An Interactive VBA Tool for Teaching Statistical Process Control and Process Management Issues

by Jaydeep Balakrishnan and Sherry Oh, Haskayne School of Business, University of Calgary, Calgary, Alberta, Canada

Jaydeep Balakrishnan *is an associate professor of operations management at the Haskayne School of Business. He has a PhD from Indiana University, an MBA from the University of Georgia, a BE (Mech) from Nagpur University, India, and is CPIM certified. He has been a visiting faculty member in Hong Kong and Singapore and has taught globally. His research interests include facility layout and supply chain management. He is an author (with M.M. Davis, N.J. Aquilano and R.B. Chase) of the textbook* Fundamentals of Operations Management, *published by McGraw-Hill Ryerson in 2004.*

Jaydeep.Balakrishnan@Haskayne.ucalgary.ca

Sherry Oh *is an instructor in operations management at the Haskayne School of Business and is currently on leave while completing her PhD in industrial engineering at the University of Toronto. She is an MBA (Thesis) graduate from the University of Calgary. She also has degrees in education (B.Ed.) and industrial engineering (B.A.Sc.) from the University of Toronto. Her current research is focused on the area of health care operations as she strives to help find solutions that recognize the dynamics and the interdependencies within a publicly funded health care system, having already done projects recently in both Ontario and Alberta.*

Sherry.Oh@Haskayne.ucalgary.ca

With a global emphasis on improved quality, Statistical Process Control (SPC) is an important process management tool with renewed significance. In order to address this issue, we have developed an interactive VBA Tool for teaching SPC and process management issues. Students can experiment with the tool to interactively examine the various issues that affect SPC and gain insight into the important issues in managing a process. The graphical nature of the interface should allow students to visually see the effect of changes in process parameters. A detailed Instructor's Manual and a Student Lab Manual accompany the software.

Introduction

With a renewed emphasis on managing processes in Operations Management (OM), discussion of Statistical Process Control (SPC) is often included as an integral part of the OM course. Also, what was once thought of as a statistical tool used mainly for production control in manufacturing has now achieved mainstream status in an increasing number of Fortune-500 companies (including service-based) adopting Six Sigma methodologies. At the same time, a review of the relevant literature revealed the need for an interactive teaching tool that could be used to enhance the effectiveness in teaching SPC concepts.

Thus the focus of our approach is to give students a better understanding of SPC, Process Capability, and process management issues through the use of an interactive Excel VBA based tool. While use of the entire tool is targeted toward mature students in MBA programs, executive programs, and students taking advanced quality management/control courses, parts of the tool may be used even in introductory courses at the undergraduate level. For example, the authors use the Process Capability and the Type I/II error sections of the tool in their introductory undergraduate Operations Management course in the business school.

The goal is to help teach both process control and process capability concepts and, through it, process management principles. The following concepts are explored through guided use of the teaching model: (1) false out-of-control and false in-control indications, (2) the role of reduced variability on improved process control, (3) process capability, (4) the role of reduced variation in ensuring better process capability, (5) Six Sigma, (6) understanding the role and differences between control and specification Limits, and (7) information from control charts.

Innovative and Unique Features

The tool uses MS Excel/VBA. The choice of using VBA was natural as the mathematical calculations are handled easily and it allows for modifications to be made quickly by anyone with access to Excel on their computer. The

graphical demonstration could be achieved with a package such as FLASH, but the interactive nature of the tool would have been more difficult to achieve as so much of the graphics are based on user inputs and subsequent calculations. The tool is thus very easy to use and at the same time provides visual representations of SPC and process capability. Figures 1, 2, and 3 show the screens that the user is provided with. The example is one of a callcenter. These are explained later in the document.

Content

An effective teaching tool will help transform business questions into a theoretical framework and then link that theory back into practice. This tool addresses managerial issues in SPC and Process Capability. While most textbooks address the mechanics of SPC, that is, creating process control charts, as managers, what is equally or more important is the managerial issues surrounding the use of control charts and managing the process. We are not aware of any other computer based interactive tool that has similar functionality.

Through this tool we believe students will attain a better understanding of issues such as: *How does increasing the z-value impact the frequency of unnecessary process stoppages or the amount of time out-of-control processes remain undetected?*; *How does focusing on training employees and better equipment improve the control of the process;* and *What is the difference between a control limit and a specification limit?* The value in this tool is that these and other managerial issues in SPC can be investigated using one tool in an interactive manner. For example, if one were to ask the question, *Why does the Type II error decrease with greater shifts in the process mean?*, with the click of a button using the VBA tool, students can see that the overlap between the distributions decreases, thus understanding why there is a decreased probability that a sample reading from one distribution will be mistakenly assumed to be from the other.

We believe that it is important to focus our innovative efforts on SPC because it is one of the more difficult concepts for students to comprehend. The theory behind SPC is based on probability and statistics, courses in which many business students are not known to excel, or have great interest. Thus, concepts such as process control limits and process capability, often taught back-to-back, are frequently confusing for many students. Similarly, explaining the effect of different z values on errors and the interpretation of sample statistics is difficult without simulating actual process measures. While the issues can be discussed with manual visual aids, using a board or overhead, an interactive computer tool is much quicker and more effective.

Pedagogy

The tool consists of three parts: an Instructor's Manual, a Student Lab Manual for students to work through, and the software. The Instructor's Manual explains the VBA tool and the issues that can be addressed using the tool. It is expected that the instructor would be projecting the software image on a screen in the classroom. The Student Lab Manual is a detailed step-by-step series of exercises so that the students can follow the instructor interactively, with space in it for them to take notes about the results of each exercise and class discussion. The manual and the software can be posted on websites so that students can download them and work through them outside the classroom if necessary. The instructor version of Student Lab Manual has also been prepared where the space for student notes has been filled in with expected results and suggested discussion (shown in text boxes in Figure 4). Since all the documents accompanying the VBA tool are in MS Word, they can easily be modified to the instructor's preference.

Each section in the manual addresses a different aspect of SPC or process capability. Thus, the instructor can choose to omit one or more of these sections depending on the topics covered in the particular course. The user can also specify the particular process management problem that is being addressed. In the example provided in Figures 1 through 3, the issue is with the management of the time a customer is put on hold before being attended to at a call center. The user can specify any situation through the Process Parameter box shown in Figure 1.

In each section the student can work through the different options provided by the instructor and graphically see the results. In Figures 2 and 3, each time the user hits the *Generate Sample* (or single observation) button, a value (sample mean or individual value) is generated from the normal distribution. Figure 2 shows an instance where the sample mean is within the control limits. If the value falls outside, it is shown as a red square. Thus, the user can generate multiple calls graphically to get a feel for the nature of the process. For example, in Figure 2 it is seen that a Type II error has occurred—the process is out of control (because the actual or current mean is different from the planned mean as shown in Figure 1), whereas the sample mean falls within the limits.

In Figure 3, given the particular situation, generating multiple observations will result in the conclusion that more than the expected number of defectives (based on the planned process) will be generated because of the shift in the process mean. It is also seen from Figure 3 that the process is a '1.2σ' process. This is related to the concept of Six Sigma.

The students can use the Lab Manual (Figure 4) to work through the exercises and note the results. The instructor can then use these results as a lead-in to more fundamental process management issues. For example, in Figure 2, a question might be: *Given the high likelihood of a Type II error, how does a manager reduce this?* This could lead into a discussion about the advantages and disadvantages of increasing sample size to reduce Type II errors.

Further, the role of reduced σ in decreasing Type II error can be discussed, including questions such as: *How can we reduce the process variation?* This would give students an opportunity to better understand the value of reduced variability and process improvement through aspects such as training and technology.

Conclusion

While SPC, process capability, and process management in general are becoming increasingly important topics, they also are among the more difficult to teach. Further, it is generally accepted that experiential learning enhances student understanding and experience. Technology provides an excellent vehicle for demonstrating hard to visualize concepts such as process management and does so in an experiential manner. Thus, we believe that the tool will be effective in helping students understand the more fundamental concepts behind SPC, process capability, and process management. One caveat in using the VBA tool is to ensure that the setup of the software is clearly explained and students are given adequate time to work through exercises during class. It can be frustrating for students if they do not follow what is going on or have missed a previous concept that the current example builds on because adequate time was not provided. Colleagues who have used all or parts of the tool have felt that it was effective in improving instruction.

Since the tool focuses on topics such as SPC, process capability, and process management issues, important to organizations everywhere, we feel that it is easily transferable globally. Instructors may use local issues in discussing process improvement in a regional context but the basic principles

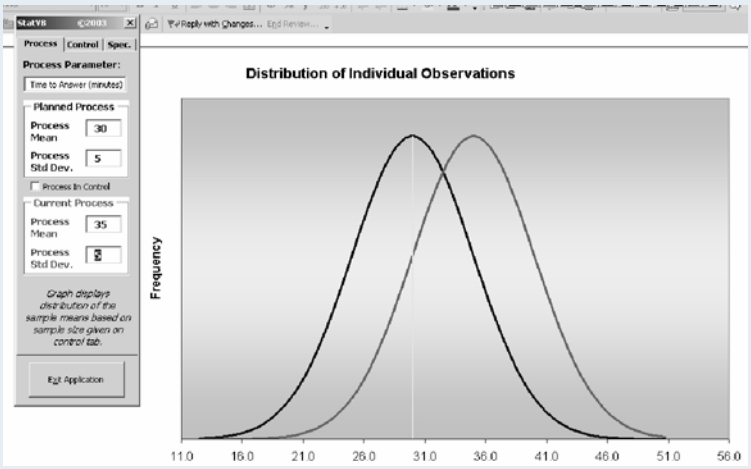

Figure 1: Process parameter sheet.

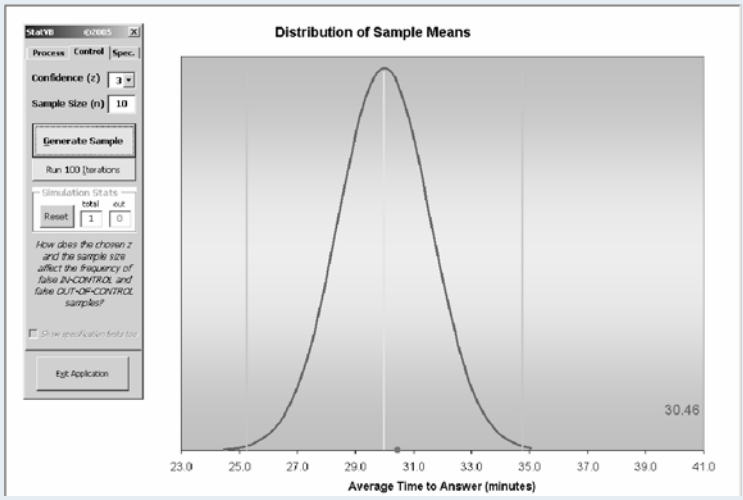

Figure 2: Process control sheet.

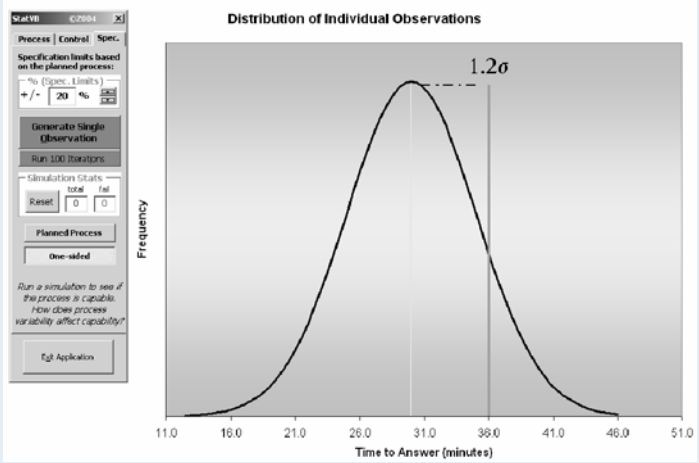

Figure 3: Process capability sheet.

Set $n = 1$, $z = 1$. Click the *Generate Sample* button. This generates a sample and calculates the sample mean. Since the sample size is 1, the mean is just the individual value. This value is shown on the bottom right of the chart, and it is represented as a **green dot** if within the UCL and LCL and as a **red square** if outside the UCL and LCL. (*Note: A sample size of one would usually not be used for SPC in practice, but required for the purpose of this demonstration.)*

Click it a few more times until you get a **red square**. In practice, if you were managing this process **what would you do when you get a red square**?

You would stop the process to investigate the cause of a sample mean outside the UCL/LCL.

Does the call on hold violate company guidelines (defective)?

Probably not… a red square is displayed if the generated value exceeds 11.5, while it would need to exceed 15 minutes in order to be 'defective'

Figure 4: Annotated student lab manual.

of SPC and process capability are universal. Further, since the tool is based on MS Excel, which is used worldwide, we do not see any technical issues with its transferability.

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Online Resource

All material discussed in the article is available online for downloading at no cost: **http://ite.pubs.informs.org/Vol5No3/BalakrishnanOh/index.php** ■

Decision Line Editor Vacancy

Nominations are being solicited for the editorship of *Decision Line* for a three-year term of service to officially begin on January 1, 2008. A description of the position and the responsibilities of the editor are presented below.

Decision Line, published five times per year, is the official news publication of the Decision Sciences Institute. It provides a channel through which members are informed of the activities of the Institute; it is a method of notification of administrative and organizational actions; and it provides an opportunity to call for papers for various meetings. It provides articles in areas of general interest to the members, including promoting innovation in teaching, research and scholarship, professional development globalization, and interdisciplinary activities. It also includes annual meeting notes and details, briefs on placement activities, and recognizes achievement of individual members.

The objectives of *Decision Line* are to: (1) serve as a means of communication among the members of the latest developments in the Institute; (2) serve as a formal notice of the Institute's activities; (3) provide a forum for opinions, discussions, and philosophical statements regarding goals; (4) be a means of keeping abreast of the latest developments within the discipline; (5) be a research clearinghouse to encourage participation among members of unpublished research; (6) and cover news of a personal nature regarding the members, i.e., promotions, retirements, etc.

The editor of *Decision Line* serves at the pleasure of the Board of Directors of the Institute for a three-year term and may be renominated and reappointed by the Board of Directors for a second three-year term. The editor is responsible for the editorial content of *Decision Line*, subject to monitoring by the Publications Committee of the Institute.

See **EDITORSHIP VACANCY**, page 41