Amp It Up! Engineering/Technology and Industry Lesson Extension

Teacher Name(s), School and District:
Mary Ham, Ipswich High School, Ipswich MA

Course Name: AP Chemistry

Lesson/Unit Name: Problem Solving Using the DMAIC (Define, Measure, Analyze, Improve, Control) Process

Science or Education Topic(s): Problem solving using critical thinking

Engineering Technology Industry Related Field/Activity: Process design, quality control & teamwork

When Taught: May 2017

Abstract: In 200 words or less, please provide a summary of your objectives, implementation, and the results of your implementation.

After visiting Medtronic, I incorporated a **DMAIC** process activity geared towards implementing an industry procedure for problem solving. Problems are identified and manufacturing processes are improved through teamwork. Students worked on the "Snowflake Manufacturing" activity to see which group could produce the most saleable snowflakes for the highest price and make the largest profit. Students go through several iterations, brainstorming modifications to their process each time. The process should include **D**efining or identifying the problem, **M**easuring or assessing the current situation, **A**nalyzing the root cause of the problem, **I**mproving the process and taking action to optimize output and **C**ontrolling the output by demonstrating improvement. Each group member should be involved in the feedback and all ideas should be discussed. Through this activity students learned to approach a problem methodically and that it may take several changes in order to optimize their time and achieve maximum efficiency.

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Objectives and assessment: Using the table below, identify at least 3-5 learning objectives (content and/or pedagogical) and describe how each will be assessed.

Objectives *By the end of this lesson/unit, the students will be able to:*	**Assessment** *How was the objective assessed? List the example of formative or summative assessment.*
1. Define the problem	Objectives 1 through 4 will be assessed with formative assessment. Each group will discuss and report their financial status at the end of each round. They will also make an improvement plan and try to demonstrate gains after each round. Records should be kept to document each round.
2. Assess the current status of the process	
3. Analyze the problem to find the root cause	
4. Improve the process by experimentation and evaluation	
5. Demonstrate improvement	At the end of the final round, students will report their overall financial status and provide evidence of procedural changes related to cost, reliability and remaining limitations. A pass/fail grade for completion will be assigned.

Engineering/Technology Link: Please check the appropriate box(es) in question 1. And provide a brief answer to question 2.:

1. How did you *introduce* engineering/ technology concepts or the company/industry focus in your course? Check the appropriate box(es) or choose Other.

   - ☐ Defined terms (science, engineering, technology)
   - ☐ Described the engineering design process
   - ☐ Engineering design challenge related to industry
   - X Overview of the company
   - X Challenge based on 'industry specific' area of focus (manufacturing process, quality control, measurement, development, teamwork etc.)
   - ☐ Other: _____

2. After introducing the concepts, what did/will the students do to explore and apply the engineering/technology and industry specific concepts? (include information about the actual activity students did, discussions they had, or instructional strategies you used)

Students will conduct the "Snowflake Manufacturing" activity. See attached for full plan.

Level of Inquiry: Which of the following best describes the level of inquiry (adapted from Bell 2005) you used for this lesson/unit? Check the appropriate level.

□ *Structured inquiry*: Instructor provides question and procedure. Students determine the results based on given procedures.

X *Guided inquiry*: Instructor provides question. Students design procedure and determine the results.

□ *Open inquiry*: Students investigate their own research question. Students design procedures and implement the procedure on their own.

Lesson Extension Plan:

Title/Topic: Applying the DMAIC process using the Snowflake Manufacturing activity
Time (minutes): 70 minutes
Company Name and brief Description: Medtronic is a medical devices manufacturing company which produces various types of catheters and implantable devices for medical procedures including cardiac, respiratory, neural and other applications.
Overview of the Lesson: This **DMAIC** process activity is geared towards implementing an industry procedure for problem solving. Problems are identified and manufacturing processes are improved through teamwork. Students worked on the "Snowflake Manufacturing" activity to see which group could produce the most saleable snowflakes for the highest price and make the largest profit. Students go through several iterations, brainstorming modifications to their process each time. The process should include **D**efining or identifying the problem, **M**easuring or assessing the current situation, **A**nalyzing the root cause of the problem, **I**mproving the process and taking action to optimize output and **C**ontrolling the output by demonstrating improvement. Each group member should be involved in the feedback and all ideas should be discussed.

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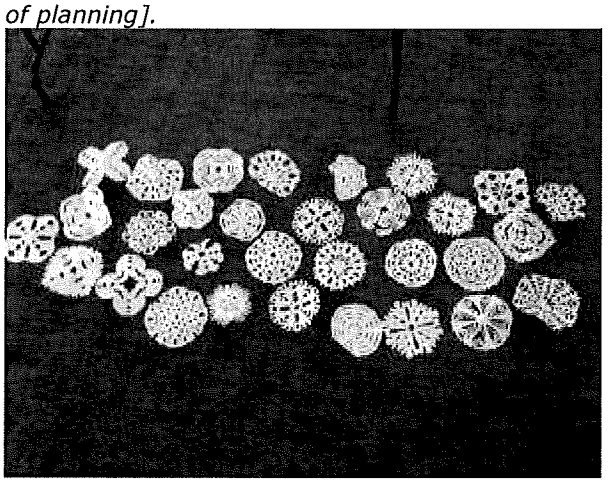
Standard(s)/Unit Goal(s) to be addressed in this lesson: **HS-ETS1-2** **HS-ETS1-3** **HS-ETS1-6** **HS-ETS2-1**
Essential Question(s) addressed in this lesson: How can the DMAIC process be used for problem solving?
Objectives : By the end of the lesson students will be able to: 1. Define the problem 2.Assess the current status of the process 3.Analyze the problem to find the root cause 4.Improve the process by experimentation and evaluation 5.Demonstrate improvement
Link to Industry: Applying the DMAIC process used to assess and refine manufacturing processes
What students should know and be able to do before starting this lesson
Instructional Materials/Resources/Tools See attached
Lesson Delivery
Lesson Opening: Introduce Medtronic and the DMAIC process
During the Lesson (activities/labs/challenges): See attached Snowflake Manufacturing activity
Lesson Closing: Collect feedback from students based on the activity and its effectiveness in providing a framework for problem solving.
Assessment
Student Assessment: At the end of the final round, students will report their overall financial status and provide evidence of procedural changes related to cost, reliability and remaining limitations. A pass/fail grade for completion will be assigned.
Delivery Assessment:

Additional resources and assessments: List the attachments here.
Attachments should include handouts, readings (with references), lab write-ups, rubrics, exams/quizzes, and/or other similar materials.

Introduction to Medtronic powerpoint
Snowflake Manufacturing Activity document
DMAIC process template

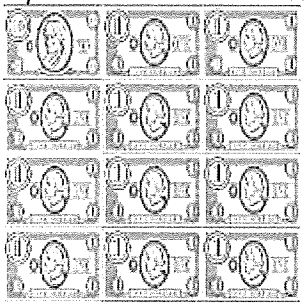
***Timing**: 70 minutes (can be extended to 90 minutes by running more iterations). Setup/explanation takes 10 minutes; we'll run 4-5 iterations of [3-minutes of execution, 3-4 minutes debrief, and 3 minutes of planning].*



snowflakes

Materials:

Pretend money (unit bills [euro/dollar], approx 100 units); ream of paper; 2 pairs of scissors for every 4 participants; audible timer; markers and flipchart for each table or dry erase board; optional gum or tape to attach snowflakes to the wall



Room needs tables that seat 4-8 people; for each table set up 1 pair of scissors, $5, and 5 blank sheets of paper. In a prominent location, add a label that says "Paper: 2 for $1; Scissors: $3". Set up a big visible chart for each team either on dry erase or flip chart; set up these column headers:
Iteration, Cash on hand; WIP; Scissors Count; Sales Qty; Paper on hand

Instructions:

Start a 3-minute timer countdown and say: "Your objective is to run a profitable business by creating and selling paper snowflakes. I'll demonstrate making one for you right now to prove it can be done in under 3 minutes.
First we fold a triangle, then fold that in half and in half again to ensure we have at least 3 axes.
We give the triangles a rounded edge as so; then cut out shapes along the folds, and unfold it to produce a snowflake like this. You'll have a limited amount of time to cut–since we're not really here to make snowflakes–we're here to experiment with running a business.
After a 3-minute iteration, we'll do a de-brief, then you can have 3 minutes to coordinate with your team (sprint planning) followed by the next iteration. If you run out of supplies, you can buy them at any time from the front of the room here. Paper is 2 for $1; Scissors are $3. Your table can self-organize around how to build the snowflakes. Any questions?"
If they ask anything about acceptance criteria, say we can discuss when they come to sell you a snowflake.

Assistant/Customer Instructions (SPOILER–do not share this with audience):

Minimum acceptance criteria: snowflake must have a general sense of being round, it must have 3 axes of symmetry, and must have even, precise cuts. Torn paper, squares/rectangles, lots of overcuts on the snowflake, paper that the audience supplied–will all be rejected. Every time a snowflake is presented to you, give simple and direct feedback, e.g., I can't buy this because these edges are torn–the quality isn't high enough; this one doesn't say "round" to me, can't buy it; this is beautiful–I'll give you $1 for it! Don't haggle, just move on to the next vendor.

***Valuation of snowflakes**:*
Intricate, unique, symmetrical, beautiful snowflakes will be bought for $1-$5. In the first round, I never see anything worth more than $1. I rarely pay as much as $3. Encourage innovation by telling people "this is the first time I've seen a signed snowflake! $2!" or some such comment. Encourage intricacy– "wow–lots of space cut out, I like that".
Size matters–small snowflakes often can be purchased only two for a dollar unless they're particularly ornate.
As you buy snowflakes, either attach them to the wall or arrange them on the table in order of low value to high value. We're not stating it in an obvious way, but hint at the valuation scheme every once in a while by hovering a new snowflake over the spectrum and say that this one "fits right about here, ok, $2".
Debrief Instructions:
Observe what the teams are doing, and help them think like a lean startup. Give only one hint per debrief, then let them try it out for the next sprint. Some teams ignore what you say; that's fine. Hints are like the following:
Do you have to cut out a snowflake to get customer feedback?
Is your team making a profit?
Do you know what the customer wants?
Have you followed the customer around a bit to see what he wants to buy?
What happens when you make clone snowflakes?
Do you have to use the whole sheet of paper?

Learning Points:
- *customer discovery is a whole team activity (product owners can give developers a false sense of security)*
- *you've got to get out of the building (or in this case, away from the table) to find out what customers are willing to pay for*
- *delivery pressure with creative work makes people forget the big picture*
- *business & learning communities work better when we collaborate and share with more people (tables don't have to remain isolated islands)*
- *waste comes from the assumption that we've got to use the whole sheet, and that volume is more important than customer discovery*
- *we don't have to make anything at all to learn the acceptance criteria: simply go up to the facilitator and ask– what are you looking for? Response: beauty, symmetry, intricacy, round shape.*
- *a good customers' time is limited and precious–use it wisely*

Modified from: http://tastycupcakes.org/2012/05/lean-startup-snowflakes/

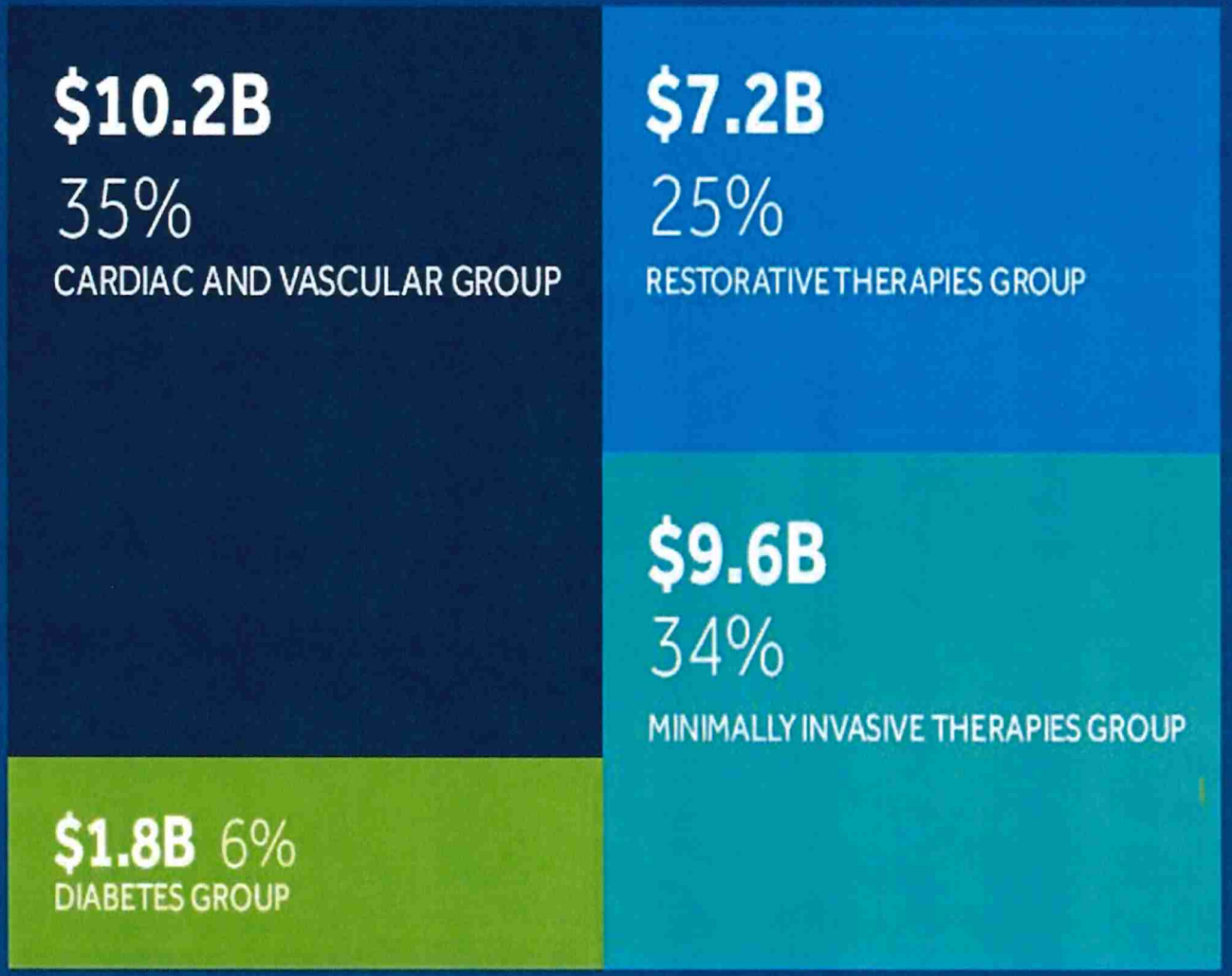
Medtronic

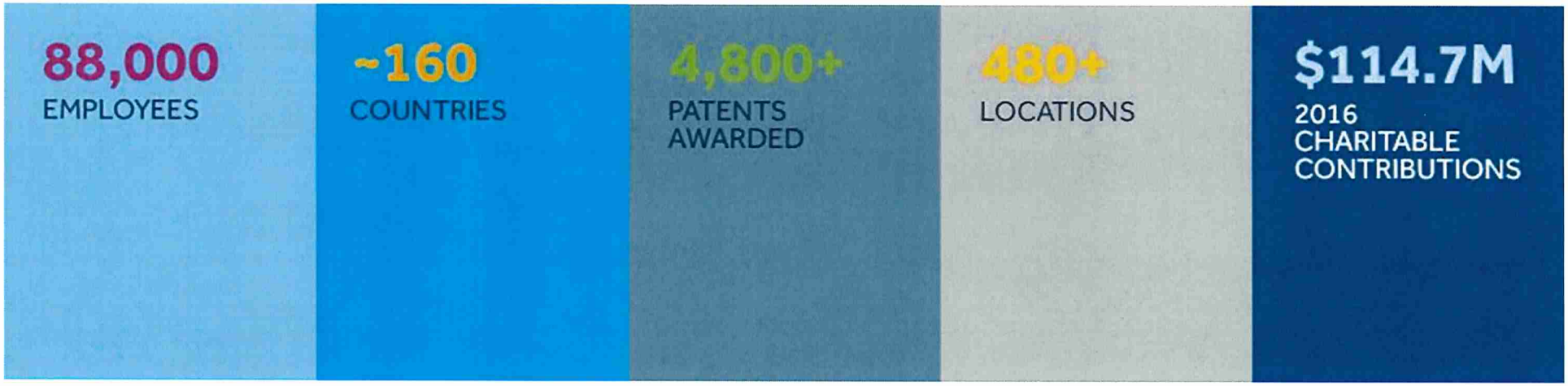
Mission Statement

- *To contribute to human welfare by application of biomedical engineering in the research, design, manufacture, and sale of instruments or appliances that alleviate pain, restore health, and extend life.*

BUSINESS REVENUE MIX

(information reflects FY2016 data)




88,000
EMPLOYEES
~160
COUNTRIES
4,800+
PATENTS AWARDED
480+
LOCATIONS
$114.7M
2016 CHARITABLE CONTRIBUTIONS

HEART & VASCULAR

- Balloon Angioplasty, Stenting, and Beating Heart Bypass Surgery for Coronary Artery Disease (CAD)
- Balloon Angioplasty (PAD)
- Cardiac Mapping for Cardiac Arrhythmia
- Catheter Ablation
- Cardiac Resynchronization Therapy (CRT) Devices for Heart Failure
- Implantable Cardioverter Defibrillator (ICD) Devices for Sudden Cardiac Arrest
- Endovascular Repair With a Stent Graft: Abdominal Aortic Aneurysm (AAA)
- Heart Valve Surgery for Heart Valve Disease
- Insertable Cardiac Monitors for Fainting (Unexplained)
- Minimally Invasive Endovascular Repair with Stent Graft (TAA)
- Pacemakers
- Transcatheter Pulmonary Valve (TPV) Therapy: Pulmonary Valve Disease

BRAIN

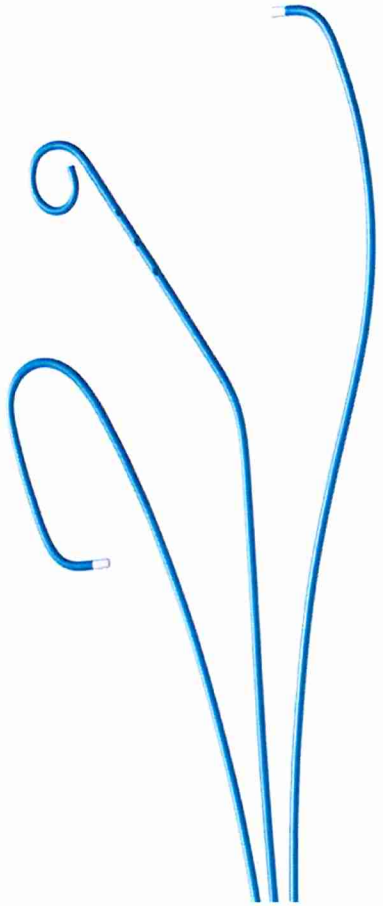
- Deep Brain Stimulation for Dystonia
- Deep Brain Stimulation for Essential Tremor
- Deep Brain Stimulation for Obsessive-Compulsive Disorder
- Shunt for Hydrocephalus
- Deep Brain Stimulation for Parkinson's Disease

SPINE & ORTHOPAEDIC

- Cervical Disc Replacement
- Cervical Fusion
- Bone Graft
- Balloon Kyphoplasty for Spinal Fractures
- Spinal Fusion for Scoliosis Surgery
- Spinal Cord Stimulation for Chronic Pain

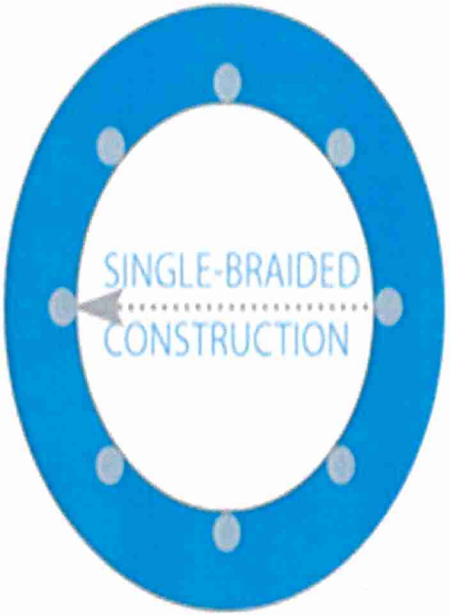
Pro-Flo Catheter

- Coronary catheterization is a minimally invasive procedure to access the coronary circulation using a catheter. The angiographic catheter is a plastic tube which functions as a conduit for contrast, fluids, and pressure measurement during cardiac catheterization of coronary arteries and the left ventricle



FEATURES

Pro-Flo angiographic catheters include:



Pro-Flo single-braided construction

- High strength polyurethane core and stainless steel single-wire braiding
- Braiding extends close to the tip, enhancing responsiveness
- Tip gradually tapers, decreasing chance of damage to delicate tissue
- Atraumatic soft tip available for ostial engagement
- Unique polymer blend gives Pro-Flo XT increased stiffness for navigating difficult anatomy

Title: Catapult Exercise for LSDPS	Version: 2	Owner: Process Solutions	Date: 5/8/2013

DEFINE: Background

Background:
Customer has requested that we develop and deliver a catapult that is preconfigured to hit 2 targets (20 in and 35 in).

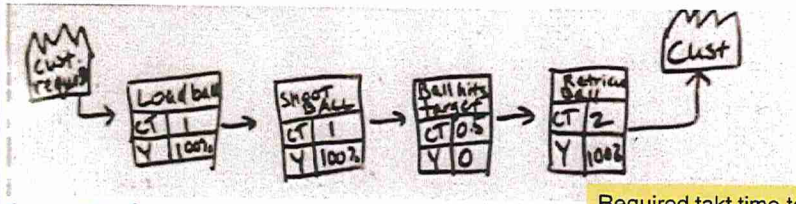
Problem Statement:
The catapult is unable to hit the target and we are unable to meet customer demand.

Goal:
Improve the number of balls that hit the target from 0% to 100% by 3:50 pm today.

Do no harm: Leadtime to hit the targets must be less than 18 seconds.

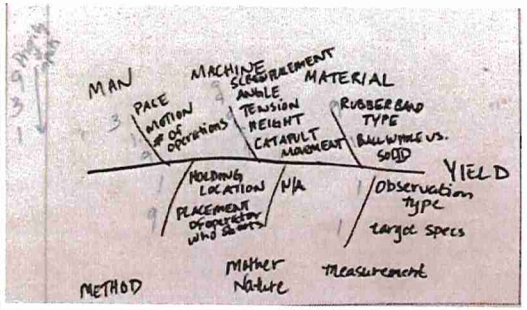
MEASURE: Current Situation

Process Thinking:



Current Performance:
LT = 4.5 sec / ball
Time to shoot 10 balls = 45 sec
Yield = 0%

Required takt time to shoot 1 ball needs to be 18 sec / 10 balls = 1.8 sec/ball



Likely Suspects (may include):
- Pullback angle
- Launch sequence
- Work Method
- Catapult settings
- Stability of catapult
- Rubber Band type

Make sure that items in orange are identified and carried over to analyze

ANALYZE: Find Root Cause

Key Inputs:
- X1 - Catapult settings
- X2 - Rubber Band
- X3 - Pullback Angle
- X4 - Launch Sequence
- X5 - Work Method / operators
- X6 - Stability of Catapult

Trial with new settings:

	Trial 1		Trial 2		Trial 3	
Adjustment	Holes	No Holes	Holes	No Holes	Holes	No Holes
X2 - Rubberband Size	Large	Large	X-Large	X-Large		
X3 - Pullback Angle	180°	120°	125°	145°	105°	170°
X1 - Hinge Point	4	4	3	3		
X1 - Stop Position	3	3	4	4		

Green = hit, Red = miss

	No Holes	Holes	Comments
X4 - Balls in "Batch"	3/5	1/1	Unable to get yield and meet takt
X4 - Alternate Balls	4/5	4/4	Unable to get yield and meet takt
X5- Alternate Balls and adjusted work method	5/5	5/6	Able to get needed hits and meet takt

IMPROVE: Optimize &Take Action

X	Countermeasure	Experiment	Result
X6	Tape down catapult		Increase accuracy
X4	Alternate launch sequence	Alternate ball launch (holes, no holes, holes)	Improve Speed
X5	Additional operator at launch	Additional operator puts ball in cup for the launcher	Improve Speed
X5	Audible cue from launcher	Launcher signals the release	Increase accuracy
X5	Audible cue for "hit"	Cut tin foil down to target size - improve ability to tell normal from abnormal	Increase accuracy
X3	Hard Stop for Pullback Angle	Pullback 100% for far target. Pullback to masking tape for short target	Increase accuracy

CONTROL: Demonstrate Improvement & Sustainability

Demonstrated Improvement:
Improved Yield = 100%
Time = 17 seconds
Happy customer!

	No Holes	Holes
Run 1	5/6	5/5
Run 2	5/5	5/5
Run 3	6/6	5/5

Sustainability:
- Mark pullback angle with tape
- Audible cues
- Daily rubber band check
- Screw catapult to floor
- Document standard work with pictures