

Continuous Improvement – How to Learn and Improve From Your Mistakes

As businesses grow and evolve, they learn from their shortcomings and work to continually improve their performance. This process of continuous improvement is why products continue to improve in performance, quality and features and often can do so at a reduced price.

FIRST Robotics teams can also benefit from continuous improvement processes by formally evaluating past performances and identifying ways to make improvements.

Continuous improvement comes from taking a good look at results and identifying what has been done well, and what can be improved on. The goal is to learn from past mistakes, and avoid repeating them in the future. An effective continuous improvement program can help you avoid the need to say “That always happens” or “We always end up like that”.

One method of a Continuous Improvement process is called Root Cause and Corrective Action or “RCCA”. In an RCCA process, the undesired result, or outcome, is examined to identify all of the contributing factors to the specific result obtained. These contributing factors are then further investigated to identify ‘root causes’. Actions are then put in place to eliminate the undesirable root causes.

An effective way to begin an RCCA process is to get a team together and brainstorm ideas regarding the undesired results. One structured brainstorming process that is widely used is ‘Ishikawa’ diagramming. (The diagram concept was developed by Kauro Ishikawa in 1943, while he was at Tokyo University.) When complete, these diagrams resemble fish bones, and they are often referred to as fishbone diagrams.

The initial fishbone diagram looks like this:

The process:

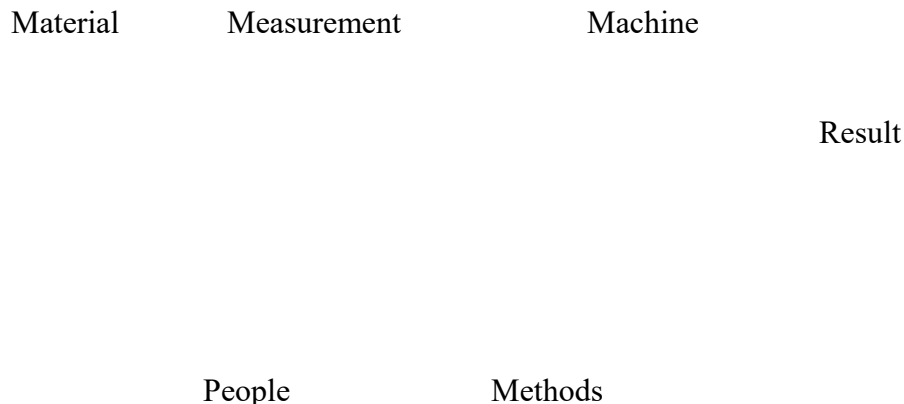
There are six basic steps to follow:

1. Agree on the 'undesired result' to be evaluated and draw the fishbone diagram.
2. Identify the main legs of the fishbone.
3. Brainstorm ideas that could cause the undesired result and list them by what leg they apply to.
4. Review and identify the most important factors or groups.
5. Identify specific actions and action plans to address the main factors.
6. Complete the actions and see the benefits of your work.

1) The fish head (A), is where the undesired result is listed. For a FIRST team, this could be poor performance in a match, a robot function that did not work properly, or a team activity that did not go well.

2) After the undesired result (A) is listed, each of the main legs of the diagram are labeled. These legs (B) are to identify major categories of issues that may be contributors to the undesired outcome. In many manufacturing processes, these legs are Material, Measurement, Machine, People, Methods (Processes), Timing, Resources and Communication.

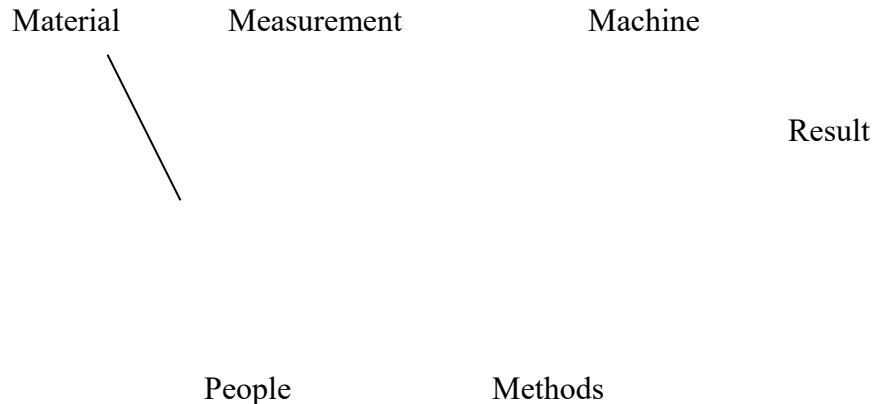
After adding these main legs (B), the diagram now looks like this:



3) Next, the team will brainstorm ideas that could have had an affect that caused the undesired outcome. These ideas are grouped in the major categories and written as smaller 'bones' on the main legs. Often, one idea might be listed on more than one leg. The team continues to brainstorm ideas until nothing new is being thought of.

Note: it is very important to have open, candid discussions during this phase. Participants must be sensitive to others, but at the same time open to constructive criticisms about past performances.

After adding more ideas, the diagram now looks like this: (imagine that each line is an idea on that leg).



4) The next step in the process is to do a quick review and identify items that appear to have the most significant impact on the undesired outcome. Action plans will need to be generated for these items.

5) This step is to identify specific actions and action plans that will eliminate the identified issue and then improve the team performance. (Simply identifying issues and determining a root cause will not make performance any better the next time. The path to continuous improvement is to create and implement action plans.) Actions must:

- a. Be Specific – clearly describe what must be done
- b. Be Assigned - assigned to a specific person when possible. One accountable person is much better than assigning an action to an entire group or team
- c. Have a due date – so the person knows when to be complete
- d. Be measurable – so that it is clear when the action is complete
- e. Be tracked – so that status and any problems can be identified.

6) The next step is probably the most challenging – and that is the completion of the action items. All of the effort is essentially wasted if the identified action items are not pursued.

It is a good idea to complete a “ranking” process to determine which actions should be completed first. Usually, there will not be enough time or resources to complete every action, so a ranking process can help set priorities of what actions to do first.

An easy method is to classify each action in one block of a four block diagram.

The Y (vertical) axis is “impact”, or how big of an influence completing the action could be for correcting the undesired results. Low impact items are low on the scale, high impact items are high on the scale.

The X (horizontal) axis is “cost”. The cost could be in dollars, or time, or weight. Low cost items are to the left, higher cost items are to the right. (The scales do not need specific values assigned – relative impact and relative cost is fine.)

Items in the #1 box would be the first to get worked. A team might then choose some #2 and some #3 items to work – this would give a mix of high cost but high impact items with some low cost and low impact items. Normally, the items in box 4 would not be worked on until everything else was finished – or they might never be worked since they are high cost and low impact.

This diagram looks like this:

The six basic steps that were followed:

1. Draw the fishbone and agree on the ‘undesired result’.
2. Identify the main legs of the fishbone.
3. Brainstorm ideas that could cause the undesired result and list them by what leg they apply to.
4. Review and identify the most important factors or groups.
5. Identify specific actions and action plans to address the main factors. Action items should:
 - a. Be Specific
 - b. Be Assigned to a specific person
 - c. Have a due date
 - d. Be Measurable
 - e. Be Tracked
6. Complete the actions and see the benefits of your work.
 - a. Actions can be prioritized so that the most important ones are worked first.

An example follows.

Example:

We will use an example from FIRST Robotics.

Let's assume that team 9999 had a good season, but their robot had a few problems during competition. One of their problems was that electrical connectors came loose in about ¼ of their matches. Sometimes it was not a big problem and they were able to play well, but other times it made them lose their matches. The team would like to understand all of the potential factors that could cause their “undesired result” (loose electrical connectors) and find a way to perform better next season.

1. Sketch the fishbone diagram and identify the undesired result of “Electrical Connectors Loose”.

Electrical
Connectors
Loose

2. Identify the main leg of the fishbone. We will use the five common legs.

Material

Measurement

Machine

Connectors

People

Methods

3. The team will brainstorm ideas and list them on the correct leg.

Material	Measurement	Machine	
Wrong wire	wires too short	Wire crimpers bad	
Wrong connectors		No protection on robot	Connectors
No one trained on wiring		No process to select connectors	

People

Methods

4 & 5. The team will now list each of the items and try to create action items to address the identified issues.

Main Factors:

1. Wrong wire was used
2. Wrong connectors were used
3. Wires were too short
4. Wire crimpers were bad
5. There was no protection on the robot
6. No one was trained on how to do wiring
7. There was no process to select the right connector

Actions:

1. We will make a chart of wire sizes and the correct connectors.
2. We will give each wire at least a 1" slack when installing.
3. We will have two people trained in the correct process to crimp wires.
4. We will buy a nice set of crimpers.
5. We will recruit an electronics person to teach us to wire correctly.

The team would then assign each of these to a specific person or small team, define a due date, determine how they will know when the action is complete and request regular status reports on longer term actions.

Actions might be ranked by priority so the most important items are worked first.

6. Complete the actions.

To be effective long term, the action and effects need to be tracked. For this team, they would monitor how the robot competed during the next season. If the team had implemented all 5 actions, and then had no loose connectors during their next season, they could assume they had found the root cause and corrected it. They could then move on to a new issue and work to eliminate the root cause of it.

If, however, the team continued to have problems with connectors the next season, they would need to recheck their work and determine what they had missed and continue their efforts to find the true root cause.

Summary

Continuous Improvement activities can help a FIRST team improve their performance each year. This performance improvement might be on the competition field, in recruiting and maintaining sponsors, in community service or many other areas. Root Cause and Corrective Action analysis, through fishbone diagramming, is a straightforward process that teams can use to help identify areas for improvement.

Through identification of areas for improvement, and then creation of specific actions and action plans, teams can continue to raise their level of performance from season to season.

Since these principles are widely used in industry, students that learn and use the basics of Continuous Improvement will have an advantage as they move through engineering studies and into the workforce.