Program Cover Document --- STA 314: Statistical Quality Control

I. Basic Course Information

STA 314: Statistical Quality Control is primarily a junior/senior level course. It is an option for MATC, Applied Statistics, MATA and MATT majors and for Statistics Minors. It is scheduled for two 80-minute meetings each week. Its prerequisites are STA 115 or STA 215, and MAT 125 or MAT 127.

II. Learning Goals

The primary goal of STA 314 is to give students an introduction to the theory and applications of statistical quality control. This is a set of techniques that have been developed to improve the quality of output of both manufacturing and service industries as well as other applications by identifying different sources of variability, eliminating those which can be controlled, and then monitoring the processes to identify when new problems occur.

The major focus of the course will be learning how to design, implement and monitor various types of control charts for different situations. This will include Shewhart type charts, including variables charts such as $\overline{X}$, R, and s charts; and attributes charts such as the p, np, c, and u charts. Non-Shewhart type charts will also be explored, including CUSUM, Moving Average, and Exponentially Weighted Moving Average charts. For each of these students will learn to derive any associated formulae, as well as learn the concepts behind determining the best way to design the parameters of the charts to deal with different types of anticipated problems. Examples of these anticipated problems include shifts in the mean or variability, which may large or small; may be either gradual or all at once, and which may or may not be sustained. Designing control charts to detect specific types of occurrences will include concepts of rational subgrouping (i.e., whether to take observations for each subgroup close together in time or randomly spread about the entire time interval) and determining subgroup sizes and frequencies to extract the maximum amount of information from the smallest number of observations.

Designing control chart parameters is often based on Average Run Length, which depends on the Type I and Type II Errors of the control chart. When doing a Shewhart-type control chart, plotting points on the chart can be thought of as equivalent to performing a hypothesis test, and the Type I and II Errors are equivalent to those of a hypothesis test. Furthermore, sample size determination depends on the Operating-Characteristic (O-C) curve, which is the inverse of the power function. Thus students taking this course will have their basic statistical inference techniques reviewed and reinforced, and will also become very familiar with Type II Error and power, which are important concepts that students often are not exposed to in other applied courses.

This course is computer intensive. There are software packages available which do statistical quality control, or the instructor may choose to have the students program the techniques themselves using a spreadsheet such as Excel.

Additional topics can be tailored to fit the needs of the students in the class. For example, if there are engineering majors in the class, the instructor may want to include topics such as acceptance sampling, Taguchi methods, and reliability/risk analysis because these are on the Certified Quality Engineer exam.

III. Student Assessment

This course is intended to be highly homework intensive. Weekly problem and data analysis assignments will constantly provide students with opportunities to show their understanding of the material. At the same time students will receive weekly feedback on their work and their progress. A combination of assignments, quizzes, and tests throughout the course will provide further valuable information both for the instructor and the individual students.

IV. Learning Activities

The specific choices of learning activities will depend upon the instructor, but it is expected that they will consist of some combination of lectures, group work, student presentations, individual homework, data analysis projects, quizzes, tests and final exam.

Departmental Course Syllabus --- STA 314: Statistical Quality Control

Introduction: A typical syllabus for Statistical Quality Control follows this sheet. Any syllabus for Statistical Quality Control should include the points listed below.

I. Basic information on course and instructor

A. Purpose statement: Statistical Quality Control introduces students to techniques used to eliminate and control variability in the output of manufacturing and service industries, among other applications. This will include learning how to design, set up, and run control charts of many different types, including $\overline{X}$, R, and s charts; attributes charts such as the p, np, c, and u charts; and non-Shewhart type charts such as CUSUM, Moving Average, and Exponentially Weighted Moving Average charts. In order to design control charts, students will learn concepts such as rational subgrouping, Type I and II Errors, Average Run Length, and Operating-Characteristic curves.

B. Course description: An introduction to the theory and application of statistical quality control. Topics include variables control charts ($\overline{X}$, R, and s), attributes control charts (p, np, c, and u), and non-Shewhart type charts (CUSUM, MA, and EWMA); rational subgrouping, Average Run Length, and O-C curves.

C. Course prerequisites: STA 115 or STA 215, and MAT 125 or MAT 127.

II. Learning goals

A. Content goals: Students will gain proficiency with many different quality control techniques. These include Shewhart type control charts, including variables charts such as the $\overline{X}$, R, and s charts; and attributes charts such as the p, np, c, and u charts. Non-Shewhart type charts will also be explored, including the CUSUM, Moving Average, and Exponentially Weighted Moving Average charts. In learning to design charts, students will learn to think about different sources of variability and how best to detect and control them. Concepts learned will include rational subgrouping, Type I and II Errors, average run length, and sample size determination using power and Operating-Characteristic curves. Optional topics include Acceptance Sampling, Taguchi methods, and reliability/risk analysis.

B. Performance goals: At the completion of the course, students should demonstrate competence in determining the proper type of control chart or other analysis technique for a given situation. They should be able to ask the proper questions about what sources of variability may be present and use this information to properly determine the proper method of obtaining subgroups, and use the desired in-control and out-of-control average run lengths to properly determine the parameters for any type of control chart to obtain the maximum amount of information from the fewest possible samples. They should be able to start with an initial process that may be out of control, identify problems to eliminate sources of variability to bring it under control, and then monitor future performance to detect any new problems. Finally, they should be very adept at using the computer to actually do the data analysis.

III. Student assessment

A. Assessment Plan: This course is intended to be highly homework intensive. Weekly problem and data analysis assignments will constantly provide students with opportunities to show their understanding of the material. At the same time students will receive weekly feedback on their work and their progress. A combination of assignments, quizzes and tests throughout the course will provide further valuable information both for the instructor and the individual students. A syllabus should clearly describe the schedule for these assessment tools and how they will be used to calculate grades.

B. Rationale: Through the use of regular feedback from homework, quizzes, student presentations and examinations, students will be able to see and correct their misunderstandings and improve their performance.

C. Methods and criteria: We will use the assessment of homework, quizzes, student presentations, data analysis projects, and examinations to evaluate student accomplishment of the course

learning goals. These assessment tools are similar to the manner in which students will need to use their knowledge in the future and are an appropriate way to assess the accomplishment of course learning goals.

IV. Learning activities

A. Summary of learning activities: The specific choices of learning activities will depend upon the instructor, but it is expected that they will consist of some combination of lectures, group work, data analysis projects, student presentations, individual homework, quizzes, tests and final exam.
B. Calendar or outline: A guide to the organization of the course, a schedule of assessment tools, and a plan for the coverage of topics should be provided to the students. Homework, quizzes, and examinations should be spaced at appropriate intervals throughout the semester.
C. Rationale: By giving students a multitude of ways to learn and do statistics, the learning activities promote a deeper understanding of statistical quality control and contribute to the learning goals of these programs. A regular spacing of assessment tools insures that students receive continual regular feedback on their work.

STA 314—Statistical Quality Control

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Course Description: This course provides an introduction to the theory and applications of statistical quality control. This is a set of techniques that have been developed to improve the quality of output of both manufacturing and service industries as well as other applications by identifying different sources of variability, eliminating those which can be controlled, and then monitoring the processes to identify when new problems occur.

The major focus of the course will be learning how to design, implement and monitor various types of control charts for different situations. This will include Shewhart type charts, including variables charts such as $\overline{X}$, R, and s charts; and attributes charts such as the p, np, c, and u charts. Non-Shewhart type charts will also be explored, including CUSUM, Moving Average, and Exponentially Weighted Moving Average charts. For each of these you will learn to derive any associated formulas, as well as learn the concepts behind determining the best way to design the parameters of the charts to deal with different types of anticipated problems. Examples of these anticipated problems include shifts in either the mean or the variability, which may be large or small, may be either gradual or all at once, and which may or may not be sustained. Designing control charts to detect specific types of occurrences will include concepts of rational subgrouping (i.e., whether to take observations for each subgroup close together in time or randomly spread about the entire time interval) and determining subgroup sizes and frequencies to extract the maximum amount of information from the smallest number of observations.

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This course is computer intensive. While there are software packages available which do statistical quality control, I believe that you will learn the techniques better if you program them yourself. Therefore we will be using Microsoft Excel to set up all of the different control charts.

Textbook: *Introduction to Statistical Quality Control*, 3rd Ed., by Douglas C. Montgomery

Homework: Homework problems will be assigned regularly. These will not be collected and graded; however, the solutions to these will be put on reserve in the library. The third weekly class meeting will be the time that I will spend answering questions on the homework. Before any problems are covered in class, I expect students to have worked them and looked at the solutions. Students are encouraged to form study groups to work on these problems. Quizzes will also be given--some will be in-class and others take-home; students may not work together on these. No take-home quizzes will be accepted late. If you want to do well on the quizzes and tests, I recommend spending a considerable amount of time on the homework.

Tests and Grading: You will have a closed-book quiz every Wednesday, covering all material covered the previous week (or since the last quiz). Any changes to this quiz schedule will be announced in class. You will also have some data analysis quizzes which require the computer and will be done outside of class. These are to be your own work only; no collaboration is allowed on these, and they will not be accepted after the due date. There will also be a project where you will identify a process and design the proper control chart(s) to determine if it is in control; collect data; and analyze it. Approximately three in-class tests will be given. It is possible that parts of these will be take-home. No test grades will be dropped and no makeup tests will be given. If you cannot attend on the day of the test, make arrangements to take the test early. No tests will be given after the tests are returned to the class. Also, a comprehensive final exam will be administered at the end of the semester. Any legitimately missed tests will be made up on the final. Any student caught cheating on tests or quizzes will be subjected to the strongest possible disciplinary action in accordance with the TCNJ Academic Integrity Policy. The grade in the course will be determined as follows:

Tests:	45%
Quizzes:	15%
Project:	10%
Final Exam:	30%.