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Bending Paper Clips to Demonstrate Natural and Assignable Cause Variation

Janice B. Eliasson and Peggy L. Hedges
Haskayne School of Business, University of Calgary, Canada

Abstract. Statistical Process Control (SPC) is a technique that is concerned with monitoring process stability. The authors have designed and tested a 20-minute hands-on activity that requires participants to bend paper clips until they break. This activity has been found to assist students in more easily understanding the difference between natural (also called normal, common, random, or chance) and assignable (or special) cause variation in SPC. The activity, although developed for use in a senior level Quality in Products and Services class, can easily be used at junior level Operations Management courses that include SPC calculations. This activity can be used prior to, or after, teaching control limits concepts.

Keywords: statistical process control; active learning; assignable or special cause variation; natural, normal or common cause variation; out-of-control process.

1. Introduction

Statistical Process Control (SPC), or the monitoring of process stability, is an important concept in Operations Management. Natural variation of a process or operation is centered around a mean and occurs with a consistent amount of variation (Foster and Gardner 2023). A stable process that exhibits natural (not assignable) cause variation is considered to be in control. With educated analysis of the output characteristics of a given process, it is possible to compare the current performance with its expected performance (using SPC control charts) to determine if the process is in control or not.

Without the application of SPC in the transformation process, organizations are unable to measure the current quality of the services or goods they produce. They are not able to detect whether the process had changed, including going out-of-control and producing defective products due to an assignable cause.

Further, understanding the technical difference between natural variation and assignable cause variation can directly impact process control decisions resulting in a Type 1 error (trying to correct a problem that does not exist) or a Type 2 error (not correcting a problem that does exist). Misidentifying the type of variation when relaying information to management can also be

problematic. For example, if the variation is due to randomness, and not an assignable cause, then action might be taken to correct a problem that does not exist. Failing to correct a problem that exists due to assignable cause can result in significant resource waste and quality issues, including rework and scrap of defective product. In either instance, the waste of materials and other valuable resources is unacceptable for companies wanting to demonstrate continuous improvement in profitability and ESG (Environmental, Societal, Governance) practices.

This article describes a 20-minute in-class activity that provides students with an easily recalled example that they can use to relate the concept of natural versus assignable cause variation in SPC. Institutionally, this activity meets several important requirements. It requires no additional classroom space, it can be scaled to small or large class sizes, it is suitable for longer and shorter class times (50 to 75 minutes), it is relatively inexpensive, it can be modified to reflect subject specific content, and it can be scaffolded to other quality concepts. The use of real data and hands-on experimentation can be especially beneficial for teaching SPC (Lindee and Roy 2020).

2. Literature Review

The concept of active and experiential learning is neither new nor well defined. Much of the current literature has evolved from what was published in the 1980s (e.g., Kolb 1984, Borzak 1981). Many authors have tried (e.g., Prince 2004, Bonwell and Eison 1991) to determine one universally consistent definition. Nevertheless, despite differing descriptions, many authors agree on the general concepts. For example, Borzak (1981, page 9) said experiential learning involves "direct encounter with the phenomena being studied rather than merely thinking about the encounter." Others, including Kotteman and Salimian (2008, page 247) have noted the importance of engaging students with information and examples they understand. They sum it up nicely when they state, "The challenge is to make the topic come alive, to make its relevancy consistently salient, and to inculcate students' personal investment in the materials covered."

By offering the opportunity to explore, discuss, debate, and criticize with their peers (Boud *et al.* 2001) students gain a deeper understanding of key concepts and are more likely to develop higher order intellectual skills (Bloom, 1953). Even for students who are somewhat disinterested in the topic, the use of activities and games can result in better student engagement and develop future subject matter interest, even if the related concepts have not been covered (e.g., Azriel, *et al.* 2005; Mehrotra 2007; Snider, *et al.* 2010).

Incorporating experiential learning into the Operations Management classroom is well documented. Lewis and Maylor (2007) reviewed over 200