Quality Engineering

ISSN: 0898-2112 (Print) 1532-4222 (Online) Journal homepage: http://www.tandfonline.com/loi/lqen20

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To cite this article: S. H. Steiner & R. J. MacKay (2015) Discussion of "Statistics: A Life Cycle View", Quality Engineering, 27:1, 126-127, DOI: 10.1080/08982112.2015.968056

To link to this article: http://dx.doi.org/10.1080/08982112.2015.968056

Quality Engineering, 27:126–127, 2015

ISSN: 0898-2112 print / 1532-4222 online
DOI: 10.1080/08982112.2015.968056

Discussion of "Statistics: A Life Cycle View"

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Professor Kenett (2015) provides us with a stimulating example of statistical engineering á la Hoerl and Snee (2010). His life cycle view (see figure 1) is a process for applying statistics to solve real problems. Within this process, he provides two important ideas related to measurement. Practical statistical efficiency is a measure of the impact of the application calculated at the last stage of the life cycle process. Information quality is a measure of effectiveness calculated as a function of several dimensions. We discuss these three ideas in order.

Kenett's life cycle view of statistics lays out a process for applying statistics (in a very general sense) starting with problem formulation ending with the assessment of impact. Some of the steps are connected by dotted lines. We presume that means that there is internal iteration within the process. Many statisticians might limit their involvement to the data collection and data analysis stages. We agree with Kenett that this is a bad mistake. A statistician can and should contribute at every one of the stages. Although catchy, we think that the life cycle process deserves a better name. We worry that the current name will be linked with the idea of a product life cycle defined as "Product life cycle is the cycle through which every product goes through from introduction to withdrawal or eventual demise" (http://economictimes.indiatimes.com/definition/Product-Life-Cycle).

We do not find "demise" to be appealing or descriptive of the process.

There are other attempts to set out a process for applying statistics in different contexts such as define–measure–analyze–improve–control (DMAIC) within Six Sigma (Breyfogle 1999) and our own statistical engineering algorithm (Steiner and MacKay 2005). Professor Kenett's process emphasizes the latter stages of the application with stages labeled "operationalization of findings" to "assessment of impact." Many of us would fail to consider these important stages. We note the following:

- Between goal formulation and data collection, the planning aspects of the application seem to be missing or at least are not shown explicitly. Planning deals with many aspects of the investigation: what to measure, when to measure, how to measure, . . ., apart from sample size calculations or details of an experimental design. A statistician can guide a project team on these issues and also help to avoid overly complicated studies that fail for lack of time, money, or attention to detail. Kenett's story of defects in molded parts (The Automobile Part Example section) provides a good example. We hope that no statistician would suggest a complex, invasive experimental study before investigating the process with simpler observational tools.

This article was presented at the Second Stu Hunter Research Conference in Tempe, Arizona, March 2014.

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- Many problems are best addressed with a series of studies within the overall project. For example, in a problem defined by excess variation, we strongly recommend separating the search for the causes(s) of the variation and the search for a solution. A single study will almost certainly fail. Each study must follow a process like the life cycle. Our favorite (not surprisingly) is QPDAC, an acronym for question, plan, data collection, analysis and conclusion (see Mackay and Oldford 2000; Steiner and MacKay 2005).

Statisticians are experts at applying empirical methods to learn about and improve processes. To improve a process, we need to measure inputs and outputs. Few would disagree with Lord Kelvin's famous statement

> When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind. It may be the beginning of knowledge but you have scarcely, in your thoughts, advanced to the state of science, whatever the matter may be (Kelvin 1889, pp. 80–81).

How can we improve the application of statistics if we cannot lay out the effort as a process and then define and measure inputs and outputs? Professor Kenett provides two such measures that allow for the assessment of impact and information quality. We applaud the idea of defining such measures. However, we find his first attempts to be overly simple and subjective and hence not particularly useful in improving the life cycle process. Although we have no idea how to refine these measures, we note the following:

- We need to assess impact on a monetary scale if we hope to convince management of the value we add.
- Because applying statistical methods and thinking is collaborative, it is difficult to separate the contribution of the statistician from other participants in the project. And making this separation may be a bad idea if we want to foster the collaboration.
- Due to subjectivity, the measures will be hard to compare across different projects.
- Because definitions of the elements are not well established or clear, different people scoring the same project will likely give very different values.
- There seems to be little value to numerically combining scores from the individual elements into a single summary score.
- As a first step, after each application of the life cycle, we should write answers to questions such as: What went wrong? What went well? Where in the life cycle did these occur? How could I do better next time? Could we have reached the end quicker, at less cost? How?

We again congratulate Professor Kenett on his stimulating paper.

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