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LESSON: Deming's Funnel Experiment

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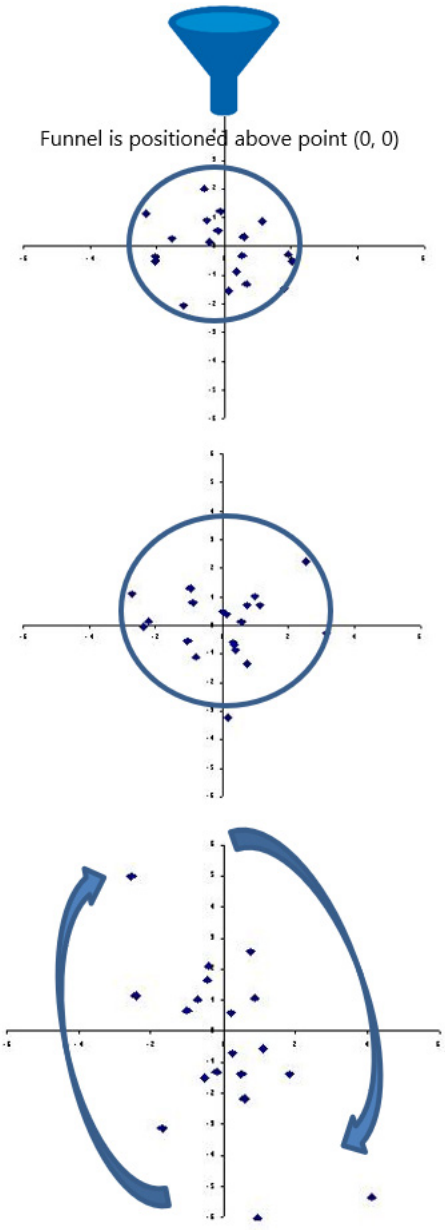
The **funnel experiment** is a mechanical representation of many **real-world processes** where we work.

- **Goal**: Demonstrate the **losses** caused by **tampering** with processes.
- **Source of tampering**: Management by results - **reacting** to every **individual result**.

In the experiment, a **marble** is dropped through a **funnel** onto a sheet of paper with a target.

- **Object**: Get the marble to come to a **stop** as close to the **target** as possible.
- **Several methods** are used on the funnel in an attempt to minimize the spread between the marble and target. These methods are referred to as "**rules**."



Rule 1:

- The funnel is aligned above the target at (0, 0) and marbles are dropped.
- **The funnel is not moved** to improve performance.
- The results of Rule 1 seem to be disappointing.
- The marble does not appear to behave consistently.
- The marble rolls off in various directions for various distances.
- There must be a better way to position the funnel to improve the pattern?!

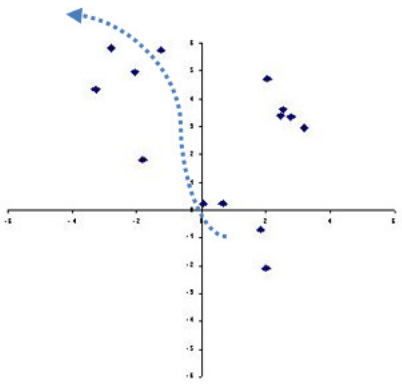
Recall – we are trying to **minimize the spread** between the location of the dropped marble and the target (at the center).

Rule 2:

- The funnel begins aligned above the target, and one marble is dropped.
- The location of that marble is examined, and the funnel is moved in the opposite direction to **"counteract" the motion** of the marble.
- This rule **corrects** for the **error** of the previous drop: If the marble rolled 2 inches northeast, we position the funnel 2 inches to the southwest of its **last position**.
- **Practical Example 1**: A worker wants to make items of uniform weight. If the last item was 2 pounds underweight, the worker increases the setting for the next item to gain 2 pounds.
- **Practical Example 2**: Changing policies and production levels based upon on last month's common cause budget variances, profit margins, and output.

Rule 3:

- A possible flaw in Rule 2 was that it adjusted the funnel from its **last position**, rather than **relative to the target**.
- If the marble rolled 2 inches northeast last time, we should set the funnel 2 inches southwest of the **target**.
- In Rule 3, the funnel is set at an **equal and opposite direction** from the **target** to compensate for the last error.
- **Practical Example 1**: Systems in which 2 parties react to each other's actions.
- **Practical Example 2**: A drought occurs one year causing a drop in crop output. Prices rise, causing farmers to plant more crop next year. In the next year, there are surpluses, causing the price to drop.



Rule 4:

- The funnel begins aligned above the target, and one marble is dropped.
- We **position** the funnel **over the last location** of the marble, where the marble just stopped.
- We drop the next marble from that last location and continue with this pattern.
- **Practical Example 1**: A common example of Rule 4 is when we want to cut lumber to a uniform length. We use the piece we just cut in order to measure the location of the next cut.
- **Practical Example 2**: The "telephone" game.
- **Practical Example 3**: The junior worker trains the next new worker, who then trains the next, and so forth.

Tampering:

- Rules 2, 3, and 4 are all examples of **process "tampering."** We take action as a result of the most recent **common or random cause** result.
  - Rule 2 leads to a **uniform circular pattern**, whose size is **40% bigger than the Rule 1 circle**. This is because the **error in distance** from the funnel is **independent** from one marble drop to the next. In positioning the funnel relative to the previous marble drop, we add the error from the first drop (by repositioning the funnel) to the second drop (the error in the marble).
  - The **standard deviation** of **adding n** identically distributed and independent **random variables** is the square root of n times the standard deviation of the individual. So the combined standard deviation is sqrt(2) = 1.41 times the original standard deviation.

Solution to Rule 2 problems: The problems of Rule 2 are corrected with "dead bands" in automated feedback mechanisms and better calibration programs. We **wait for a certain error to build up before taking action**. But how is the dead band determined? A control chart provides the answer. Plot the results on a control chart and **recalibrate (or give a feedback signal) when a statistically significant change is detected**.

- Rules 3 and 4 tend to "blow up."
  - In Rule 3, results swing **back and forth** with greater and greater oscillations from the target.
  - In Rule 4, the funnel follows a **drunken walk off** the edge of the table.
  - In both cases, **errors accumulate from one "correction" to the next**, and the marble heads off to infinity.
  - Rules 3 and 4 represent **unstable systems**, with over-corrections tending to occur.

Conclusion:

- Schemes to control the location of the funnel should be **control chart based**.
- Also think "outside of the box" to make improvements:
  - If we lowered the height of the funnel, we would fundamentally reduce the variation

in the process.

- If we added cloth to cushion the marble's landing, then the marble would roll less.
- The impact of these changes would be detected by the control chart and show whether an improvement did occur.

Reference for additional information on Deming and his funnel experiment:
The New Economics for Industry, Government, Education, W. Edwards Deming, Chapter 9.