

## **Design and Conduct of a Partially Asynchronous Course on Total Quality Management**

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### Abstract

In this paper, design and conduct of a partially asynchronous course on Total Quality Management are explained. Students enrolled in various engineering and other programs in a university can take the course. Also people from other institutions and industry are allowed to register for the course on a special status. In the design and conduct of the course, total quality principles are used. Planning for the future, clear objectives, participation, motivation, teamwork, leadership, problem solving, continuous improvement, empowered students, and learning assessment are given special emphasis. Major stakeholders are identified as students, graduates, instructors of the course, potential employers of the students, and the university management. Their expectations from the graduates are taken into account while designing the course. Difficulties due to the asynchronous nature of the course conduct are studied, and tried to be minimized by the design. In conducting the course, a student team is formed to improve the quality of the course as a project. The instructor works with the team in collecting data each week to assess the performance, and facilitating the team's course improvement. One semester's conduct of the course is evaluated, and the results are discussed.

### I. Introduction

In this study, a graduate course of the Industrial Engineering (IE) program of the Middle East Technical University (METU) is designed as a partially online course. The course title is Total Quality Management (TQM). It has been thought for two years in a classical in-class format before its online design. Since there has been a considerably high demand for the course from various other departments, and outside of the university, it has been selected as one of the courses to be offered online by the university. The design is developed as a part of a research project supported by the Turkish State Planning Organization and the Informatics Institute of the METU.

Distance education is in a growing trend recently. Wild<sup>1</sup> says that by the year 2020 every education and training program leading to a qualification or a credit towards one will be available in three models: full time, part time and through distance learning. The Internet is being used for distance education, and as a supplementary tool for teaching courses.

In the design and conduct of the course, total quality principles and approaches have been followed. Total quality in education requires planning for the future, clarity of objectives, active participation of the students in learning, high motivation for learning, teamwork, leader instructors, problem solving capability, continuous improvement mechanisms, empowered students, and assessment of learning through evaluation of the teams as well as the individuals. Dahlagard, Kristensen and Kanji<sup>2</sup> discuss use of total quality principles in education. Zadelhoff, Wet, Pothas and Pretorius<sup>3</sup> redesign and deliver an operations research course by utilizing team learning and assessment, and empowering students to improve motivation and learning. Krishnan and Houshmand<sup>4</sup> use Quality Function Deployment (QFD) for identifying the stakeholder requirements in designing the engineering curricula. Hillman and Plonka<sup>5</sup> also use QFD for curriculum design. Similarly, Burgar<sup>6</sup> chooses to use QFD in designing a course. Mazur<sup>7</sup> designs the Total Quality Management course at The University of Michigan College of Engineering utilizing the QFD approach. Köksal and Eđitman<sup>8</sup> study the stakeholder requirements from IE graduates, and how they should affect the education provided by the IE department of the METU.

## II. Course Design

The course is designed to serve mainly industrial engineering graduate and undergraduate students. However, it is acknowledged that students registered for other engineering, physical and social sciences and interdisciplinary programs can take the course, as well as people from other institutions and industry. Since this course is a part of the industrial engineering curriculum, it should help build knowledge and skills required from the industrial engineering graduates. These requirements are expressed by the students themselves, graduates, instructors, potential employers of the students, and the university management. A previous study (Köksal and Eđitman<sup>8</sup>) performed in the IE department lists the requirements of students, industry, and faculty from the IE graduates. Priorities of these requirements are also determined in that study. Those results are used in developing the course.

First of all, the course design team formed by the instructor and the teaching assistant, has identified knowledge and skills that should be provided or improved by the course. For this purpose, similar courses have been benchmarked, textbooks and reference materials have been studied, including Evans<sup>9</sup> survey on quality related topics. Also a sample of the IE and other departments' students have been interviewed about their expectations of the necessary knowledge and skills in the area. Finally, the list shown on the top of the matrix in Figure 1 has been obtained.

		KNOWLEDGE AND SKILLS PROVIDED BY THE COURSE																				1	2
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
		TQM implementation	Basic quality improvement (problem solving) techniques (brainstorming, Pareto charts, etc.)	Continuous improvement	Customer relations	Total Quality Management principles	Integrating customer needs into products	Policy and strategy determination	Supplier relations	Innovation	Empowerment	Teamwork	Quality standards (ISO 9000 and the others)	Benchmarking	Communication	Reengineering	Leadership	Quality awards	Variance reduction	Statistical process control	Overall importance	Ranking	
STAKEHOLDER REQUIREMENTS	1																						
GENERAL SKILLS	2																						
Learning ability	3											△										5,1	8
Research ability	4		△	△						△		△		△								4,6	11
Knowledge and skills in non-professional areas	5				△		△		△		○	△					△	△				2,3	18
Open to change	6	○		○		△	△	△			△	○			△	△						5,4	7
Creativity	7		△					○		●						○						7,3	3
Entrepreneurship, risk taking	8	△				△		○		○	△											4,7	9
Responsibility	9	●		△		△					△	○					△					8,9	2
PROFESSIONAL SKILLS	10																						
Ability to manage	11	○	○	△	△	△	△	○	△		○	○			△		○					2,1	19
Integration ability	12	△	△		△		●	○	△		●		○	○		○						3,0	17
Communication ability	13		△		○		○				●			●		△						4,7	9
Being a facilitator	14	△	●	△	△	○	○				●			○	△	○		△	△			2,0	20
Self-confidence, independent judgement	15					△					△	△			△	△	△					6,1	6
Professionalism, trustworthiness and work-ethics	17	△		△		△									△							7,2	4
Consciousness of cost, quality, time, human and society	18	○	△	○	△		○		△	△		△	△			△		△	△	△		4,5	12
Contribution to IE profession	19	△		△							△						△					1,6	21
Adaptability to different industries	20	○	○	△	△		△		△	△		○		○	△							3,2	16
Development and effective use of professional tools	21		●			△				○		△								○	○	4,4	13
Intuitively improved	22	△	△	△			△	△		△		△										3,5	15
System concept and approach	23	○	△	○		△	○	△	△													9,4	1
Practicality	24	○	○	△								△										3,8	14
Analytical thinking	25		△	△			△	△	△	○						○	△		△	△		6,2	5
Importance weights	1		244,1	146,3	139,6	40,6	58,2	152,7	110,0	30,7	159,6	35,6	228,8	6,8	35,6	91,3	85,5	65,3	6,8	34,7	34,7		
Percent importance	2		14,3	8,6	8,2	2,4	3,4	8,9	6,4	1,8	9,4	2,1	13,4	0,4	2,1	5,3	5,0	3,8	0,4	2,0	2,0		
Ranking	3		1	5	6	12	11	4	7	17	3	14	2	18	13	8	9	10	18	15	15		

Figure 1. Relations of knowledge and skills provided by the course to those that the IE graduates are expected to have (●: Strong (9), ○: Moderate (5), △: Weak (1))

The knowledge and skills that should be provided by the course are related to the stakeholder requirements of the IE graduates previously determined by Köksal and Eđitman<sup>8</sup>. This shows which topics of the course are more important than the others for the fulfilment of the IE stakeholders' requirements.

The same list of course knowledge and skills has also been given to the students enrolled in the course, at the beginning of the first semester. And the students have been asked to specify how much they think they should gain about each topic, using a scale from 1 to 5 (5 being a full understanding and competence). Table 1 lists the ranking of the topics based on the percentage of the students who choose 4 or 5 as an answer to each topic. This ranking is compared to that obtained from Figure 1 in the same table. Of course, this comparison does not take into consideration opinions of the other stakeholders than the students. Yet, the two rankings agree considerably (within  $\pm 4$  ranks).

<b>Knowledge &amp; Skills Provided by the Course</b>	<b>% of students desiring full understanding</b>	<b>Students' desirability ranking</b>	<b>QFD ranking</b>
TQM implementation	100	1	1
Teamwork	86.36	6	2
Innovation	95.45	3	3
Integrating customer needs into products	90.91	5	4
Basic quality improvement techniques (brainstorming, Pareto charts, etc.)	95.45	3	5
Continuous improvement	99.97	2	6
Policy and strategy determination	86.25	8	7
Communication	77.27	14	8
Re-engineering	81.82	10	9
Leadership	68.18	16	10
Total Quality Management principles	81.82	10	11
Customer relations	86.25	8	12
Benchmarking	81.82	10	13
Empowerment	81.82	10	14
Statistical process control	27.27	19	15
Variance reduction	36.36	18	15
Supplier relations	77.27	14	17
Quality standards (ISO 9000 and the others)	86.36	6	18
Quality awards	42.86	17	18

Table1. Importance of course topics obtained from Fig.1 compared to those obtained from the students' evaluations.

At the second step, the design team has developed course characteristics considering both online and in-class features of the course. These characteristics are, then, related to the knowledge and skills that should be provided by the course (Figure 2). This analysis shows which characteristics of the course are more important than the others. The most important characteristics, in descending order, turn out to be: Projects, class discussion, written cases, reading assignments, field trips, online lecture notes, online discussion, online project presentation, face to face teamwork exercises, lecture in class.

	1	COURSE CHARACTERISTICS																1	2				
		Lecture in class	Online lecture notes	Face to face teamwork exercises	Online teamwork exercises	Class discussion	Online discussion	Reading assignments	Projects	In class project presentation	Online project presentation	Homework	In class quizzes/exams	Online quizzes/exams	Field trips	Written cases	Cases on video						
KNOWLEDGE AND SKILLS PROVIDED BY THE COURSE	1																						
TQM implementation	2		○	○		○	○	○	●	△	○				●	●	●	14,3	1				
Basic quality improvement (problem solving) techniques (brainstorming, Pareto charts, etc.)	3		△	○	○		△	△	○	●	△	○	●	△	△	△	△	8,6	5				
Continuous improvement	4		○	○		○	○	○	○	△	○	△	△	△	○	○	△	8,2	6				
Customer relations	5		△	○	△		○	△	○	●	△	△			○	△	△	2,4	12				
Total Quality Management principles	6		○	○		○	○	○	△	△	△	△	△	△	△	△		3,4	11				
Integrating customer needs into products	7		○	○	△		○	○	○	●	△	○	○	△	△	△	○	8,9	4				
Policy and strategy determination	8		△	△		○	△	○	△		△					○		6,4	7				
Supplier relations	9		△	○		○	△	○	○	△	△	△			○	○	△	1,8	17				
Innovation	10		△	△		○	○	△	△						△	○		9,4	3				
Empowerment	11		○	○		△	△	○	○	△	△	△			△	△	△	2,1	13				
Teamwork	12		△	△	●	○	○	△	△	●	△	△	△	○	△	△	△	13,4	2				
Quality standards (ISO 9000 and the others)	13		△	△			△	△	○	○	△	△			○	△		0,4	18				
Benchmarking	14		△	△			△	△	○	●	△	△	△	△	△	○	○	△	2,1	13			
Communication	15		△	○	●	○	○	○	○	○	●	○	○	△	△	○	△	○	5,3	8			
Reengineering	16		△	△			○	○	○	△					△	○		5,0	9				
Leadership	17		△	△	●	△	△	△	△	○	△	△			△	○		3,8	10				
Quality awards	18		△	○			△	△	○	○	△	○	△	△	△	○	△	△	0,4	18			
Variance reduction	19		△	△			△		△	△	○		○	△	△			2,0	15				
Statistical process control	20		△	△			△		△	△	○		○	△	△			2,0	15				
Importance weights	1		247,5	321,5	256,8		97,3	413,9	313,9	377,1	585,5	137,5	264,3	199,8	107,9	54,3	339,9	392,7	194,2				
Percent importance	2		5,8	7,5	6,0		2,3	9,6	7,3	8,8	13,6	3,2	6,1	4,6	2,5	1,3	7,9	9,1	4,5				
Ranking	3		10	6	9		15	2	7	4	1	13	8	11	14	16	5	3	12				

Figure 2. Relations of the course characteristics to knowledge and skills provided by the course. (●: Strong (9), ○: Moderate (5), △: Weak (1))

As a result, the course is designed as a partially online course. Figure 2 shows that certain knowledge and skills cannot be gained sufficiently through online education. Especially teamwork skills are hard to improve through online exercises. Discussions, team exercises, oral project presentations, and certain exams are planned to be performed in class.

Based on the above results, the project team including also experts in online course tool development has developed ten basic elements of the online part of the course as shown in Figure 3.



Figure 3. Homepage of the course (<http://www.ii.metu.edu.tr/~ie545/demo>)

1. **Syllabus:** The syllabus of the course, and information about the course conduct are given here.
2. **Lecture Notes:** At the beginning of every week, that week's lecture notes are made available to the students. The lecture notes include pictures, animation, links to some references and software as well as questions to make learning attractive, effective and easy. Each week's lecture notes begin by stating the learning objectives. At the end of each week's lecture notes, an assessment of learning is done for the purpose of monitoring the students' understanding, and determining whether or not the section objectives are reached. Assessment of learning includes the following questions, in general:
  1. What is the most important thing you learned from this week's lecture notes? (minute paper idea of Angelo and Cross<sup>10</sup>)
  2. What important questions are being unanswered? (muddiest point idea of Angelo and Cross<sup>10</sup>)
  3. Is there any topic you wanted to learn this week, but could not find in the lecture notes, or the reading material?
  4. Were the lecture notes and the reading material helpful in reaching the section objectives?
  5. Comment on how this section can be improved.
  6. Do you have any problems about the on-line system?

The assessment results are summarized online and in class. Based on the assessment results, unclear issues are discussed in class and/or online, lecture notes are revised, problems with the online system are worked on for solution, and suggestions for improvement are evaluated.

3. Assignments: The homework questions and reading assignments are placed in this section. Every week, a homework and/or reading are assigned to the students. The students submit their homework online. Solutions of homework problems and evaluation results are accessible online. For some team assignments, the teams read and grade each other's homework paper. Such homework papers are made available on the Internet. In addition, the students are expected to carry out a team project. These projects are presented in class. Each presenting team prepares a short quiz, and right after their presentation, they give it to the class. The quiz papers are evaluated by the presenting team. The students also prepare at least five questions each for the final exam. These questions are made available online. The final exam includes some of these questions. Student-generated test questions are recommended by many including Felder<sup>11</sup>, and Angelo and Cross<sup>10</sup>.
4. Additional Links: Some links to relevant sites about the course topics are provided in this section.
5. Contact: Information about how the students can reach the instructor is given here.
6. Announcements: The announcements concerning changes, management of the course, and warnings are given here. The students are required to check this page every day. The homework, quiz and assessment results are also presented here.
7. Forum: It is an online discussion section of the course. This section is a substitution or enhancement of the face-to-face communication. A student can post his/her questions and comments here. The others have the chance to reply, or post a new message.
8. Student: This is the part that allows students to reach test questions, submit their answers, and access personal information.
9. Instructor: This part is used by the instructor to design test questions, make them available to the students, access the class list, and reach course related information about the students, such as login statistics.
10. Tips: The information about hardware and software requirements, creating an html document, easy surfing through the pages, etc. is placed in this section.

A demo version of the course material is available at  
<http://www.ii.metu.edu.tr/~ie545/demo/>

### III. Course Conduct and Improvement

29 students were registered for the course, the first semester. They were enrolled in a total of ten departments of the METU ranging from psychology to food engineering as well as industrial engineering.

Two hours were hold in class every week, instead of three hours required by the classical version. These hours were used for discussion, team exercises, project presentations, and exams.

Questions designed for assessment of learning were answered by the students every week. The instructor took action to improve the course before the semester ends, based on these answers. These improvements included supplementing lecture notes with additional material, and links, correcting format of the course material, and providing more timely feedback.

A quality improvement team (QIT) was formed in the first two weeks of the semester. The team provided additional feedback to the instructor about the course conduct. The quality improvement team analyzed problems with the course as well as strengths and weaknesses of the course. They identified the major problems as shown in Table 2.

<b>Problems</b>	<b>Stated by (%)</b>
Slow Internet connection	79.31
The students can not sufficiently interact among themselves	65.52
Many students do not participate in the forum discussion	58.62
Students do not use Web effectively	48.28
Homework questions are not motivating well enough for further reading	31.03
The classroom sitting is not appropriate for teamwork	31.03
Teamwork exercises are not enough in number	17.24

Table 2. Major problems related with the course

The QIT also identified strengths and weaknesses of the course. Table 3 shows the results of this analysis.

<b>Strengths</b>	<b>Weaknesses</b>
Internet usage and getting used to Internet facilities	Limited chance of applying the course tools in class
Teamwork	Limited chance of observing real life applications
Popular course topic	Limited face-to-face interaction
Different students from different disciplines	Technical problems related with the on-line part of the course
Projects, cases, and presentations	
Instructor's experience, willingness and friendly attitude	
Students' participation in course improvement	
METU facilities for the course necessities (library, Internet, etc.)	
Effective web design of the course	
Usage of different auditory and visual tools	
Shorter in-class lecture time	

Table 3. Strengths and weaknesses of the course.



When the first semester ended, the students were asked to evaluate the course overall by answering a questionnaire containing questions under seven different headings.

These headings are:

1. Preliminary Information
2. Course Content
3. Interaction
4. Homework, Assignments, Projects, Etc.
5. Evaluation and Grading
6. Software and METU Online Service
7. Overall

Only a few people (6 out of 29) filled out the questionnaire. The results indicate, they are most satisfied with the "Evaluation and Grading", and the least satisfied with the "Interaction" part of the course.

All of these results show that the most important problem about the course is insufficient participation of students in the forum discussion and poor interaction among the students. This is partly because of the online part of the course, and partly because students from various different disciplines take the course. As a remedy for this problem, at the second semester, the instructor has formed the teams by assigning students with different backgrounds in the same team as much as possible. The instructor has motivated more, the second semester, the use of the forum by placing interesting questions, stories, news on the forum and following up more closely the students' participation. The instructor has increased the number of team exercises, which helped students interact more the second semester compared to the first one.

The students ask for observing and discussing more real life applications and cases. In response to this, the number of cases and field trips have been increased at the second semester. Also some guest speakers have been invited to class to talk about certain course related topics that require expertise.

The students express a need for better and more homework questions for understanding the subjects. The homework questions have been redesigned to motivate more for learning.

Another major problem about the course is mostly related with the hardware such as server problems and the slowness of the Internet connection. The METU Online service providers work on the server problems with the aim of minimizing them. To improve the speed of Internet connection, the course pages have been modified to decrease graphics and audio files. A small number of students have complained about the time it takes to prepare homework and projects for use in the electronic media. Therefore, the Tips section about creating an HTML document has been improved.

At the second delivery of the course, the demand for it has been around a hundred students, but only thirty-five students from twelve different programs have been allowed to take the course. Currently the course is being delivered. Again two hours in-class are hold every week. The QIT of this class is working as the previous one. Weekly learning assessments continue. The instructor is collecting data to compare the two semesters. The partial results indicate more interaction in class and the forum,

and more motivation for learning. The results of the second semester's conduct and a comparison of them to the previous results will be given in a later publication.

#### IV. Concluding Remarks

The course designed for partially asynchronous use as explained above has provided several benefits to the students and the instructor. A major benefit obtained from the asynchronous nature of the course is the flexibility in time and place to study the course material. Organization and availability of the course material on Internet help improve learning. Distinctive characteristics of the total quality approach utilized in this course are: Planning of the course, empowerment of the students in the learning process, instructor's role as more of a leader or a facilitator than the lecturer, receiving timely feedback and acting on it continuously for improvement. These all help reaching the course objectives better every time.

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