

## Introducing Students to Total Quality Management Concepts in an Authentic Context

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### Summary

First- and second-year engineering students at the Colorado School of Mines are introduced to open-ended problem-solving, technical oral and written communication, and team processes in the four semester EPICS (Engineering Practices Introductory Course Sequence) program. EPICS provides students with an experientially-based authentic context for solving real world projects for clients from industry and government and, thus, represents an ideal setting for introducing students to the **principles** and **practice** of Total Quality Management (TQM). Rather than lecture about these topics, we introduce TQM concepts using a series of modules and then allow students to immediately adapt and apply these concepts as they complete project work for their customers. This paper will describe the TQM modules we have developed and illustrate how use of these modules has improved the quality of student project work in EPICS. We will also report data which measure changes in student attitudes and perceptions towards the value of TQM in problem-solving, team processes, and project management.

### Introduction and Background

U.S. firms must increasingly compete in international markets to survive and, as a result, the need for engineering graduates to understand and apply TQM principles has never been greater. Results from several recent surveys of U.S. business executives including one published in **Prism** magazine [1] consistently suggest that undergraduate engineering curricula are not doing enough to introduce students to “quality” as a key tenet of engineering practice. Gary Tooker, president of Motorola, has been quoted as saying “We’re not asking colleges to add courses; we want you to include a quality dimension to existing courses.” [1]

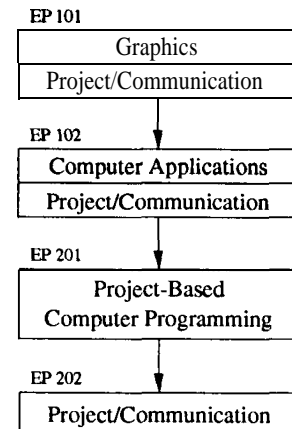
This comment suggests that we must do more than lecture to our students about TQM terminology, definitions, and theories. Rather, our students must be given the opportunity to actively practice these concepts in an authentic, team-based, project setting so that they can construct their own understanding and meaning about the validity and utility of TQM in their professional lives. For nearly 15 years, the Colorado School of Mines has introduced our first- and second-year students to “real-world” engineering practice in the EPICS program, and therefore, EPICS represents an ideal context in which to introduce students to authentic and meaningful applications of TQM to their project work. The objective of this paper is to briefly describe the EPICS program, describe how TQM concepts are introduced to engineering students in EPICS using “quality” modules, and discuss the effectiveness of the modules in improving students’ project work.



## The EPICS Program

EPICS is a four semester, 11 credit hour sequence designed to enhance engineering students' abilities in: 1) open-ended problem-solving, 2) oral, written, and graphical communication, and 3) team dynamics and team-building [2]. As shown in Figure 1, students learn fundamental skills in engineering graphics (visualization, sketching, and drafting) and computer applications (word processing, spreadsheets, presentation graphics, x-y plotting, and computer-aided design) in their first-year courses, EP 101 and 102. They also learn and practice technical oral and written communication and teamwork in the context of "cliented" project work. Second year students learn to solve problems using computer programming (EP 201) and conclude their EPICS experience in a capstone project course (EP 202) where they utilize the skills they have acquired in previous EPICS courses.

Figure 1-- Schematic Representation of Four Semester EPICS Curriculum



In the project/communication component of EPICS, students work in teams of 4-5 to solve "real world" open-ended problems for clients from industry and government. Throughout EPICS, we treat students as professionals using an engineer/manager rather than student/teacher relationship. In the EPICS culture, students are expected to meet required deadlines, arrive for classes and meetings on time, strive to continuously improve the quality of their team processes and work products, and meet their client's expectations. All EPICS project/communication courses are team-taught by an engineer or scientist and a communication specialist. Faculty serve as coaches or managers of the student design teams rather than as lecturers and also act as occasional liaisons between clients and students. EPICS classes meet in two-hour blocks twice a week with rarely more than 30 minutes per class devoted to mini-lectures, announcements of upcoming deadlines, and general feedback about progress on the projects.

Students work on a new design team for a different client each semester; all class assignments are directed towards satisfactory completion of the project and professional presentation of their results and recommendations to their client. Faculty members answer questions, provide guidance as requested, and coach students through difficulties; however, faculty do not portray themselves as authority figures with all the right answers.

Because of our focus on "cliented" projects in a professional context, the EPICS experience has always stressed customer satisfaction, continuous improvement, and other quality tenets, but until recently we have not formally used TQM language to describe them. Since EPICS provides students the opportunity to practice project work in an authentic, experiential context, we hypothesized that a simplified introduction to TQM concepts and ideas could be meaningfully applied by first-year students to improve the quality of their project work (both process and product).

## Total Quality Management in EPICS

In 1993 the Colorado School of Mines was awarded a grant by the Procter & Gamble Curriculum Development Grant Program to expose all CSM students to TQM concepts and applications. A portion of the grant was devoted to introducing first-year students to TQM concepts in EPICS so that they can: 1) use these principles to improve their educational experience, and 2) become comfortable with authentic applications of TQM concepts before entering industry or government. To fulfill these goals, we developed, piloted, and evaluated the effectiveness of TQM modules in first-year EPICS project/communication classes.

### TQM modules in EPICS project/communication courses

We developed the following modules for use in first-year EPICS project/communication courses:

- Introduction to Total Quality Management
- Use of Quality Management Tools
- Conducting an Effective Meeting
- Technical Report Checksheet
- Quality Teaming

After briefly discussing the motivation to learn about quality and apply it to EPICS project work (“remaining cost competitive in today’s global markets requires a devotion to quality”), the “Introduction to Total Quality Management” module introduces five basic TQM tenets [3]:

- quality is defined by the customer
- quality excellence derives from well-designed and well-executed systems and processes which emphasize prevention rather than detection
- continuous improvement must be a part of the management of all systems and processes
- analysis and decisions must be based on data and facts
- the quest for quality must involve and empower everyone in the organization

The module then briefly discusses each of these tenets in jargon-free language. For example, we describe the need to focus on customers and quality in the following way:

The overall goal in developing a quality product or service is to delight customers by exceeding their needs. To do this, customers must first be identified and their needs determined. While this may sound easy, in reality every product or service may have numerous customers, both internal (within the organization) and external (outside the organization).

We end the module with a series of focus questions which ask students to identify all the customers for their current project, determine factors that will encourage or inhibit their team’s ability to produce a quality product and delight their customers, consider how they can continuously improve their work during the semester, and develop strategies to ensure that all team members feel empowered to make important contributions to the team’s work. Overall, students find that they can easily relate to the concepts of customer focus, effective teamwork, and continuous improvement discussed in the module. One student even commented that “this is all common sense -- of course we should do these things.”

“Conducting an Effective Meeting” was created to help EPICS student teams perform more efficiently by organizing and participating in meetings where all members are actively engaged in decision-making discussions and the team rarely strays off-task. The module focuses on the concept of a “meeting cycle” [4] in which each meeting is viewed in a larger context of work assigned to team members outside of the meeting, use of agendas to keep meetings on track, and an explicit assessment of the quality of each team meeting.



Two assessment instruments [4,5] are included as part of the module and, near the conclusion of each meeting, students are required to discuss and agree upon the quality of their teamwork and progress towards completing their project (“How well were tasks accomplished today?”; “How well did we work to build relationships?” “How clear were our goals?” “How cooperative were we?” “How productive were we?”). Use of these instruments quickly becomes a routine part of the students’ work and they find the explicit discussions of team performance a valuable way to improve use of their limited meeting time and improve the quality of their team interactions.

The “Technical Report Checksheet” was written to help students produce high quality team reports, a task with which first-year students are rarely comfortable. While not meant to be prescriptive, the checksheet provides structure and guidance as the students draft their reports and helps them to include in proper form all needed report sections, visual aids, literature references and citations, etc. We also use copies of the checksheet to facilitate our feedback to students about their draft reports.

Modules entitled “Use of Quality Management Tools” and “Quality Teaming” are still being developed and modified for classroom use. In these modules, we describe simple tools and techniques such as brainstorming, fishbone diagrams, Pareto charts, decision matrices, Gantt charts, deployment charts, and characteristics of highly performing teams to help students improve the quality of their work. A simple example of each tool is also provided to help students easily apply the tool to their project work.

As part of our pilot study, we distributed copies of the completed modules to students in EP 101 during fall semester 1994 and EP 102 during spring semester 1995. Students were asked to read the modules and to arrive at class prepared to discuss the information presented. Rather than lecture about the information in each module, we commonly used free writing in class as a technique to help students focus on important quality concepts and principles and decide how these ideas might help them better conduct their project work. Students were not tested on the content of the modules, but were expected to begin applying quality principles to improve team performance and the final products for their client. We observed that students were generally willing to consider what the modules had to offer. Team members immediately understood the importance of customer satisfaction and were particularly eager to please their external clients, to evaluate and improve their meeting quality, and to attempt to continuously improve through the semester.

### **Evaluation of TOM module effectiveness**

**Evaluation** activities have focused on measuring the impact of introducing TQM modules into EPICS first-year project/communication classes. Our primary vehicle for this work has been a questionnaire designed to measure students’ perceptions and attitudes towards the worth of TQM principles and concepts in their project work. Questionnaires were administered prior to introducing the modules in class (“pretest”) and near the end of the semester as students completed their projects (“post test”). Questionnaires were also administered to baseline EP 101 and 102 classes in which TQM modules were not used. Results suggested that students using the modules significantly improved their understanding of

- customer focus
- quality teamwork/effective meetings
- quality tools
- TQM goals and principles
- using valid data to make improvements in quality



For example, as shown in Figures 2 and 3, a significant portion of the first-year students in EPICS class sections using the TQM modules grew to understand the importance of customer “delight” and satisfaction during the semester. In EPICS sections not using the modules, fewer students became aware of this important quality tenet. Informal feedback from project clients and EPICS instructors suggested a similar trend. Students who worked with our quality modules tended to stay more focused on their client’s needs, tended to perform better as teams, tended to attempt to continuously improve, and produced higher quality project solutions and final project reports than students who did not explicitly discuss “quality” in their EPICS class.

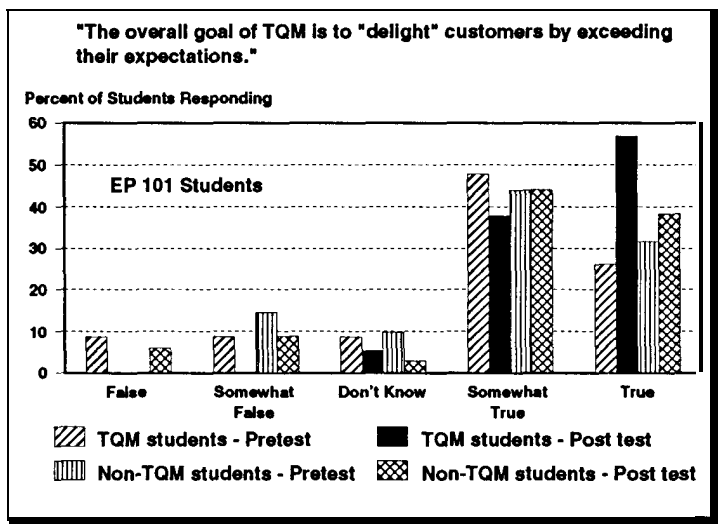


Figure 2-- Comparison of EP 101 Students Attitudes about Customer Delight [TQM students= students who have worked with TQM modules; Non-TQM students = students who have not worked with TQM modules]

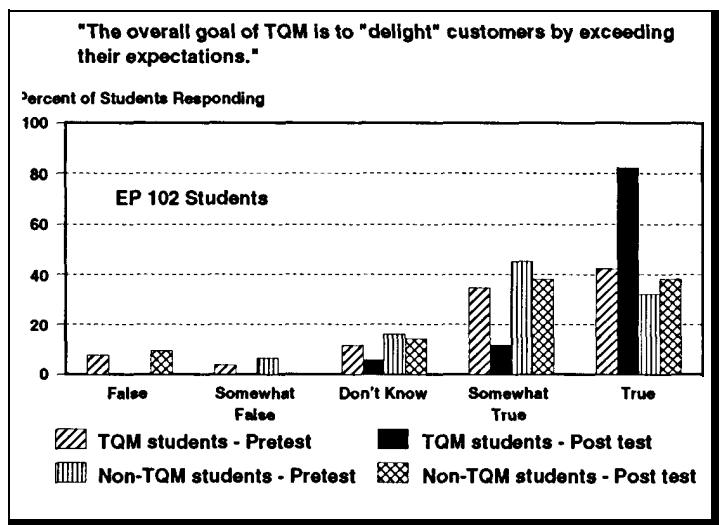


Figure 3-- Comparison of EP 102 Student Attitudes about Customer Delight [TQM students= students who have worked with TQM modules; Non-TQM students = students who have not worked with TQM modules]

Students were asked to rate the quality and usefulness of each module they studied and used. Results of these ratings are shown below (the “quality teaming” and “quality management tools” modules were not rated since they were still under development):

<u>Module</u>	<u>Avg. score (1 = very poor, 3 = average, 5 = very good)</u>
Introduction to TQM	3.5
Effective Meetings	3.5
Report Checksheet	4.0

Clearly, students who worked with the pilot modules were generally satisfied with the quality and usefulness of these documents. However, we have room for improvement and we are using students’ helpful suggestions to improve the readability and utility of each module. Our modest success in the pilot program has encouraged us to extend use of TQM modules to all sections of first-year EPICS project/communication courses with eventual expansion into second-year EPICS and senior design courses.

### Conclusions

We have created and successfully tested a series of “quality” modules for use in project-based courses which provide first-year engineering students with instruction and practice in appropriate uses of total quality management principles. Even though inexperienced in team-based, “real-world” problem solving for external customers, our students are capable of successfully applying TQM tenets to focus on customer satisfaction and improve the quality of their project solutions and final reports. Copies of all modules described in this paper are available by sending an email message to the first author at [rlmiller@mines.edu](mailto:rlmiller@mines.edu).

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