretary of Labor of the USA appointed a commission from industry to say what was wanted of the graduates of our schools, they identified five competencies and a three part foundation of skills and personal qualities needed for solid job performance.[5] The table on the next page is taken directly from the SCANS report.

DEFINING QUALITY IN EDUCATION

What do I mean by quality in education?

> **QUALITY in education is what makes learning a pleasure and a joy. Some measures of student performance may be increased by threats, by competitions for grades, or by prizes, but the attachment to learning will be unhealthy.**
>
> **It takes a quality experience to create an independent learner.**
>
> **JOY is ever changing. What is thrilling at one age is infantile at another. Teachers must be ever alert to engage the students in a discussion of what constitutes a quality experience. The negotiations and discussions are never done.**
>
> **It takes constant engagement to wed a student to learning.**

You know you are providing quality in education when you find your students working diligently, and with enjoyment, in independent study and discussing what they have learned, in an animated way, eager to engage you in debate or to show you what they have discovered for themselves. This is the kind of joy I have in mind. It is based on doing a quality job because a quality job feels good.

If you are a teacher, imagine how it would feel if,, after giving a lecture and asking, "Are there any questions?" , the students didn't ask, "Will this material be on the exam?"

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[5] What Work Requires of Schools--A SCANS Report for America 2000, The Secretary's Commission on Achieving Necessary Skills, US. Department of Labor, June 1991.

WORKPLACE KNOW-HOW

The know-how identified by SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance. These include:

COMPETENCIES--effective workers can productively use:

Resources--allocating time, money, materials, space and staff;

Interpersonal Skills--working on teams, teaching others, serving customers, leading, negotiating, and working well with people from culturally diverse backgrounds;

Information--acquiring and evaluating data, organizing and maintaining files, interpreting and communicating and using computers to process information;

Systems--understanding social, organizational, and technological systems, monitoring and correcting performance, and designing or improving systems;

Technology--selecting equipment and tools, applying technology to specific tasks and maintaining and troubleshooting technologies.

THE FOUNDATION--competence requires:

Basic Skills--reading, writing, arithmetic and mathematics, speaking, and listening.

•

Thinking Skills--thinking creatively, making decisions, solving problems, seeing things in the mind's eye, knowing how to learn, and reasoning.

•

Personal Qualities--individual responsibility, self-esteem, sociability, self-management and integrity.

The difference between *features* and *quality*.

In the application of quality principles, it is important to distinguish between the concepts of *features* and *quality*.

Features are what you put into the product to distinguish it from other products and to appeal to the people for whom the product is intended. Thus, the kinds of knowledge and know-how that are included in the curriculum represent the *features* of the educational program.

A school of engineering may boast, for example, of the excellent laboratories and shop facilities it has for student use. A business school may tout its computer facilities and internship program with industry. These are features.

Quality, on the other hand has to do with the way the features are delivered. Laboratories may be unkempt, equipment may not always work, the instructions may be poor. The internship in industry may be just an excuse to send the students away for a time, and allow them to earn some money, while the faculty consults.

The Difference Between Teaching and Learning

TEACHING occurs when I show you how I solve a problem.

LEARNING occurs when you figure out how to solve your problem.

Quality management in education should be concerned with the improvement of both processes, teaching and learning.

Learning, of course, cannot ever be separated from the motivation to learn. One of the most powerful principles of learning is this:

People learn best when they feel the need to know.

Teachers, therefore, should, therefore, pay great attention to creating a healthy situation in which the students feel a need to know.

A common mistake in teaching is to create a need to know through fear, i.e., announcing an important test, to be given in the near future, and emphasizing that grades will be strongly dependent upon the results. This is the aspect of education that made Einstein say that it was only after his education that he could begin to learn! W. Edwards Deming is explicit on this point: **Eliminate fear!** Fear is destructive of education. At best it produces conditioned reflexes. At worst, it generates cynicism and disgust with education.

There are many possible relations between teacher and learner. They may be put in a spectrum, as indicated in the following diagram[6].

A SPECTRUM OF POSSIBLE RELATIONSHIPS

TEACHER	DO TO	DO FOR	DO WITH	ENABLE
LEARNER	No Choice Captive Antagonist	Captive Passive Dependent	Dependent Accepting Follower	Independent Investigator Seeker of Knowledge
ATTITUDE	LET ME OUT!!	I'LL TOUGH IT OUT	I'M OK YOU'R OK	JOY IN LEARNING
MOTIVATION	EXTRINSIC	EXTRINISIC	EXTRINSIC	INTRINSIC

INCREASING AUTONOMY →

The Role of Tests and Examinations

Just as the leaders in quality in world commerce have eliminated the need for final inspection, so should the aim of academia be to eliminate the need for final examinations in education. Final inspection used to be the method whereby a manufacturer attempted to assure the company and

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[6] This diagram was given to me by students at Mt. Edgecumbe High School, Sitka, Alaska.

its customers that the product was fit for use. It seemed like a reasonable approach and, for most educators, the concept of a final examination seems rational. It isn't.

In industry we have found that reliance on final inspection increases cost, produces inferior products and masks the inefficiencies of the process.

As one who has been an executive and has had to rely upon the education of my employees to produce better, more competitive products, I can testify to what every engineering executive will tell you: Most of our employees do not know how to make use of the materials they studied in school. Most use only a very small fraction of what they have been taught. The efficiency of the teaching/ learning process is low. Education, for most students, is getting past the next examination. The teacher asks, "Are there any questions?" and the first question is always, "Is this material going to be on the test?"

Many educators are beginning to understand the following principle with regard to examinations:

> **The only legitimate purpose of an examination is to enable the teacher and learner to decide what to do next.**

What is implied in this principle is that the learning process should be a process of constant improvement in the acquisition of knowledge, know-how, wisdom and character. The assessments should be designed to provide feedback to both the student and the teacher, as a means to improve the processes of teaching and learning.

> The student should use the feedback to improve the learning process. The teacher can use the information to help the student improve the way the student learns. Since each student may have a different style, students should be encouraged to perform tests and to measure the results of different approaches. (Does background music help or hinder learning? Try it both ways and see.)
>
> The teacher should use the feedback, from all the students, to assess the effectiveness of the teaching process and to improve it. (Do the class notes really help? Did the text provide a better result? Divide the class in half and see if you and the students can tell.)

COMPETENCY BASED EDUCATION

At the beginning of the semester, the teachers should discuss with the entire class the list of competencies, and the level of mastery expected, for each competency. The students should participate in the discussion of each competency, how they, themselves, will know their level of competency, how they will demonstrate it, how the teacher will assess it and what the teacher will do to help them achieve it. An example of what can be done, *at the high school level*, is given in the appendix. I look forward to some day seeing a similar example at the college and graduate school level.

THE PURPOSES OF SCHOOLS OF ENGINEERING AND BUSINESS

Questions of purpose in the professions of engineering and business are not new. They have been discussed for at least a century. Statements of purpose of schools of engineering and business are important. If students, faculty and administration are to cooperate, they need a common goal. They need to share a common vision of how this goal will be achieved. They need

to know how well they are achieving it and they need to be able to discover, for themselves, what they can do to achieve it better. Setting goals and developing visions begins with a sense of purpose. What should be the purpose of a school of business or a school of engineering?

I have examined a number of statements of purpose of different schools. Most consist of lofty phrases, with nary a testable proposition among them.

I do recall, however, the dean of a prestigious business school telling the wives of his students, "We teach our students how to get next to the money." Another dean of another prestigious school told me, "We prepare the leaders of business." That conversation, by the way, was part of a discussion in which he explained to me why he did not want his school of business to be too close to a school of engineering. He believed the engineering schools were not intent on the preparation of leaders but intended to prepare journeymen in their trade.

The best definition of a proper goal for a school of business that I know came from Tomas Bata who said[7] in 1924: "The purpose of the Business Colleges is to teach their students to create values by honest work."

Today, I would modify that only by saying:

> **The purpose of a School of Business is to teach students how to organize and lead the efforts of others in the improvement of processes which create value for customers by honest work.**

I would modify this statement for schools of engineering only insofar as the objective would emphasize the skill and ability to *design* and to *work with physical systems.* Thus, for engineering I would write:

> **The purpose of a School of Engineering is to teach students how to create value through the design of high quality products and systems of production, and services, and to organize and lead people in the continuous improvement of these designs.**

In this statement of purpose, *management is considered a part of, not apart from, engineering.*

We should recognize, of course, that the statements of purpose of schools of business and of engineering cannot be totally inconsistent with the views of business and other enterprises outside the school system. If they are to be *professional* schools, they need to play a role in reshaping these views. The question of the purpose of our enterprises is now undergoing a healthy review, thanks in no small part to the quality movement. A decade ago, if I asked a CEO, chosen at random, "What is the purpose of your business?" he would probably have immediately shot back, "To make a profit!" and turned away, thinking he had met someone who was hopelessly naive. Today I no longer meet very many like that. The managers of successful companies in today's markets know that profit is a result of achieving a purpose which attracts the hearts and minds of customers and employees. Making a profit is essential to survival, but it is not a purpose of successful companies. Breathing is essential to living, but it is not a purpose. Eating is essential to survival, but it is not a purpose. Profit is essential, but it is not a viable purpose.

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[7] Tomas Bata, Knowledge in Action, IOS Press, Amsterdam, 1992, pg 106

THE VISION

I have a vision of how education should be conducted in schools of business and engineering. The features, i.e., the topic included in the education, will differ, of course, but the approaches to quality will be the same. I visualize a process of change, with the following steps:

1. The administration and faculty of the school meet and develop a statement of purpose of the school. That purpose will make the "development of the ability to lead others in the creation of value" central to the mission of the school.

2. The faculty and administration will develop goals for themselves and their students. These goals will include learning objectives for the administration, the faculty and the students. The goals will each be stated in such a way that an assessment is possible. The assessment should be planned to be *continuous*, not *periodic*, and designed to *improve* , not rank students and faculty.

3. The students, faculty and administration develop *policies* with respect to how the education should be presented. These policies describe the responsibilities of all three parties. In many of the transactions of the school the different parties are, at one time or another, customers and suppliers of one another. A teacher giving an assignment is a supplier for a student. A student turning in a report is a supplier to the teacher.

   Policy statements should be based on the "quality first" principle, that is, every supplier should aim to provide customers with the highest possible quality goods and services. [8]

4. Faculty and administration should develop a list of competencies as a way of defining the content of the educational offering of the school. Each competency should be described by giving both the level of competency and the method of assessment[9]. These lists cannot be developed by faculty alone, because each item on the list has resource implications which the faculty cannot meet, without administrative support.

5. Faculty and administration should develop their own approaches to the development of wisdom and character.[10] These, too, have resource implications.[11]

   The main tool for teaching wisdom and character is the group project. Experiences with group activities, in which the members of the group are required to exhibit honesty, integrity, perseverance, creativity and cooperation, provide the basis for critical review by both students and teachers. Teachers will need to learn to function more as coaches and resources and less as givers of knowledge.

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[8] At Mt. Edgecumbe High School, in Sitka, Alaska, the students developed two policy statements: "If it isn't perfect, it isn't done" and "No excuses".

[9] Descriptions of level of competency and methods of assessment are given in the appendix.

[10] Specific methods for developing wisdom and character are given in a later section.

[11] My experience in education, over a period of 40 years, has taught me that when the objectives of education are set high enough and carried out with integrity, the resources can be found. We should not look upon education as a zero sum game, to be played out with limited financial resources, even in the public sector. When they have reason to believe in it, citizens will tax themselves to support education.

6. All teaching/learning situations will be under constant review by faculty, students and administration, seeking to find ways to improve their quality. There will be a new division of labor.

STUDENTS will monitor their own learning activities and, with the guidance of teachers, develop measures of quality and productivity (such as amount learned as a function of time spent in different ways to learn). The students will each be seeking to improve the quality of their own, individual, learning processes.

FACULTY will monitor the effectiveness of the teaching/learning process and the statistical distribution of various measures of effectiveness among the students as a guide to improvement of the teaching process.

ADMINISTRATION AND FACULTY will develop measures for and monitor the development of wisdom and character among the students. Since this will often require cross-functional cooperation, the administration should provide leadership in breaking down barriers between departments and among subjects.

QUALITY MANAGEMENT METHODS ADAPTABLE TO EDUCATION

Many special tools and techniques have been developed for TOTAL QUALITY. These range from new graphical representations to methods appropriate for group problem solving. The various tools and techniques may be readily adapted to education. In the remainder of this report I will touch on only a few of the techniques.[12]

Nominal Group Technique (NGT) [13]

Eight years ago, when I began to teach quality management methods at the graduate level at MIT, I introduced total quality into the teaching/learning process in several ways. On the first day of the class, I used NGT to explore the question: "What Do We Want To Gain From Attending this Class?" In the process the students and I defined and voted on the priorities of our objectives. Note that I included myself as a participant in the voting, for while I invited the students to participate, I did not abdicate my responsibility as a teacher. The results of the prioritization of interests guided to me in the preparation of the remainder of the semester's work.

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[12] The tools and techniques are described in many publications. A concise summary of the most important may be found in: The Memory Jogger II and The Memory Jogger Plus+ available from Goal/QPC, 13 Branch Street, Methuen, MA 01844

[13] See Scholtes, Peter R. and others, The Team Handbook, Joiner Associates, 3800 Regent Street, P.O. Box 5445, Madison, WI 53705-0445. Nominal group technique is akin to brain storming, but much more productive in developing a consensus on objectives. The Team Handbook contains many examples of techniques for quality improvement.

Deployment Flow Charting

One of the principles of quality management requires a focus on the processes which produce a product, instead looking only at the product itself. Therefore, I introduced the students to flow charting, using their own work, as indicated in figure 1, showing only the starting phases of their work. The students were required to complete the diagram, making it specific to their own project.

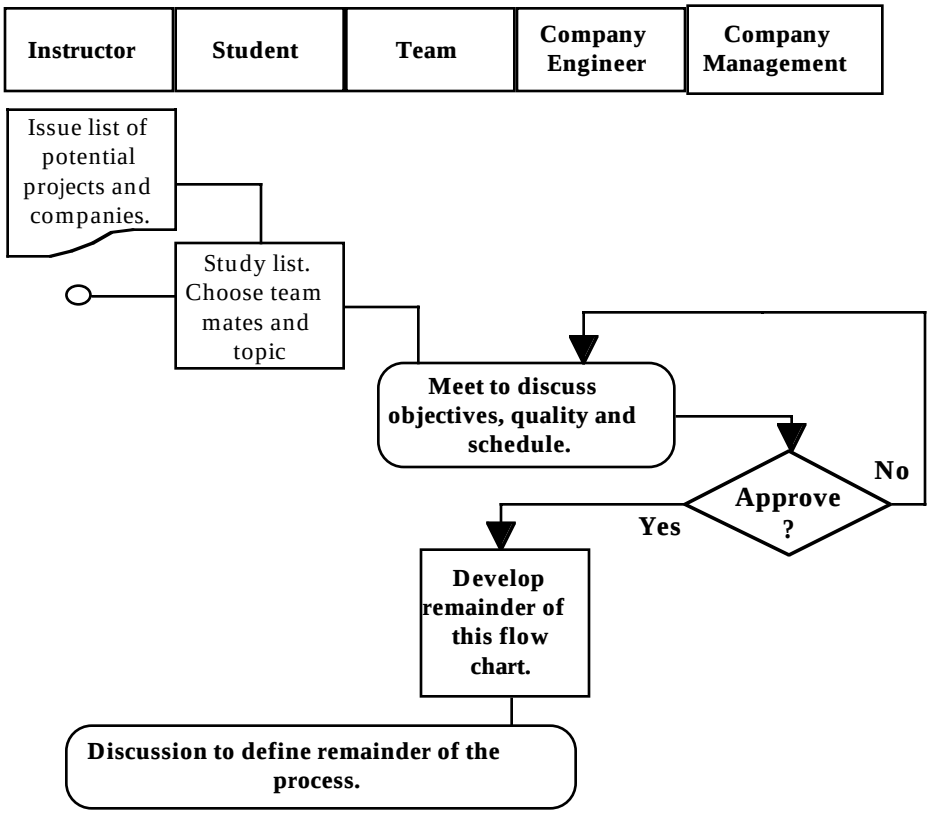

Figure 1. An example of a deployment flow chart.

We found these flow diagrams, which were revised as the semester went along, very useful as a means of charting progress and of testing the students' understanding of what they were doing. Within the teams, the students were encouraged to develop more detailed flow charts showing assignments of team members and how the work was expected to flow. Today I would give this much more emphasis than I did then, for the charts display "customer supplier" relationships, in which students need to supply information to one another, and such relationships can be used to advantage in studying not only how attention to quality reduces the need for rework, but also how students need to cooperate with one another if the job is to be done on time, in budget and with high quality.

If I were teaching the course again, I would spend much more time in discussion with the teams regarding the way they set their own priorities and the way their understanding of quality influenced this setting of priorities. Flowcharting is a useful tool in helping students to become aware of their own group process.[14]

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[14] This point is developed more fully in the Team Handbook, referred to earlier.

The student projects were selected in cooperation with industry and involved a search for a way to improve an ongoing process. Eight years ago all of the companies we met were at the very beginnings of their quality journey (or had not even started, even if they said they had) so each of the projects turned out to have a dual purpose:

1. We applied quality management processes to the organization of the work done by the students, as part of their education.

2. We applied quality management processes to the work of the company we were trying to improve, and introduced some of them to the advantages of total quality.

The biggest barrier to our efforts was the need to assign grades to individual students. MIT was (and is) the same as most schools in regard to grading. Most faculties believe that competitiveness is essential to the maintenance of the reputation of their school. They often create a highly competitive environment for both students and faculty, despite the evidence to the contrary.[15]

Quality Characteristics Evolution Diagram

Teamwork is essential to quality management. This teamwork should extend not only sideways in the enterprise, allowing people to break down barriers between departments, but also upwards and downwards, transcending historical patterns of human behavior in a hierarchical structure. A method to transcend the vertical barriers is to develop flow charts and quality evolution diagrams in a "layered" fashion. The diagrams below, for example show how the major topic "Quality Management" might appear from a high level. Each of the boxes on the right of the diagram is marked with a "drop shadow", which indicates that more information is to be found on another sheet. The box labeled "statistics" is expanded in the second diagram. A curriculum planning committee might develop the first diagram, while the staff teaching statistics might develop the second.

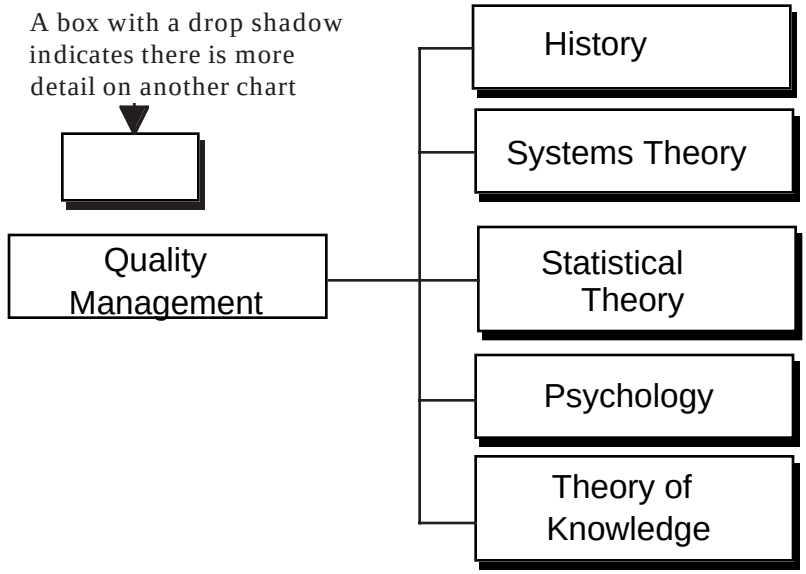


Figure 2. A quality characteristics evolution diagram has a tree structure in which each branch leads to a finer and finer detailed description of what is meant by the phrases to the left.

[15] Kohn, Alfie No Contest

Figure 3 shows a greater level of detail. Once the diagram of figure 3 has been completed, the faculty, with some input information from students and potential employers, should consider, for each topic, the level of competency to be attained by the students, how it will be developed, self-monitored by students, assessed and demonstrated. (See appendix for an example)

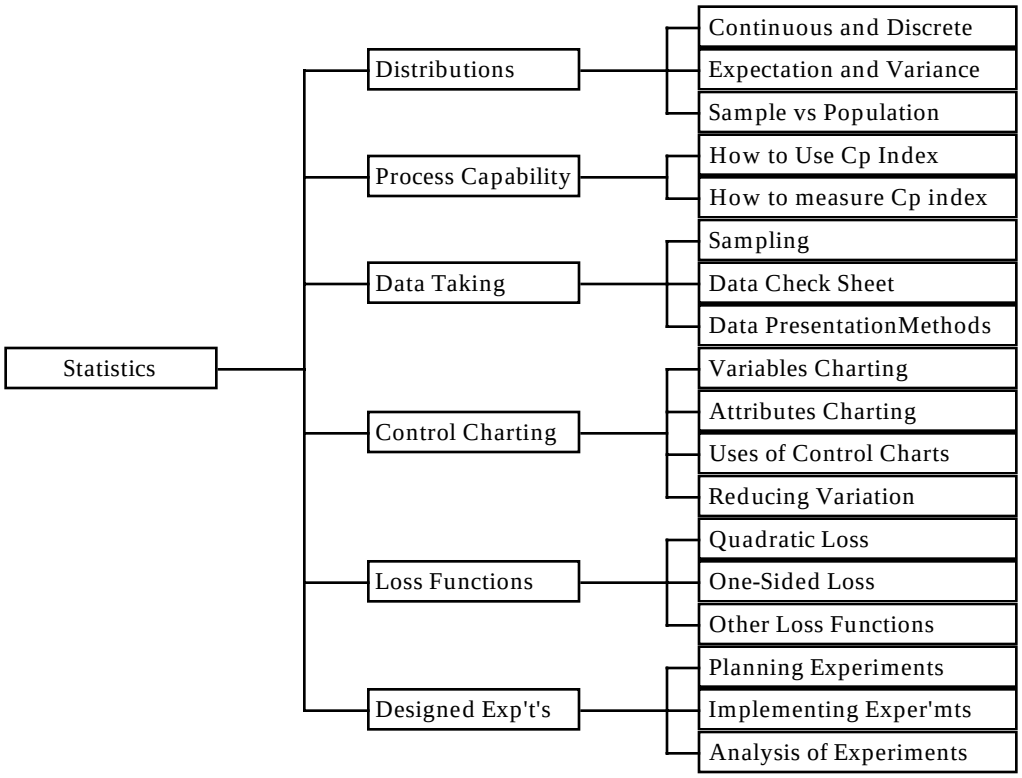


Figure 3. Second level quality evolution diagram.

Quality Function Deployment (QFD)

Once the desired core knowledge and know-how are identified and once there is general agreement on the attributes the faculty would like to see in the students, QFD may be used to see how the institution is deploying its resources against its professed objectives. An example of a QFD matrix is shown in figure 4.

The numbers in the matrix of figure 4 indicate the teaching/learning objectives in each of the topics, as agreed upon by the faculty, including input from students from previous years.

The actual work can be done by a small committee. Software for the detailed work has already been developed by GOAL/QPC. Figure 4 indicates how faculty teaching different courses may examine whether the desired objectives (as developed in the quality characteristics evolution diagram) can be attained with the courses in the curriculum.[16]

[16] Figure 4 is not complete. At the right end of each row the faculty should provide a reference to the definition of competency required for successful completion of the course, using the format shown in the appendix. For a more detailed discussion of QFD, see, for example,
King, Robert Better Designs in Half the Time, GOAL/QPC, 13 Branch Street, Methuen, MA 1987

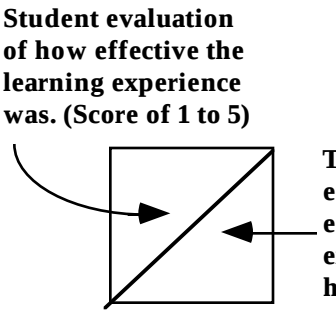
		COURSES			
		Introductory Statistics (Stat 101)	Manufacturing Laboratory(ML103)	Intermediate Statistics (Stat 121)	Engineering Laboratory (EL37)
STATISTICS	Continuous and discrete	2			
	Expectation and Variance	2			
	Sample vs Population	1			
	Use of Cp index	1			
	Measurement of Cp index	1			
	Sampling Data				2
	Data Check Sheets		2		
	Data Presentation Methods		2		3
	Control Charts, variables		3		
	Control Charts, attributes		3		
	Uses of Control Charts		2		
	Reducing Variation		2		
	Quadratic Loss Function			2	
	One Sided Loss Functions			2	
	Other Loss Functions				
	Planning of Designed Experiments		2	2	
	Conducting Designed Experiments		2		
	Analysis of Designed Experiments		2	3	

Figure 4. A portion of a Quality Function Deployment Matrix

A diagram such as the one shown in figure 5 may be prepared and distributed to the students, with a request for them to fill it out by giving their subjective evaluation of how much the specified experiences contributed to the capabilities desired.

Many schools use "instructor evaluation" forms which serve to give a "grade" to the teachers. My experience with these forms has been that they are nearly useless. If I rated high (and I often did) or if I rated low, there was nothing in the forms which guided me to improvement. The QFD matrix is readily adapted to become a tool for the improvement of teaching and learning, *but only if the instructor wants to improve and the reward structure encourages improvement.*

Through the use of a list of competencies, developed in detail in a tree diagram, the instructors may use the details in the branches of the tree as the inputs to a QFD matrix. The QFD matrix may be used for student evaluation of the teaching process in a form which will guide the instructor to continuous improvement. If the students are made aware of the competencies to be developed and how they are to be evaluated they will be <u>responsible</u> because they have been made <u>response-able.</u>



	LECTURE	TEXTBOOK	CLASS NOTES	TEAM PROJECT #1	TEAM PROJECT #2	TERM REPORT	GUEST LECTURER #1	GUEST LECTURER #2
Data Check Sheet								
Data Presentation Methods								
Control Chart, Variables	3/5	3/5	4/4	2/3	4/4	2/3	1/2	4/3
Control Chart, Attributes								
Uses of Control Charts								
Reducing Variation								
Planning of Designed Experiments								
Conducting Designed Experiments								
Analysis of Designed Experiments								

Figure 5. Using the QFD matrix for evaluation by students and faculty.

Where to Begin?

Quality management methods may be introduced into a school in three distinct, but not exclusive, ways:

1. Apply quality methods to administrative practices.

This approach is the least threatening to the faculties and, therefore, may be expected to be the first step Universities take. Because so many of the administrative practices are similar to those which occur in industry, it will be easy to find consultants and to obtain guidance from friends in industry. Proceeding along this line, however, will have but marginal effect on education. It can make life better for the officers of the institution. It probably will save money. The support s staff will become happier.

2. Introduce courses in quality management.

This approach will have an immediate effect on the students in the classes and the faculty who are teaching the subject. This approach has two potential consequences, both of them positive:

a. If the students engage in improvement projects which involve processes in the school itself, many people outside the class will become aware of what quality methods can accomplish.

b. If, and this is a big IF, the teacher is truly a practitioner in quality, he or she will conduct the class using quality management methods. The resulting change in student behavior and performance will, most likely, be very dramatic and, therefore, the behavior and competence of the students may be used to help persuade other faculty members to do likewise. For example, student projects can be presented to faculty meetings.

c. If the class is conducted using quality techniques, the students will become evangelists for the new way to teach and learn. They will become the shock troops in the transformation of the school.

3. Use quality management as the "way of life" in the school. This means bringing the philosophy and methodologies of quality to bear upon all aspects of the enterprise. In a school of engineering this implies that continuous improvement will occur not only in the offices, the support functions and in the classroom, but it will infect all parts of the schhool, including research, student advising, sports, student activities and extra-curricular activities.

I am not too sanguine about how quality methods will appear in universities. Discussions with personnel at all levels, from University Presidents to students and secretaries, make it clear that Universities are "hard nuts to crack". The more prestigious the institution, the more likely it will resist the paradigm shift. A case in point is MIT which recently announced that it will "re-engineer" its administrative processes. When I inquired whether this meant that the committee assigned to the task would employ quality management tools and techniques, I was told that MIT wasn't ready for that yet.

Conclusion

This paper merely scratches the surface of our topic. The literature in the field of education is rich in information dealing with each and every topic discussed in this paper. What is necessary is the will and determination of the leaders in engineering and business education to apply this knowledge.

As all of you are aware, changing a curriculum is no easy task. I know. In my teaching career, spanning 45 years, I have been involved in three fundamental changes of curriculum. I agree with the statement, "It is easier to move a graveyard than to change a curriculum." Yet, change we must. The change will not take place over night. We are talking about changing the way we educate our youth and ourselves, from pre-school through grade school, high school and the undergraduate years in the University and even the graduate school. It is not a task for those of tender skins or faint hearts.

The current system of education must be reformed. It must be changed from one which sorts, ranks and winnows the youth of the Nation to one which develops them into quality performers, at whatever level and in whatever field they choose to work. The quality methodologies t provide the tools and techniques to do the job. For the sake of future of this Nation, I hope you will learn to use them and apply them well.

APPENDIX
Levels of Competence[17]

LEVEL 1. KNOWING (Remembering)

|<----------HOW STUDENT ----------> |<---HOW TEACHER---------->|

SELF TESTS	LEARNS	SHOWS	ASSESSES	TEACHES
Can I recall? Bring to mind right material at right time? Have I been exposed to the information? Can I answer questions?	Reading material. Listening to lectures, watching videos, taking notes, taking a written test	Name? List? Tell. Define. Who? Where? What? When? Did..? Was..? Is...? How many? How much? What did book say? Meaning of key words?	Asks questions which may be answered by simple recall.	Directs, tells, shows, examines information necessary to this level

LEVEL 2. COMPREHENSION (Understanding)

|<----------HOW STUDENT ----------> |<---HOW TEACHER---------->|

SELF TESTS	LEARNS	SHOWS	ASSESSES	TEACHES
Comprehend and understand what is said. Make use of the ideas by relating them to other material. Able to participate in the conversation on the subject.	Explaining the idea in written or oral form. Translating idea to own words. Providing an example. Doing textbook type problems. Recognizing and extracting relevant information.	Give an example of... What is most important idea? What caused this? Compare... Contrast... Why do you say that? Give idea in own words? What does ..... mean?	Asks "Give the idea in your own words." Give tests which require material to be organized in students own words.	Demonstrates, listens, questions, compares, contrasts, examines information and student's knowledge.

LEVEL 3a. THINKING (Applying, solving a problem)

|<----------HOW STUDENT ---------- -----> |<---HOW TEACHER---------->|

SELF TESTS	LEARNS	SHOWS	ASSESSES	TEACHES
Tests ability to use ideas, methods, concepts, principles and theories in new situations. Recognize limits of own knowledge and ability.	Applying in a new situation. Solving problems unaided, adding other techniques to one being tested. Recognizing new situations and developing useful tools.Evaluating utility of tools.	Solving, finding answer to .... Applying the generalization to..	Observing student involved in problem and solving new situations with minimum of prompting. Asking application questions. Use tools appropriate to question.	Shows, facilitates, observes, criticizes work being done by the student.

[17]This material was prepared by David Langford and his students at Mt. Edgecumbe High School, Sitka,Alaska.

LEVEL 3b. THINKING (Analysis, logical ordering)

|<----------HOW STUDENT ---------- --->|<---HOW TEACHER---------->|

SELF TESTS	LEARNS	SHOWS	ASSESSES	TEACHES
Examines, methodically, ideas concepts, writing and separates into parts or basic principles. Break down information into component parts to make the organization clearer. Use previous knowledge, comprehension and application	Analyzing how knowledge is applied. Explaining rationale for each step. Discussing why steps are in given order and how they might be changed. Dissecting the basic logic of the process.	Gives reason for conclusions. Uses logical method to convince teacher of correctness of results. By consciously filtering out words which are biased or emotional. Organizes evidence in support of conclusion.	Ability to break idea into component parts for logical analysis. Ability to identify assumptions, facts, opinions, logical conclusions. Ability to demonstrate a logical ordering to process, identify causes and effects.	Probes, guides, observes, acts as a resource.

LEVEL 3C THINKING (Synthesizing, creating)

|<----------HOW STUDENT ---------- ----->|<---HOW TEACHER---------->|

SELF TESTS	LEARNS	SHOWS	ASSESSES	TEACHES
Can recognize new problems and develop tools to solve them. Create own plan, thought model, hypotheses for finding solutions to problems. Can put together the parts and elements in a unified whole. Create a self consistent design.	Creating something: Physical object, a communication, a set of abstract but related concepts. Discussing, generalizing, relating, comparing, formulating.	By developing a plan, developing a thought model, combining parts to create a new whole.	Examines statements, plans, products which are new to the student. Ability to extract good ideas from one application and apply in another.	Reflects, extends, analyzes, evaluates.

LEVEL 4 APPRECIATION (Evaluation)

|<----------HOW STUDENT ---------- -->|<---HOW TEACHER---------->|

SELF TESTS	LEARNS	SHOWS	ASSESSES	TEACHES
Explicitly develops criteria and applies them to judge and appreciate the value of ideas and methods.	Evaluating works, ideas, presentations for utility, aesthetics and logic. Judges theories for consistency and utility.	By demonstrating ability to write about or discuss a work, theory, process, method or treatise and exercise judgment.	Written or oral presentations, formal and informal with respect to applying judgment with respect to criteria.	Clarifies, accepts, harmonizes and guides.

A FEW REFERENCES TO LEVELS OF COMPETENCE

Gallagher, J.J. and Aschner, Mary Jane, "A preliminary report: Analysis of Classroom Interaction," Merril-Palmer Quarterly of Behavior and Development 9 (1963): 183-194

Wiles, Jon and Bondi, Joseph Supervision: A guide to Practice, Charles E. Merrill Publishing Company, Columbus, Ohio (1980)

Benjamin S. Bloom, editor, et. al., Taxonoomy of Educational Objectives: The Classification of Education Goals: Handbook I, Cognitive Domain Longmans (1956)

Clark, Barbara Growing Up Gifted Merrill Publishing Company, Columbus, Ohio (1988)