Statistics and Belts: How Much? How Deep?

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Different organizations teach statistics to their Six Sigma Belts at significantly different levels of scope and depth. I have seen many Master Black Belts (MBBs) who were highly qualified practical statisticians and a few who did not know the difference between a 2-sample t-test and a paired t-test. Black Belts (BBs) in general are taught statistics at a less intensive level, because they can lean on their MBBs for help. However, it is the Green Belts (GBs) and—if I may coin the term—base-level BBs who seem to exhibit the most variation in statistical knowledge.

It's important to note that many organizations believe in a standard body of knowledge that all BBs should master. This concept of a certified professional BB is valid, but we are now focused on GBs and base-level BBs. The toolkit taught to these people might be more appropriately linked to their specific field, factory, or office. If no one in the organization uses certain tools, they may be "nice" to teach but doing so is likely a "waste of overprocessing."

Some organizations teach GBs to the same level as BBs. The rationale is that both need the same toolkit, because the main difference between a GB and BB in these organizations is that one works projects part-time and the other full-time. Other organizations treat GBs as simple team members. These GBs learn the importance of data and the concept of Analyze and Control, but they may not be permitted access to statistical packages. This last approach, unfortunately, has a logical basis: statistics can be complicated; it has a "use it or lose it" factor; and it can be dangerous in improperly trained hands. Potential danger lurks in selecting an improper tool, using tests without verifying assumptions, using insufficient sample sizes, using data that isn't trustworthy, or simply misinterpreting the analysis.

What are some possible solutions?

First, statistical software companies should recognize the fact that most of their users are not statisticians, and their software should provide for input and output in clear English (or French, or Chinese). Consider the

Seven Ways Statistical Software Can Support Quality Professionals

1. Since most users are not statisticians, statistical software for quality improvement should provide for input and output in clear language.
2. Software should automatically validate assumptions and provide clear warnings when providing statistical results.
3. Software should guide less experienced users through a logical sequence of actions that result in a proper analysis.
4. Software should use tests that are robust to common assumptions whenever possible.
5. Training materials should avoid statistical jargon except when critical.
6. Training courses should reflect participants' current and future needs.
7. Ongoing support should be provided to belts, including training on how to access help functionality in their software.

adage that "If your only tool is a sledge, then every problem looks like a spike." Simply put, software should provide a basic toolkit to a GB and an advanced one to a MBB, and it must be comfortable for either user. Ideally, you want one software package suitable for both beginner and expert. This has two clear advantages. First, as the GBs progress to become BBs and perhaps even MBBs, the tool they use remains consistent. In addition, MBBs use the same tool whether doing an advanced analysis or assisting a GB.

Second, software should, wherever possible, automatically validate assumptions and provide clear warnings in easily understandable language when providing statistical results. For GBs, I am uncomfortable both with output that provides no checking of assumptions (with the expectation that the user knows how to and actually does validate all assumptions) as well as "Black Boxes" that give "THE" answer without reporting on data quantity and quality, and the status of the assumptions.

Third, software should guide or, even better, semi-automatically lead the GBs through a logical sequence of actions that result in a proper analysis. This sequence should consist of data validation, critical graphical analysis, assistance in choosing the appropriate statistical analysis, and a crisp conclusion drawn from a properly executed statistical procedure.

Fourth, software for GBs should use tests that are robust to common assumptions and provide statistical clarity. Here are four examples:

1) Use a Welch's ANOVA vs. a classical F-test as the Welch's does not require the assumption of equal variances.
2) Automatically default to the use of tests 1, 2, and 7 for SPC. This matches current research and findings in the statistical community and minimizes false alarms while maximizing the investigation of the process.
3) Clarify when common assumptions are not important, such as the assumption of normality in a 2-sample t-test with sample sizes greater than 20.
4) Provide automatic comparisons of level mean differences in a One-Way ANOVA instead of providing a single p-value.

Fifth, training should avoid "stat speak" except where critical. We should also understand that participants in a typical two-week GB training or even a four-week BB class need to learn a tremendous amount of Six Sigma theory and the use of many different soft tools so they can complete projects. Devoting adequate time to these topics typically leaves insufficient time to comfortably teach statistics and supporting statistical software. As a MBB, I spent 7 years instructing BBs and GBs, and was always stretching to cover the concepts of Lean Six Sigma, change management, project management and reporting, project selection and scoping, financial analysis and reporting, in addition to conducting in-class project reviews and coaching. I felt unable to provide proper statistical training and practice.

As a Minitab instructor for the past 6 years, I have found myself on the other side of the issue. About 40% of students in my Minitab classes have served as Belts or are being trained as Belts. In almost every class I hear someone say, "Gee, I didn't learn that in my Six Sigma class." I always respond that, given the time allowed, the Six Sigma instructor can only teach the basics. We do not consider a Belt's Lean Six Sigma skills to be complete at the end of a few weeks of training; rather, we wait until they have time to apply and improve those skills over a period of time—typically a year and/or several completed, juried projects. Why do we then assume all statistical training is complete and mastered in initial training? Statistical knowledge, like most other Lean Six Sigma components, must be nurtured and augmented over that first year.

Sixth, we should teach to the right level. One size does not fit all. I have been in many service organizations that do not use traditional continuous gages and thus have no reason to use a traditional Gage R&R analysis. Why teach it? On the other side of the coin, I was teaching Lean Six Sigma to a service organization and they said they did not see the value in learning DOE. I convinced them that while they were correct in that we should not spend three days on DOE instruction and practice as called for in their organization's manufacturing group's training material, we should do a 3- to 4-hour "awareness" training so that the class would have knowledge that the tool exists, what it can do, and its basic requirements. They agreed, and later 2 of the 25 attendees appropriately used simple 2^K DOEs in their first project.

Seventh, we should provide ongoing support to Belts. This should include training on how to access help functionality in the software they use. This is a basic tool but one that is frequently ignored. The first line of action for any Belt who is stuck should be to use in-software help.

I will close with an observation: Statistics is the heart of Lean Six Sigma, but it is not the activity to which a Belt devotes the most time. During a project that spans three or four calendar months, a Belt may use a statistics/data package for 10 to 20 hours. However, statistics is a crucial tool—for without it, how would we quantify our baseline capability and verify that it comes from a stable process? How would we know if a change was statistically valid or due to random chance, and how would we properly quantify our final state?

Statistics is *required*—conference sessions proclaiming "Six Sigma without Statistics" notwithstanding—but it should and can be made more accessible, easier to learn, and safer.

About Paul Sheehy

Paul Sheehy is a technical training specialist at Minitab Inc. He earned bachelor's degrees in both industrial technology and mechanical engineering while employed at General Electric, but believes that his most valuable training came from learning and applying practical business statistics and continuous process improvement in a real-world environment. After becoming a Master Black Belt, he deployed the Six Sigma program at the GE Power Systems facility in Bangor, Maine, and taught Six Sigma methodology at both user and "Train the Trainer" levels at various GE locations. Before joining Minitab, Sheehy was a master consultant and trainer at the Six Sigma Academy, where he developed training material for Black Belt and Green Belt programs and trained Six Sigma Black Belts at companies such as Ford, Visteon, Johnson Controls, Tyco, Kerr McGee, and Lear. Sheehy has presented at multiple conferences and has delivered several luncheon keynotes at the American Society for Quality's Lean Six Sigma Conference. He was lead author of the Black Belt Memory Jogger.