BROWNCOATS
Team 7842 Engineering Notebook

Date	Location	Start Time	End Time	Week #
Off-Season	AvaLAN Wireless	2:00 p.m.	6:00 p.m.	0

Meeting Goals: Learning to use the new go-BILDA kit, CAD class, Engineering Process Team Discussion

Learning To Use The New goBILDA Kit - David, Jaxon, Joel, Nathan

Over the summer, the team made the decision that rather than building an almost entirely custom robot during the 2020-21 season, we would go back to using a building system. This decision was primarily fueled by the fact that the team expert in the use of the CAD software, Ian, had graduated out of the team last spring and was unavailable to do a lot of shoulder-to-shoulder mentoring due to the ongoing COVID-19 pandemic.

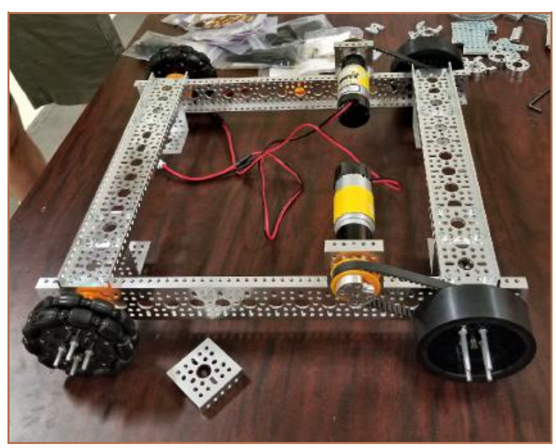
In past seasons, the team had used both the Tetrix and Rev building systems with great success; however, most of the parts from those older systems were pretty well worn out or bent up. After some on-line research, it was found that the goBILDA system was getting substantial continuous support (that is, new parts were being frequently added) and it was metric, which would work better with some of the team's existing belt drive hardware. On top of that, the goBILDA parts were found to be very sturdy and robust, addressing one of our major complaints about the older building systems we had experience with.

Early in the summer, an FTC Master kit was ordered from goBILDA. When it arrived, mentors John and Ryan worked with the team, most of whom were rookies, to assemble a drive train as a 'get acquainted with the new build system' exercise. This turned out to be a very good exercise--everyone gained an appreciation of how the goBILDA system goes together; with the discovery of some of goBILDA's online documentation, particularly their Product Insights, the team learned how some of the specialized goBILDA parts were intended to be used; simple lessons learned were re-learned, such as why the use of lock nuts and LockTite were so important; and the team discovered what key components the Master kit lacked and needed to be purchased separately.

Learning To Use The New goBILDA Kit- David, Jaxon, Joel, Nathan (continued)

One of the mentors, John, took this opportunity to demonstrate how SolidWorks could be used to design and virtually assemble the drive train using STEP files of the goBILDA parts. Several assemblies from the goBILDA Product Insights were included in the new design including Face Thru-Hold Pillow Blocks backed by Stainless Threaded Plates for the wheel bearings and Thrust Bearings to remove the friction generated by the Mecanum side-to-side motion. Other features included Low Profile U-Channels arranged in a very compact profile and motors centered in the robot chassis for balance. Also incorporated was a timing belt transmission, with custom designed 22 tooth drive pulleys and 24 tooth motor pulleys, yielding a 17.6:1 gear ratio. This ratio was arrived at based upon the team's experiences from the past two seasons with similar drive transmissions.

The very first chassis completed was a pushbot drive train with two powered goBILDA Rhino Wheels and two goBILDA Omni Wheels. Power was transmitted from the motors to the drive wheels through a pair of spur gears. Electronics were mated to the chassis and everyone had an opportunity to drive it around. Though rather crude and painfully slow, quite a bit was learned about what goBILDA components are necessary to build drive trains. As a result, a follow up order was placed with goBILDA, which included a set of their Mecanum wheels (preferred by the team for their maneuverability), more U Channels in various sizes, and a large assortment of nuts and bolts.



CAD Class Taught By John Bateman - Ellie, Jaxon, Joel, Nathan (8/14/2020)

Solidworks is a 3-D CAD program that can be used to design and create blueprints and 3-D models of objects that engineers want to build. It is used in a number of industries. We had a CAD class hosted by John, one of our student mentors, which taught us the basics of designing in Solidworks. In this class, John covered:

Product ideation
Part design
Part assembly with mates
Precision 3D modeling

John introduced the team to the fundamentals of computer-aided design (CAD) and drafting. He focused on the basic operations used for creating and modifying part drawings. John's class has also helped the team to better understand the basics of how to design parts in CAD. This knowledge will let our team be able to create and edit parts and designs for our robot quickly and easily, for 3D printing, for instance. Our members look forward to using this knowledge to make new robot parts!

Team Discussion About Engineering Process by Mr. Jeff - Ellie, David, Jalynn, Jaxon, Joel, Nathan (8/21/2020)

During our August 21st meeting, Mr. Jeff did a presentation on the Product Developement Process and the supporting Engineering Design Processes used in industry.

Every year before Kickoff, Mr. Jeff sits down with the team and talks about what an Engineer is and how they solve big problems by breaking them up into smaller, more manageable problems.

He then moves from a general Engineering Process to a process that the team might use to design and build this year's robot. The goal is to have a design process in place so that everyone on the team knows the steps they are expected to follow.

We also talked about how important vocabulary is, and how different things (parts, mechanisms, robot assemblies, etc.) need unique names to help communicate clearly. For instance, there are two types of prototypes. Proofs of Principles (POPs) show or prove that an idea or principle could work and why, using everyday things (like cardboard and duct tape). Final prototypes are mechanisms that are proposed as mechanisms for the final robot.

Because the team is made up of mostly rookies this year, Mr. Jeff included some more detail like definitions and general concepts. The team definitely benefitted from Mr. Jeff's presentation, and we hope to apply what we learned to this season's robot build.

What is an Engineer and What does He do?

- A practical problem solver that figures out how to build stuff.
- More formally:

  Engineers apply the foundational work of scientists and researchers to design structures or products that satisfy human needs while considering the practical limitations imposed by requirements, cost, schedule, regulations, and safety.

How does an Engineer Solve Problems?

Engineers are often employed to work on some very large
– Elephant Sized –
problems.

So: How does an Engineer eat an elephant?

How does an Engineer Eat an Elephant?

Answer: One bite at a time.

What does that mean?

- Engineers work on really big problems by dividing and sub-dividing them into managable pieces, distributing them, then working them separately. [Decomposition, Partitioning, Allocation, Delegation]
- Engineers generally have a defined recipe for how to approach the overall problem and a plan to work each piece in a reasonable amount of time for a reasonable amount of money. [Program Plan, Engineering Process and/or Methodology, Schedule, Budget]
- Engineering tools are often employed to work on the appropriate aspects of each problem/sub-problem. [CAD, SDKs, Modeling Tools, Math Tools, Drawing Tools, Scheduling Tools, Requirements/Problem Management Tools, Word Processors, Presentation Tools, ...]

Recipe: The Real-World Product Development Process/Lifecycle

Phase 1: Concept Development – Decide WHAT is to be built.

Phase 2: Design – Decide HOW to build it and CHECK IT OUT.

Phase 3: Production – BUILD it.

Phase 4: Field & Support – USE it, SUPPORT it, and IMPROVE it.

Engineering Processes may be applied within several of these Phases

More Approaches:

Sometimes Appropriate:

- Point Solution: The solution is obvious – Jump to it

Most Efficient - Very Dangerous - Sometimes Appropriate:

- Hero Driven: One guy does it all – **Caution:** Suseptable to Single Point Failures

Words of Wisdom from an Actual Engineer

Tim Theorem #1:
If you can't draw it, it probably won't work.

Corollary 1: Just because you can draw it, doesn't mean it will work.

Corollary 2: If you can't read it, you haven't drawn it.

Corollary 3: Different parts need different ~~numbers~~ NAMES.

BROWNCOATS
Team 7842 Engineering Notebook

So What?

Great, but how does that help us build a
FIRST Tech Challenge
Robot
?

Part 2: The Browncoat's Robot Development Process

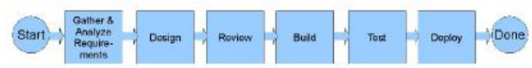
Engineering Processes

- Used within the overall Product Development Process
- There is no single "Best" Engineering Process (But they all have much in common):
  - Some organizations have a very detailed, fixed process.
  - Others allow flexability that depend upon the problem, known technologies, whether the problem has been solved before, the experience of the staff, ...
- The CRITICAL bits are:
  - **Buy In:** Everyone UNDERSTANDS and AGREES to what is to be done and in what order.
  - **Teamwork:** There must be a role for EVERYONE – One person cannot do it all.
  - **Communications:** Everyone needs to know what is going on.

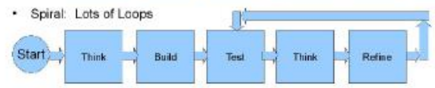
Engineering Processes - Approaches

There are many possible approaches:

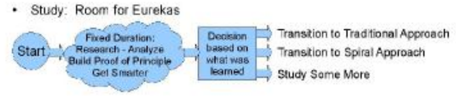
- Traditional / Waterfall: Very Linear



- Spiral: Lots of Loops



- Study: Room for Eurekas



Vocabulary is Important

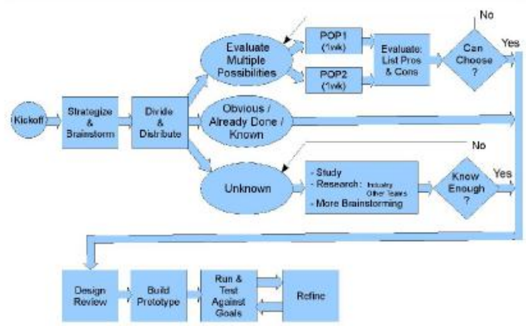
- A common, agreed to Vocabulary is <u>Very Important</u> to <u>Clear Communications</u>.
- Again: Different parts / ideas / concepts / tools need different names.
- Really helps those putting together the Engineering Notebook.
- First set of definitions (key to understanding the Robot Development Process):

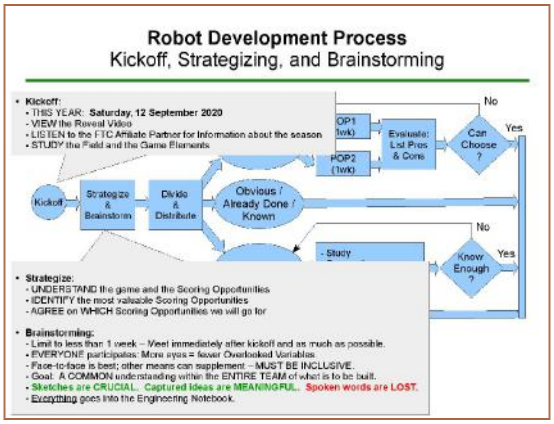
Prototype — Something that you expect will end up, in some form, on the final product.
- Must pay attention to all details, rules, and constraints.
- May end up on the robot as the final solution.

Proof of Principle (POP) — Risk reduction - Proves that an idea is viable:
- Build the quickest, simplest thing possible.
- Popsicle sticks, duct tape, Legos – Anything goes.
- Boil down to the **SINGLE PRINCIPLE** being proven.

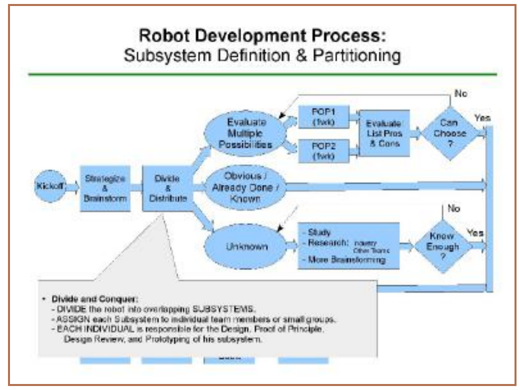
- More later....

Robot Development Process

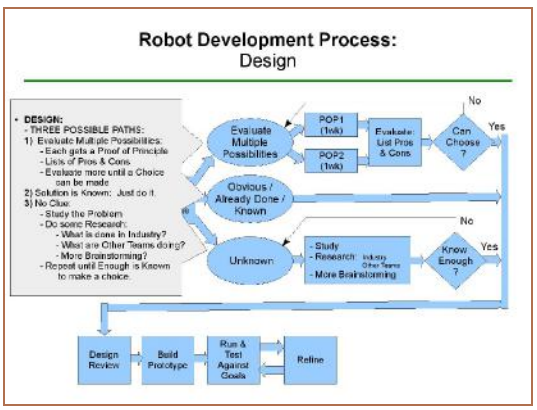




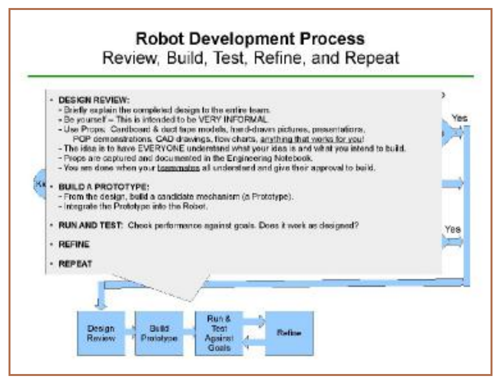
Robot Development Process
Kickoff, Strategizing, and Brainstorming
• Kickoff:
- THIS YEAR: Saturday, 12 September 2020
- VIEW the Reveal Video
- LISTEN to the FTC Affiliate Partner for Information about the season
- STUDY the Field and the Game Elements
Kickoff
Strategize & Brainstorm
Divide & Distribute
Obvious / Already Done / Known
POP1 (1wk)
POP2 (1wk)
Evaluate: List Pros & Cons
Can Choose ?
Know Enough ?
No
Yes
- Study
• Strategize:
- UNDERSTAND the game and the Scoring Opportunities
- IDENTIFY the most valuable Scoring Opportunities
- AGREE on WHICH Scoring Opportunities we will go for
• Brainstorming:
- Limit to less than 1 week – Meet immediately after kickoff and as much as possible.
- EVERYONE participates: More eyes = fewer Overlooked Variables
- Face-to-face is best; other means can supplement – MUST BE INCLUSIVE.
- Goal: A COMMON understanding within the ENTIRE TEAM of what is to be built.
- Sketches are CRUCIAL. Captured Ideas are MEANINGFUL. Spoken words are LOST.
- Everything goes into the Engineering Notebook.



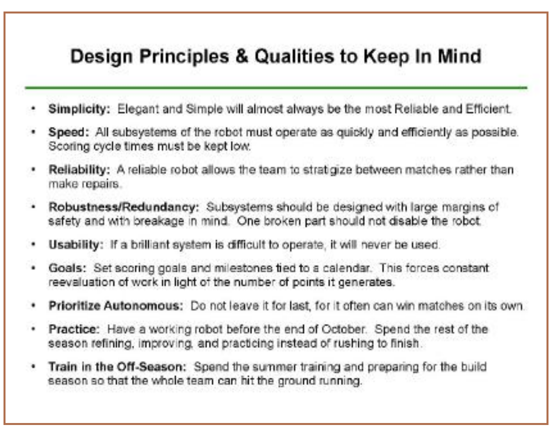
Robot Development Process:
Subsystem Definition & Partitioning
Kickoff
Strategize & Brainstorm
Divide & Distribute
Evaluate Multiple Possibilities
Obvious / Already Done / Known
Unknown
POP1 (1wk)
POP2 (1wk)
Evaluate: List Pros & Cons
Can Choose ?
- Study
- Research: Industry Other Teams
- More Brainstorming
Know Enough ?
No
Yes
• Divide and Conquer:
- DIVIDE the robot into overlapping SUBSYSTEMS.
- ASSIGN each Subsystem to individual team members or small groups.
- EACH INDIVIDUAL is responsible for the Design, Proof of Principle, Design Review, and Prototyping of his subsystem.



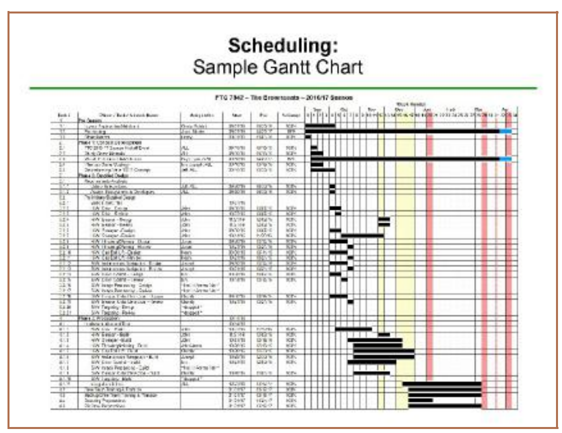
Robot Development Process:
Design
• DESIGN:
- THREE POSSIBLE PATHS:
1) Evaluate Multiple Possibilities:
- Each gets a Proof of Principle
- Lists of Pros & Cons
- Evaluate more until a Choice can be made
2) Solution is Known: Just do it.
3) No Clue
- Study the Problem
- Do some Research:
- What is done in Industry?
- What are Other Teams doing?
- More Brainstorming?
- Repeat until Enough is Known to make a choice.
Evaluate Multiple Possibilities
POP1 (1wk)
POP2 (1wk)
Evaluate: List Pros & Cons
Can Choose ?
Obvious / Already Done / Known
Unknown
- Study
- Research: Industry Other Teams
- More Brainstorming
Know Enough ?
No
Yes
Design Review
Build Prototype
Run & Test Against Goals
Refine



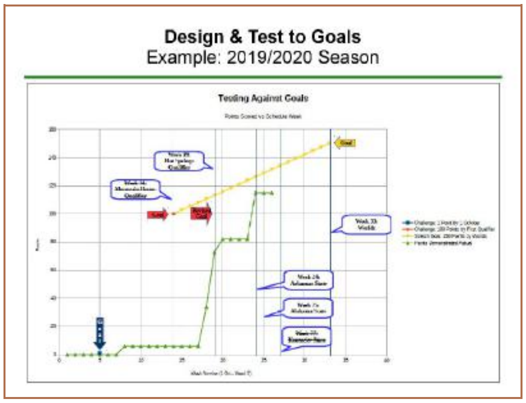
Robot Development Process
Review, Build, Test, Refine, and Repeat
• DESIGN REVIEW:
- Briefly explain the completed design to the entire team.
- Be yourself – This is intended to be VERY INFORMAL.
- Use Props: Cardboard & duct tape models, hand-drawn pictures, presentations, POP demonstrations, CAD drawings, flow charts, anything that works for you!
- The idea is to have EVERYONE understand what your idea is and what you intend to build.
- Props are captured and documented in the Engineering Notebook.
- You are done when your teammates all understand and give their approval to build.
• BUILD A PROTOTYPE:
- From the design, build a candidate mechanism (a Prototype).
- Integrate the Prototype into the Robot.
• RUN AND TEST: Check performance against goals. Does it work as designed?
• REFINE
• REPEAT
Yes
Design Review
Build Prototype
Run & Test Against Goals
Refine

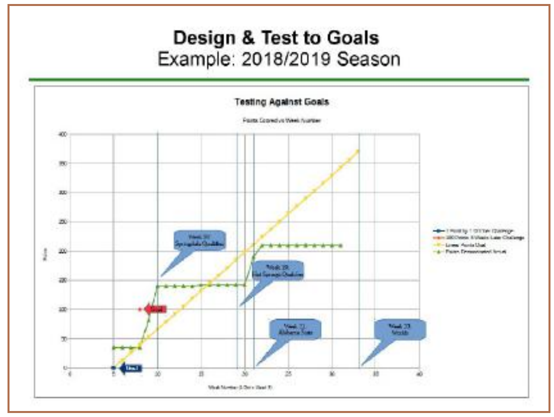


Design Principles & Qualities to Keep In Mind
• Simplicity: Elegant and Simple will almost always be the most Reliable and Efficient.
• Speed: All subsystems of the robot must operate as quickly and efficiently as possible. Scoring cycle times must be kept low.
• Reliability: A reliable robot allows the team to stratgize between matches rather than make repairs.
• Robustness/Redundancy: Subsystems should be designed with large margins of safety and with breakage in mind. One broken part should not disable the robot.
• Usability: If a brilliant system is difficult to operate, it will never be used.
• Goals: Set scoring goals and milestones tied to a calendar. This forces constant reevaluation of work in light of the number of points it generates.
• Prioritize Autonomous: Do not leave it for last, for it often can win matches on its own.
• Practice: Have a working robot before the end of October. Spend the rest of the season refining, improving, and practicing instead of rushing to finish.
• Train in the Off-Season: Spend the summer training and preparing for the build season so that the whole team can hit the ground running.



Scheduling:
Sample Gantt Chart
FTC 7842 – The Browncoats – 2016/17 Season



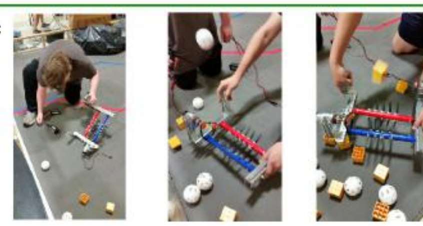


Summary of Key Expectations

- **PROOF OF PRINCIPLE (POP) Experiments:**
  - Need PICTURES for the Engineering Notebook
  - Need a brief WRITE-UP of what was learned -- Part of the daily write-up
  - Need to SHARE your results with everyone on the team!
- **DECISIONS:**
  - Discuss with majority of teammates and get agreement.
  - WRITE-UP the decision (part of the daily write-up) for Engineering Notebook.
  - COMMUNICATE: Make sure coaches and mentors know!
- **DESIGN REVIEWS:**
  - AFTER design is complete but BEFORE prototype construction begins.
  - Informal and short. Just tell your teammates what you've come up with.
  - Show design work, POP results, models, flowcharts, sketches, CAD, ... whatever
  - **MAJOR** input into the Engineering Notebook.

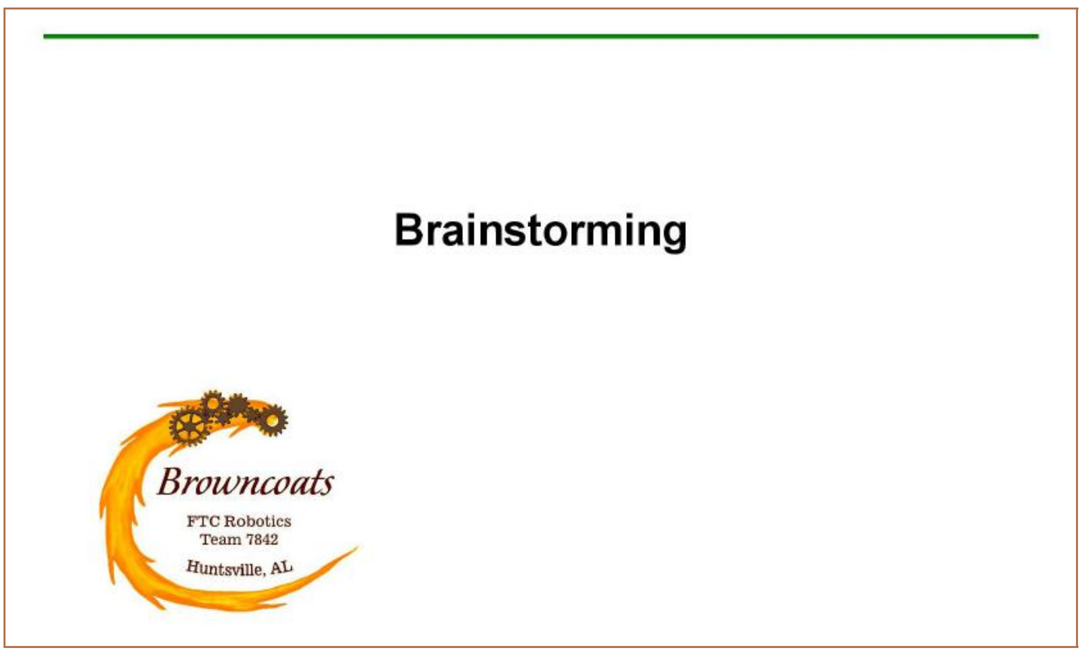
Example of a Proof Of Principle (POP) Experiment

- **Pictures:**



- **Date:** 9 September 2018
- **Who:** Ian, Joel, and John
- **Purpose:** Show if sweeper made of contra-rotating neoprene tubing can grab and lift both blocks and balls.
- **What was done:** Put together simple sweeper. Powered by 2 motors (20's). Manually ran over minerals on floor at height of about 4 inches.
- **Conclusion:** It can!

Pre-Kickoff Presentation- Ellie, David, Jalynn, Jaxon, Joel, Nathan (9/11/2020)
This meeting we got ready for Kickoff and the reveal video that was coming the next day. Mr. Jeff had prepared a presentation about the expectations concerning apparel, behavior, and competitive playing. The whole team was taught or reminded about gracious professionalism on and off the playing field. We were all reminded that we should be helpful, polite, and always on our best behavior everywhere.



Brainstorming

Brainstorming is a process that generally consists of the following steps:

1. **Generate Ideas**: Often a meeting conducted with simple rules:
   - There are three defined roles:
     Faciliator - Sets a specific goal/topic, keeps the team on topic, asks "what else" a lot.
     Scribe - Records all ideas.
     Everyone Else - Shares their ideas in an orderly fashion dictated by the Facilitator.
   - **NO** criticism, debate, or critical remarks are allowed. Questions for clarification are OK.
   - No idea is dumb. Wild ideas are encouraged. Adding to ideas is OK.
   - Emphasis is on generating as many ideas as possible.
2. **Evaluate / Edit / Prioritize Ideas**:
   - Generally a second group discussion that refines, combines, and prioritizes the ideas generated during step #1.
   - No idea is dumb, but they may be combined with others or assigned a low priority.
3. **Implement Ideas**: Act on the highest priority ideas agreed to in step #2.

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