Session 1463

How a Course in Statistical Process Control Can Utilize Real-time Data from an Industrial Production Facility

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Abstract

Engaging students as active learners in applied statistics courses and getting them to think critically about the workings of a full-scale production facility is a difficult task. Yet it is an important challenge that educators face when teaching a statistical process control course.

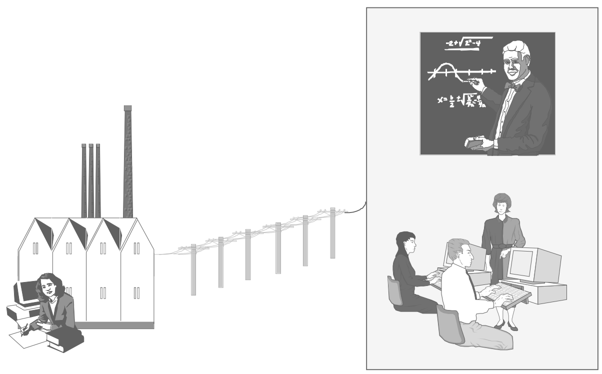
This challenge has been addressed at GVSU by giving students an opportunity to participate in projects and to interact with professionals in the field. In this initiative, real-time statistical process control data is being continuously collected on the factory floor. Once it is collected it is automatically transferred from the production facility to GVSU via the Internet for use in a statistical process control course. The data is updated on a daily basis and is continuously available to students for analysis purposes. This paper describes the experiences of the authors and their students with this approach over a period of two years. The authors will discuss how student projects were utilized throughout the semester and how a plant tour (at the beginning of the semester) was set up and leveraged throughout the course.

Good data is a critical need of an applied statistical process control course and this project represents an opportunity for industry to share data from billions of dollars in equipment investment with academia. Consequently, industry benefits by acquiring student analyses on their manufacturing process, and ultimately industry benefits by hiring graduates that are more aware of how quality control is accomplished.

I. Introduction

Traditional instruction of a course in statistical process control (SPC) involves a heavy dependence on examples described in textbooks and applications presented in lecture. Unfortunately, neither faculty lectures nor textbook examples give students a chance to see or touch the broad range of materials, tools, equipment, and processes involved in making finished parts and products. As a result, the student rarely receives a <u>complete</u> understanding of the scope of the manufacturing problem or how to apply what he or she has learned in class.

Over the past several years the authors have developed and maintained a relationship with an industrial sponsor that has provided a real-world SPC experience for their students. Specifically, the authors have created an infrastructure to support student projects for an SPC course where students will upload real-time production and quality data from the factory floor of a full-scale production facility operated by an industrial sponsor. This continuously updated data is transmitted daily and is always available to the students for analysis. The students will be required to complete several multi-week group projects that require independent data collection, analysis, and presentation of results. As a result, the student can perform as a member of the production or quality control team for the industrial sponsor. This cooperative climate between industry and universities (that is depicted in the figure below) has the potential to revolutionize the way that courses in SPC are taught.



II. Overview of the Student's Participation in this Initiative

During the first week of class an assignment is given that requires the students to visit the industrial sponsor's web site and complete a Pre-Tour Report. This report requires the students to investigate:

1. the range of products the industrial sponsor manufactures,
2. the everyday applications of the industrial sponsor's products,
3. the countries in which the industrial sponsor operates, and
4. at least four quality concerns associated with the sponsor's products.

After the students have completed the Pre-Tour Report, one of the authors spends a period giving the students some technical background into the industrial sponsor's primary products. This background helps the students be inquisitive during the upcoming plant tour.

All the students are now prepared to visit the actual production facility at the industrial sponsor. This will allow the student to observe a complete manufacturing system and begin their understanding of the many facets of control in a full-scale production environment. The plant tour is given by one of the quality control engineers at the sponsor site, and the students have an opportunity to meet the personnel who work on the factory floor. As a natural part of this venture, students will be recruited as active participants in the learning process. By looking at an operational full-scale manufacturing system in detail, students can see how solutions involving hardware, software and people has its own unique set of capabilities and limitations. During the tour the sponsor representative emphases the parts of the production process related to the data that the students will be analyzing. In addition, the representative explains the significance of the data that is being collected and identifies some of the anomalies that the students might encounter in the data. Then throughout the semester the students will upload "live" data from the operating production facility to complete their projects. Several advantages of use of this "live" data are that the student can:

- relate this data to the sights, sounds, and smells from the plant tour
- be inquisitive and discover the complete problem, and
- think about the type, quantity, and accuracy of the data collected.

After the tour each student must complete a Post-Tour Report that requires the student to:
1. discuss how their opinion of manufacturing the product changed from what they saw,
2. describe the production facility they saw at the industrial sponsor (explaining their observations on the sights, sounds, and smells of a production facility),
3. pick a specific machine area (work space) and describe the flow of materials and some of the efficiency issues for that area,
4. identify at least four quality concerns associated with the sponsor's products,
5. discuss how human fatigue or neglect might contribute to quality problems, and
6. describe some of the costs associated with assuring quality.

Additional details regarding how the industrial partners are providing their production facilities as an on-line quality control laboratory are provided in a companion paper by Garrett and Stephenson.[1]

Throughout the semester (in conjunction with the coverage of the appropriate material) student groups are assigned several projects that utilize the transmitted data. The following three projects have been used by the authors in our SPC course at GVSU.

Project #1 - A Control Chart for Variables-Type Data

Objective: This project provides the students with a technique that is useful in distinguishing the types of variation associated with a process. The objective of this project is to construct control limits for a control chart of the mean and standard deviation of variable-type data. These control limits can be used to monitor the mean and standard deviation of a process quality characteristic of interest in the future.

Deliverables: Each student group will be expected to submit the following:
1. histograms of the subgroup means and standard deviations of the process quality characteristic of interest,
2. initial upper and lower control limits for the subgroup means and standard deviations of the process quality characteristic,
3. revised upper and lower control limits for the subgroup means and standard deviations of the process quality characteristic, and
4. a demonstration of how the control limits can be used to monitor the process quality characteristic.

Project #2 - A Control Chart for Attribute-Type Data

Objective: This project provides the students with a technique that is useful for monitoring the fraction of nonconforming items manufactured by a process. The objective of this project is to construct a control chart for monitoring the percentage of nonconforming units produced per day. These control limits can be used to monitor the percentage of nonconforming units produced per day in the future.

Deliverables: Each student group will be expected to submit the following:
1. initial and revised upper and lower control limits for the fraction nonconforming, and
2. a demonstration of how the control limits can be used to monitor the future process.

Project #3 - An Initial Process Capability Study

Objective: This project provide the students with a technique that can be used to investigate and estimate the variation of variable-type data. The objective of this project is to conduct a process capability study on important characteristics affecting the quality of the product. The result of a process capability study is a measured assessment of the ability of a process to produce parts that conform to specification.

Deliverables: Each student group will be expected to turn-in the following:
1. appropriate numerical descriptions for each of the variables (e.g., the mean, median, standard deviation, range, etc.),
2. a box plot or histogram of the data for each of the variables,
3. a time series plot of the data for each of the variables and a description of any observed trends and/or cycles,
4. upper and lower natural limits for each of the variables, and
5. a computed value for a capability index for each variable and an interpretation of the result.

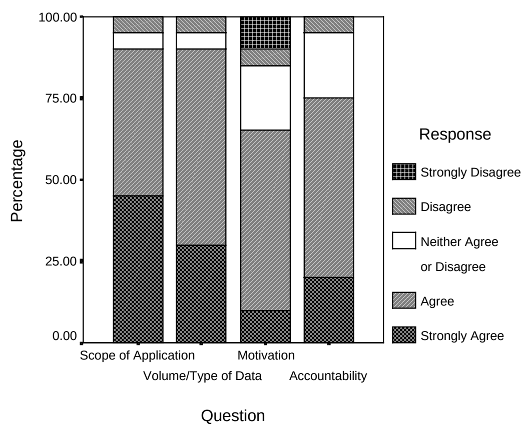
Once the analysis for each of the projects has been completed each group must write-up their results in a professional report (the text of which should not exceed three pages in length). This report should outline the project, describe the data that has been collected and the analysis that has been performed, and interpret the results. The report will be forwarded to the contact person at the industrial sponsor.

III. Evaluation

As stated earlier, engaging students as active learners and providing an environment that fosters critical thinking about the workings of a full-scale production facility was a significant part of this pedagogy employed here. In an effort to evaluate the students' perceptions of this initiative, a survey of the students in our SPC course was conducted in the fall of 1999. The first four questions asked the students to read a statement and respond on a five-point Likert-type scale (defined by Strongly Agree, Agree, Neither Agree or Disagree, Disagree, and Strongly Disagree). The four statements were:

- Compared to traditional textbook examples and faculty lectures, your experience from this initiative has given you a more thorough understanding of the scope of a real-world application.
- Compared to traditional textbook examples and faculty lectures, your experience from this initiative has given you a more thorough understanding of the volume and type of data in a real-world application.
- Compared to traditional instruction and examples, your experience from this initiative has increased your motivation to learn quality control.
- The realization that the industrial sponsor is using the results of your projects has motivated you to give your best effort and has increased your sense of accountability.

The following figure is a stacked bar chart that displays the results from the first four questions.



The results of this survey indicate that most of the students that participated in this initiative agreed or strongly agreed with all four statements. In addition, the students were asked to identify the most significant benefit to their education resulting from their participation in this initiative. Some of the benefits the students identified are:

- experiencing a first-time exposure a manufacturing facility, people and machines,
- getting a thorough understanding of where the actual data originates,
- realizing that analyzing actual data requires a broader understanding of the problem and is much more challenging than analyzing textbook data,
- becoming aware of the fact that data manipulation is very time consuming,
- seeing how real data relates to an actual operation that someone performs, and
- feeling a sense of responsibility and accountability to give the sponsor correct information.

In conclusion, it has been our observation that aspiring manufacturing engineers and manufacturing professionals with few exceptions have a practical, hands-on orientation. They are likely to be kinesthetic learners. They enjoy the practical application of theory. This new initiative captures the student’s interest. By looking at an operational full-scale manufacturing system in detail, students that take this course will be able to confirm the fundamental principles of industrial control and management. They can enjoy participating in the analysis of a complete manufacturing system and begin their understanding of the many facets of operating a production system.

IV. Participation Opportunities

There is a great opportunity today due to advances in computer technology and the capability of the computers residing on the factory floor. Potential sponsors exist in nearly every community. A NSF-sponsored workshop will be held to train faculty in the setup and operation of an equivalent system. The workshop will provide:

- an opportunity for an on-site visit to see the functions of this system,
- the software which was developed for data transmission,
- documentation (including a course outline, classroom exercises, system diagrams and other relevant information), and
- direct consultation with some of the industry participants in this project.

Faculty who attend the two-day workshop will be shown: (i) how to upload current quality data from the factory floor, (ii) how the entire system was setup at GVSU, and (iii) how to set up the same system back at their home institution.

Acknowledgements

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Bibliography

1. Garrett, R. W. and Stephenson, P. L. "Industrial Partners Providing their Production Facility as an On-line Quality Control Laboratory", Proceedings from the ASEE Annual Conference, June 2000.

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Dr. Stephenson received his M.S. in Mathematical Sciences and Ph.D. in Management Sciences at Clemson University. His areas of expertise are quality control and design of experiments. While at Clemson University he served as an editorial assistant for the *Journal of Quality Control*. Dr. Stephenson is currently an Assistant Professor of Mathematics and Statistics at Grand Valley State University (stephenp@gvsu.edu) where he teaches introductory statistics, statistical process quality control, and design of experiments. He is a member of the American Statistical Association.

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