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Process Variation: Demonstrating Responsibility

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Abstract

W. Edwards Deming preached that understanding variation is of paramount importance. He created the Red Bead Experiment (DRBE) to illustrate that variation is present in all processes and that ultimately, management, not the willing worker, is responsible for the variability that is inherent in a process. We modify DRBE to demonstrate these lessons to undergraduate management and accounting students. Our results indicate that DRBE is a successful way for these students to learn how variation applies to their respective studies.

Introduction

In order to provide a hands-on experience for managers attending his well-known management seminars, W. Edwards Deming (Walton, 1987) created his Red Bead Experiment (DRBE). Deming wanted managers to understand how variation occurred and to realize who was responsible for variations in the processes.

The purpose of this article is to provide an illustration of how DRBE can be utilized for quality management and cost accounting students, because most students lack real life experience or understanding of processes that DRBE captures. The next section contains background information on Deming and variation in processes and how these relate to quality management classes as well as a brief history of management accounting and the importance of knowledge gleaned from DRBE to cost accounting students. The section on the classroom demonstration explains how instructors can use the modified DRBE in their classrooms including the equipment needed and a monologue for the instructor. These sections are followed by our results, a discussion of the results, and a conclusion.

Background

Variability exists in everything that we do. Even performing a task repeatedly requires different amounts of time. Understanding this is particularly important to students learning about quality for processes that businesses employ to deliver goods and/or services to their customers. It is through these processes that businesses add value to the goods/services that their customers desire. In an era when the customer is always right, quality is of utmost importance and management students must be able to distinguish between the two types of variation that might disrupt quality. Common cause variation is the variation that occurs in processes due to countless minor factors and events that are happening as the process takes place. These factors are characteristics of the system or process and are inherent in them. The second type of variation is special or assignable cause variation. This occurs when something out of the ordinary happens during a process and is the responsibility of the process operator(s).

Common cause variation is also known as a floor solvable problem (Amsden, Butler, & Amsden, 1989). Thus when the process is not operating in a normal way, process operators should investigate and take corrective action to return the process to a normal

or stable state. If the process is operating in a normal fashion, the variability that is present is a result of the process. It is built into and an intrinsic component of the process. Since management is responsible for the process, it is responsible for the variation that is present in the process. This is known as a management solvable problem (Amsden et al., 1989). In today's business environment, addressing the two types of variation and correcting them is essential to managers' success.

Additionally, the accounting curriculum leaves little room for operations or quality control classes that are crucial to understanding the relationship between cost accounting reports and the underlying manufacturing/service processes they must reflect. Thus, accounting students graduate with little understanding that this knowledge would increase the utility of reports they prepare. Most organizations rely on some form of operational control in a continuous improvement environment (Perez, et al, 2008) and management accountants have an important role in promoting this goal.

The original designers of cost accounting were those who had intimate knowledge and hands on experience with organizational processes (Johnson, 1975). Slowly, however, accountants assumed narrower accounting roles and those in the main line of the business concentrated on processes with little interaction with accountants (Kaplan, 1989). This became especially evident in the 1980s when processes changed radically and accounting methods no longer reflected those processes in any meaningful way. The viability of cost accounting was questioned (Patell, 1987) and academics and practitioners in the field recognized that accountants needed to understand organizational processes better (Chenhall, 1998) if their accounting reports were to reflect processes accurately. Identifying and measuring quality costs (Yang, 2008) is a significant problem, and it is important for management accountants to recognize and respond to these needs of the organization.

Consequently, students in both quality management and cost accounting must understand organizational processes. However, there are different reasons for the two areas to address these issues. In quality management, managers need to reduce and control variability so that they can deliver products and services to their customers in a consistent, repeatable manner. Excessive amounts of variability can lead to unpredictability in both manufacturing and service processes. From a cost accounting perspective, students need to 1) determine who controls costs, 2) understand how a quality process operates and 3) recognize how to treat the result of variation. Determining who controls costs helps the management accountant prepare performance reports on items for which the manager is held responsible, which improves the reliability of the performance report. Certainly identifying and reducing variation from a quality management perspective as well as the cost accounting perspective of determining who controls costs rely on an understanding of the use of statistics in both fields of study.

W. Edwards Deming was a strong advocate in understanding variation and in distinguishing between the two major types of variation: special cause and common cause. He was also clear as to who is responsible for these two types of variation, their investigation and correction. Deming went on to state that willing workers were not typically to blame for the variation that is seen as they go about completing the tasks to which they have been assigned. Rather it is the system that is to blame for the observed

variability. However in practice, workers are often blamed for any variation, even if it is a result of the process and hence common cause variation (Deming, 1993; Evans & Lindsay, 2008). Thus, Deming devised the Red Bead Experiment (DRBE) so that this distinction between types of variation and their responsibility could be demonstrated in a very visible, hands-on way. He used it in management seminars (Walton, 1987) and its modified version was used in our quality management and cost accounting classes for the same reasons.

Classroom Demonstration of DRBE

In order to carry out the modified DRBE, the instructor needs a supply of red and blue beads in the ratio of 80:20, a container to hold them, and an implement to use to extract beads. Our demonstration was carried out in several sections during the past three years with 400 beads obtained at a bead shop, a wooden box, and a flat potato masher with holes that would catch approximately 25 beads. Note the beads must be sufficiently large so that they don't fall through the holes in the implement. To speed up the process we have the students count the blue beads and subtract them from 25 even though the implement might not always extract exactly 25 beads.

Each class was divided into an appropriate number of teams based on the class size. The following instructions were then read to the class.

1. I am the owner of a factory that produces red beads. That is what my customers want and that is what they will get. I have spent considerable time and resources designing and obtaining the equipment to implement this process to produce red beads. I want to hire a team that will work for me. I intend to pay you a good salary, with benefits and incentives, if you can produce red beads for me.
2. Your job is to produce red beads. Since you have selected the teams that you wish to be a part of, I will hire the team that performs the best for me.
3. Remember that your future depends upon getting this job. Don't let your teammates down. Don't let your family down. You have student loans to repay. Your car is ready for the junkyard. You need this job.
4. Here is all you need to do to start on a well paying career path.
 - a. From each team, I need one inspector and 2 willing workers (assuming a 3 person team).
 - b. The job of the inspector is to count the number of red beads and record the number. Remember that it is the red beads that we want.
 - c. For the workers, you must take the production tool and dip it into the box of beads. You will do this twice. The results will be recorded. If you do well enough you may be promoted or may be given a raise. If you do not do well, perhaps you will be fired. Remember that you need this job.
 - d. These steps will be repeated until every team has had a chance to prove that it knows how to do the work.
 - e. I, as the owner, will select the best team and hire it to work in my factory. The rest of you will be fired and will be serving hamburgers the rest of your life.
 - f. In the event of a tie, I will select the team that I like the best. After all, I am the owner and it is my company.

(Note that the instructions may change contingent on the situation or the particular element of variation management that is being emphasized.)

Throughout the work process, the instructor praises or chides the worker. This friendly "harassment" is meant to put some humor and a bit of competitiveness into the demonstration, but relates to the instructor's personality and how much the students will understand that this is a learning experience. A written or oral evaluation should follow the demonstration.

Results

Based upon samples collected in the three most recent sections of juniors and seniors process variation produced: 1) between 0 and 14.9 blue (defects) beads with an average of 7.9; 2) an average of 5.6 blue beads with an upper and lower bound 11.8 and 0, respectively; and 3) an average of 6.8 blue beads with an upper bound of 13.4 and a lower bound of 0.1 blue beads. From a theoretical perspective, since we know that the total number of beads contains 80% red beads and 20% blue beads, the average number of blue beads is 5 with upper and lower control limits of 11 and 0 respectively. It is apparent that the demonstration in the second class closely reflected the theoretical outcome.

Students enjoyed doing this and reacted more favorably to the instructor afterwards as indicated from significantly improved student evaluations for one cost accounting class (t-test: difference in means = 1.15, $p < .01$). They immediately recognized that the number of blue beads in the box meant that workers were not going to extract all red beads regularly. However, less than 10% of the students determined who was responsible for the observed variability and what should be done to prevent so much variation from occurring.

Discussion

The class then discussed what was observed. Why were so many blue (defects) beads produced? Usually, there was a wide level of variation among the participants. What was the reason for this variation? After all, everyone wanted this job – it paid well, had good benefits and was a great place to work. What could explain the differences? All the workers received excellent training as provided by the instructor. Certainly the results obtained by these workers are a result of their own individual efforts. The system, designed by experts, could not possibly be responsible for the production of all of these defects! Or could it be?

Typical student responses on variation included: get a better supplier that sends fewer blue beads, change the process so that you can select only red beads, hire better workers, foreman, or inspector, those workers need a union. Responses on the effectiveness of DRBE were as follows: best lesson so far, you tricked us, changed class atmosphere, different way to learn, use it in future classes, you're human, everyone was paying attention, it made us laugh while learning difficult concepts, not only reinforced variation types, but allowed everyone to participate, incorporated well into class material. But the best confirmation of the value of DRBE was: I work at a production plant and we have to deal with this 'real life' type of problem every day. We are always trying to boost production but there are always "wrong" beads.

In the quality management classes, the data collected from the DRBE was used to introduce the concept of statistical process control. This was accomplished through the use of control charts which provided a means by which common cause and special cause variation could be distinguished from one another. By creating an appropriate control chart (in this case a p-chart or proportion defective chart) students could clearly distinguish between variations that was common cause versus special cause. Upper and lower control limits, at a 3-sigma level, were calculated and the demarcation between the two types of variation was calculated. In other words, if the sample points lay within the upper and lower boundaries, the process was 'in statistical process control'

or simply 'in control'. This variation reflected common cause and was inherent to the process. If the degree of variability present was not acceptable, management must provide the resources necessary to change or improve the process (Evans & Lindsay, 2008). However, if the sample points lay outside these control points, assignable or special cause variation was present. These points must be investigated, by willing workers, to determine the special cause of the observed variation so that it can be corrected and eliminated.

In the cost accounting classes, a control chart has not been used. The basic concepts of responsibility accounting are clarified easily using DRBE. Responsibility accounting requires that responsibility center managers control costs in their region, division, or process over which they have authority. Once responsibility is fixed then the management accountant can use relevant financial data to prepare a report that reflects the manager's performance. However, fixing the responsibility is not always easy. Complex organizations may require additional methods to evaluate the performance of managers at several responsibility centers, especially when the centers are engaged in a group project (Rowe et al, 2008). Students realize that they must ask themselves, is this cost controllable by the buyer, the foreman, or a specific manager? The management accountant works with area participants to develop budgets for each center or process. Ideally, the final performance report will help in the evaluation of the manager who can be identified as having primary responsibility for making cost decisions in a specified area (Horngren et al, 2008).

Discussion of DRBE is revisited in process costing. DRBE enhances understanding among accounting students to the notions of normal and abnormal spoilage. Normal spoilage, the result of common cause variation, increases the cost of the product or service and is treated as an addition to the cost of the product or service produced. Abnormal spoilage, the result of assignable cause variation, must be separated and included as a loss due to a rare occurrence, which does not increase the cost of the product or service, but reduces income. This difference is essential to evaluating costs and in preparing the Cost of Production reports for process costing.

And finally DRBE's use of statistics to evaluate costs leads to analyzing cost behavior where additional mathematical modeling of costs such as regression and exponential curves highlight that not all costs may be treated the same.

Lessons Learned

In order to assess student comprehension of this material a variety of questions (multiple choice and essay) were posed on examinations in addition to classroom discussion. The results range from a low of 77.8% to 100% of students correctly responding. Based upon these results students appear to be grasping the understanding of variation and who is responsible for the correction of the two types of variation.

Conclusion

Discussing variation by using an example such as driving times does not have the impact on student learning, comprehension, and retention that DRBE does. The use of hands-on demonstrations to illustrate and emphasize concepts contained within business and accounting information is important (Fish, 2007; Heineke & Meile, 1995). Based on the results of a modified version of DRBE, students were introduced to the

concept of variation, different types of variation, how to distinguish between the two different types of variation inherent in processes and who is responsible for the investigation and correction of variation. From a cost accounting perspective, students are better able to determine responsibility and distinguish between the two types of spoilage as well as develop an understanding of quality control. DRBE awakens students to the realization that understanding quality management is essential to their future careers. Perhaps as important is the change in some students' attitudes toward class and the instructor.

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