



## Computer Based Demonstrations of Statistical Quality Control for Engineering Students

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### ABSTRACT

Computer based education approach is used as a learning tool to demonstrate Metrology and statistical quality control concepts and their industrial applications for engineering students. An educational package has been built and used for regular students at technology college and for senior engineers attending training courses. The experience shows that this tool is very effective to accelerate the pace of learning and most importantly as a problem solving procedure. Improvements of the package are still undergoing to fully incorporate web-based technologies (Internet home page, HTML, Java programming etc...).

**KEY WORDS:** *Engineering education, Computer based, web-based, Information technology, Scientific Computing, HTML, Java.*

### 1 – Introduction

The rapid diffusion of Information Technology at all levels of economic, social, political and educational lives is gradually transforming our modern society into an information society. Educators all over the world have realized the value of computers and the emerging information technology tools for enhancing the quality of engineering education and training. The capability of the computer to interact with its user, to compute and then display the results of that interaction in a dynamic form provide an excellent avenue for learning that is simply not available in classical classroom or a textbook environments. Educators have exploited now a days computers' capability by developing educational computer packages to solve standard engineering problems and illustrate fundamental engineering concepts and phenomena. Such programs range from simple routines written in Basic programming language to full multimedia packages.

The advance in information technology tools in the form of the World Wide Web, HTML, Java programming, Microsoft Office, Scientific Computing Environments and Multimedia have been shown to offer real opportunities for enhancing the quality of engineering education and training. Many Web-based educational packages have been presented in the technical literature; Lee (2002), Emami (2001), Devenport (1999) and Kamal et al. (1999) presented comparisons between traditional and web-based approaches applied to engineering education and training.

These educators showed clearly the capability of web-based and computer based packages to enhance the quality of engineering education.

Over the years Quality Control methodology has become more and more widely used throughout industry as a quality improvement tool. With the availability of today's computer systems their practical application continues to win ground over other techniques. Within actual competitive market, modern companies are expecting the engineer and the technician they hire to have strong and effective training in quality improvement techniques together with Information Technology tools. It is therefore vital that engineering students are introduced to modern tools of information technology as early as possible and constantly exposed to them. The paper is dedicated to present a computer-based educational package to demonstrate quality control concepts to engineering students and to discuss the following aspects:

- Computer-based enhancement of engineering teaching and training;
- Web-based tools effect on engineering education quality.

These important issues are discussed in general and demonstrations are presented through an experience in developing a web based graduate course on Metrology and Quality Control and a training course for senior engineers and technicians. Practical applications including both approaches are discussed and conclusions are drawn.

## **2 – Computer Based Approach in Engineering Education and Training**

Science and engineering have advanced remarkably over the past decades. With the fast pace of change in some areas of engineering, it is crucial to keep both the engineering students and the working engineer up-to-date with the recent advents. The engineering curriculum has been continually revised during the twentieth century to incorporate ongoing advances in fundamental sciences and engineering knowledge. The present engineering curriculum taught at university level has been designed to provide an intellectual base which will give engineering students the ability to work productively in many different technical areas during their engineering careers. However, the engineering curriculum is still viewed by many of our students as a collection of discrete and isolated bodies of knowledge. Quinn (1994) noted that engineering teachers and educators realized more than ever that there is real need for unifying applications which can bridge the apparently disparate elements of the curriculum. Such applications would certainly aid students acquiring comprehensive and insightful knowledge about important engineering tools and learn about the interrelationships and constraints in real industrial systems.

With the fast growing popularity of personal computers and the explosion of the new internet technologies (www, HTML, Java, Networking, browsing etc...), computer-based and web-based education approaches have been continually developed by engineering educators with the aim to enhance education quality and produce problem-solving thinking engineers. Recent research presented by Valdez et al. (2002) from the North Central Regional Education Laboratory in the United States, show clearly that computer based technologies offer opportunities for learner-control, increased motivation, connections to real world problems and creativity.

Scientific computing environments such as Matlab and Microsoft office programs such as Excel and Access have been shown to offer good opportunities to build up computer based frameworks for engineering education purposes; The computing power and the analytical capabilities of these programs associated with the Visual basic environment (VBA) allow educators to present engineering concepts in a more pedagogical manner; Dorner (1997, 1999) showed that Microsoft Excel is an excellent package to teach and demonstrate quality improvement techniques such Pareto Diagram, Control charts etc... Grunwald et al. (1999) and McClellan (2002) showed

clearly the power of the Matlab computing environment in the development of teaching-software for engineering students.

### **3 – Web-Based Approach**

The advantage of web-based education is that it presents information about a body of knowledge in a non linear format that can be personal to an individual student. Traditional access to bodies of knowledge are presented in a linear fashion, while web-based applications allow cross referencing and browsing. Such activities stimulate the student's curiosity, and allow them to have scientific information in a context where they can see how the information is used to solve engineering problems. An advantage of including interactive computations in web-based applications is that the novice student is more intellectually engaged in the application. With this approach students can easily simulate the operation of a complex engineering system. The students do more than read textual information and look at graphical representations, but can directly compute the effect of the change in a parameter on the performance of an engineering system. The graphical interfaces offered by most of the internet technologies add the ability to interactively change the parameters, which is then evaluated and displayed in real time.

The notion of virtual laboratories has been extensively introduced in recent years by engineering educators and teachers. Important funds have been spent to support research to develop virtual laboratories or web-based interactive environments to teach engineering students basic concepts and their applications in real industrial lives. Lee (2002) showed that the recent developments in web applications, Java programming and pre-designed spreadsheets can be used effectively to enhance the quality of engineering education in a laboratory classroom. The time taken for students to perform classical calculations of experimental data and to plot graphical representations can be reduced significantly. The students can therefore use longer time on the analysis and discussion of the results and to propose alternative design possibilities in order to solve engineering problems.

### **4 - Development of a Web Based Metrology and Quality Control Course**

**4.1 - Course Description :** All institutions, whether for manufacture, public and government services (including education, health, finance, defense etc...) are more than ever concerned with quality and its continuous improvements. Improving quality means gathering data by means of measuring the quality characteristics and then analyzing these data in order to assess the state of a process, experimenting with methods to improve the process and assessing the benefits of alternative designs. Within actual competitive market, modern companies are expecting the engineer and the technician they hire to have strong training in metrology and quality improvement techniques.

The mechanical engineering curriculum at a graduate level includes theoretical teachings and laboratory work in metrology and quality control. Mainly the principle subjects taught cover :

- Basics of metrology
- Dimensional metrology techniques
- Basics of quality control
- Fundamental of Statistics
- Quality improvement techniques
- Sampling techniques and methods
- Control charts for variables and attributes
- Process reliability

Laboratory coursework includes practicing sampling techniques, making measurements of different quality variables (mainly dimensions and mass), construction of frequency distributions, calculation of control limits and construction of control charts for the process. At the end of each laboratory session, students are asked to produce a formal technical report where a thorough discussion is made on the collected data and the behavior of the manufacture process. In order to achieve this task, the student, working within a group, has to go through a tremendous amount of statistical calculations of the measured data, plot the necessary graphs on a paper and then discuss his results. This classical approach has been found to take almost 100 percent of laboratory time. Only short time remains to students to discuss together and with their laboratory tutor about reasons for quality problems and possible design alternatives.

**4.2 – Description of the Package:** Computer-based approach described in early sections has been shown to be very effective as an engineering education tool. It allows student to learn engineering concepts, analyze data, produce formal technical reports and develop communication skills in reasonable time.

In order to facilitate to students taking the metrology and quality control course understand the concepts of the subjects and their practical applications, a computer based educational package has been proposed. When building the package the steps shown in figure 1 have been followed; These are:

- Data collection (using sampling, dimensional and mass metrology techniques)
- Construction of a PC-based package on Statistical Quality Control techniques (statistical analysis, frequency distributions and control charts) using both Fortran 77 and Microsoft Excel: In early work, Aichouni and Al Nais (2002) presented the package which was built using scientific programming language Fortran 77 associated with a post processor Tecplot to visualize the computed results; More developments have been done using Microsoft Excel which combines the power of statistical computations and the ease of graphical representations; The ability to load Excel spreadsheets into HTML pages is one of its best advantages (Dorner (1999)). Figure 2 shows the Excel module which is used to analyze control charts for variables based on dimensional measurements taken by the students.

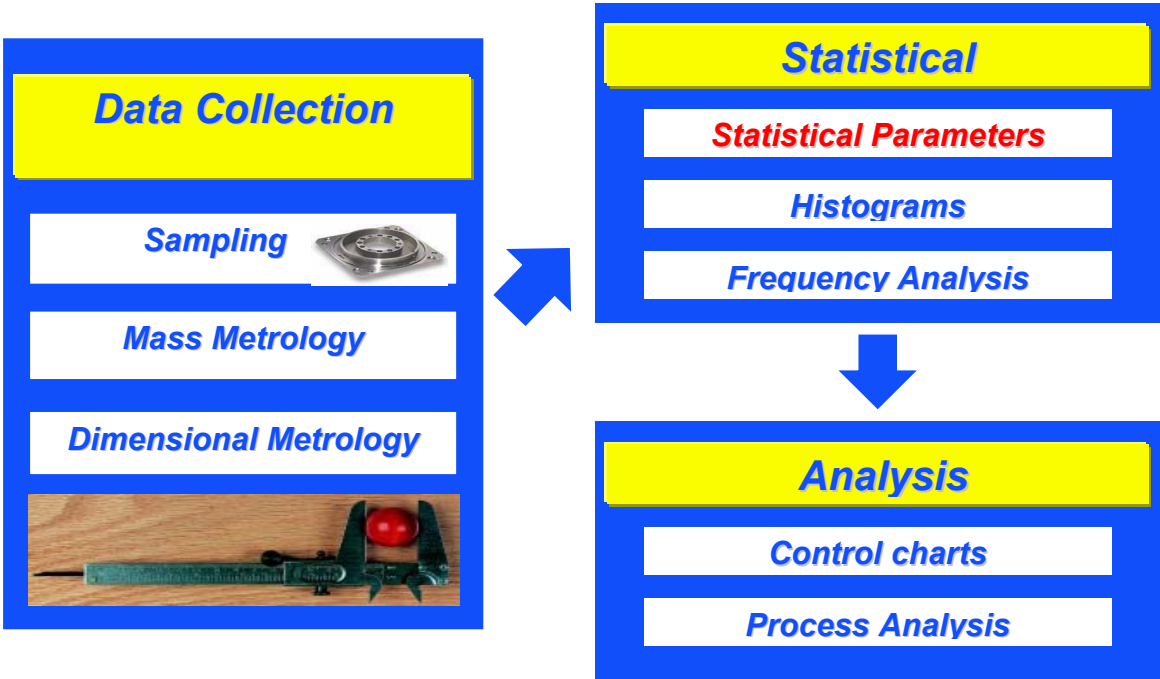
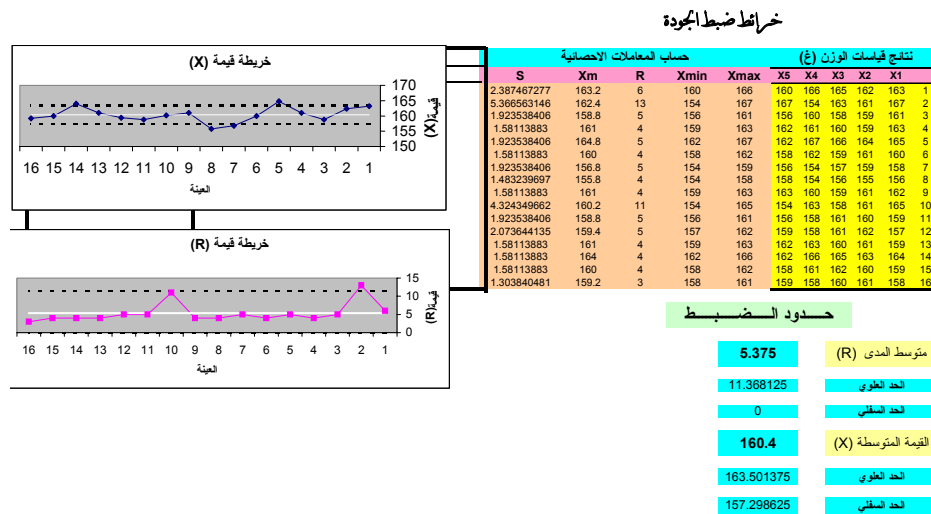


Figure 1 – The basic frame work of the computer package

- Modification of the package to become a web-based package using HTML, Java programming and multimedia tools: The objective is to develop a home page for the Metrology and Quality Control course to be hosted on internet for our engineering students and the senior engineers attaining the training courses held at the department. Several HTML pages which include textual and graphical explanation of the engineering concepts have been designed; Some of the lectures have been prepared as Microsoft PowerPoint presentations and past exams have been included as PDF files; Demonstrations and graphical illustrations on the major dimensional measurements techniques have been developed and tested by our engineering students. Developments of Quality improvement techniques are still under construction mainly in the form of Java applets. Figures 3 shows the main page of the course built using HTML programming.



**Figure 2 – Microsoft Excel Module for Quality Control Charts**

## 5 – Conclusions : Assessment of the of the Package as a Learning Tool

Up to now, the PC-based package has been used and tested extensively for two academic terms by both regular engineering students at the mechanical engineering department and senior engineers and technicians attending continuing education training at the department. The web-based package is still under construction and initial offline use has been tried recently. In both approaches, the number of students and trainees enrolled was about 120. The package was evaluated as a learning tool and the following conclusions emerged:

1. The majority of the students agree that the computer-based package helped them understand the concepts of quality control;
2. Students and trainees think that computer-based tools are an essential part of engineering problem solving procedures;
3. The experience show that that students tend to be traditional and will not use interactive computer-based tools without specific assignments.

In the view of these conclusions modifications of the demonstrations is still undergoing to achieve the goal of promoting active use of the proposed package as an effective learning tool for engineering students at technical colleges and universities and for distance learning.

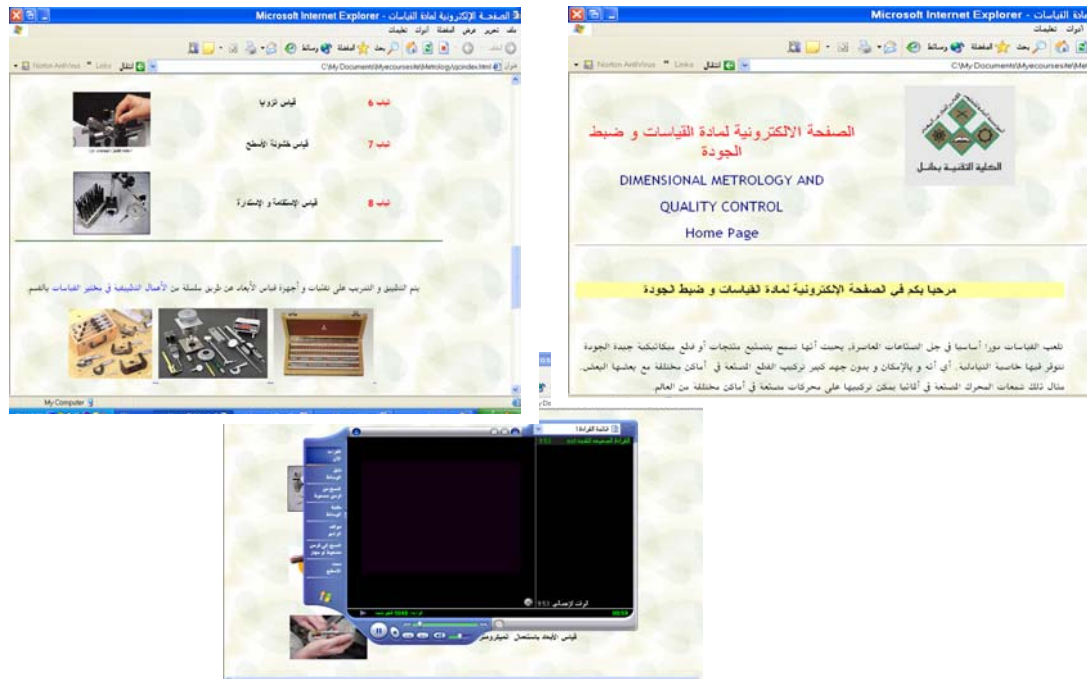


Figure 3 – The web-based Metrology and Quality Control course Home Page

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