From Vex to Google: The Engineering Design Process

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Los Angeles, California

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Special Thanks To

Andrew Theiss, our mentor

Xin Guan, software engineer from Google

Why Google?

Google has worked with VEX Robotics to empower students by hosting signature events, sponsoring online challenges, and supporting Girl Powered workshops. We thought it would be fitting to explore what a career at Google looks like and how VEX Robotics can prepare us.

Sam Sepah, an HR Project Manager at Google, gives a tour in sign language (photo courtesy of Seek the World)

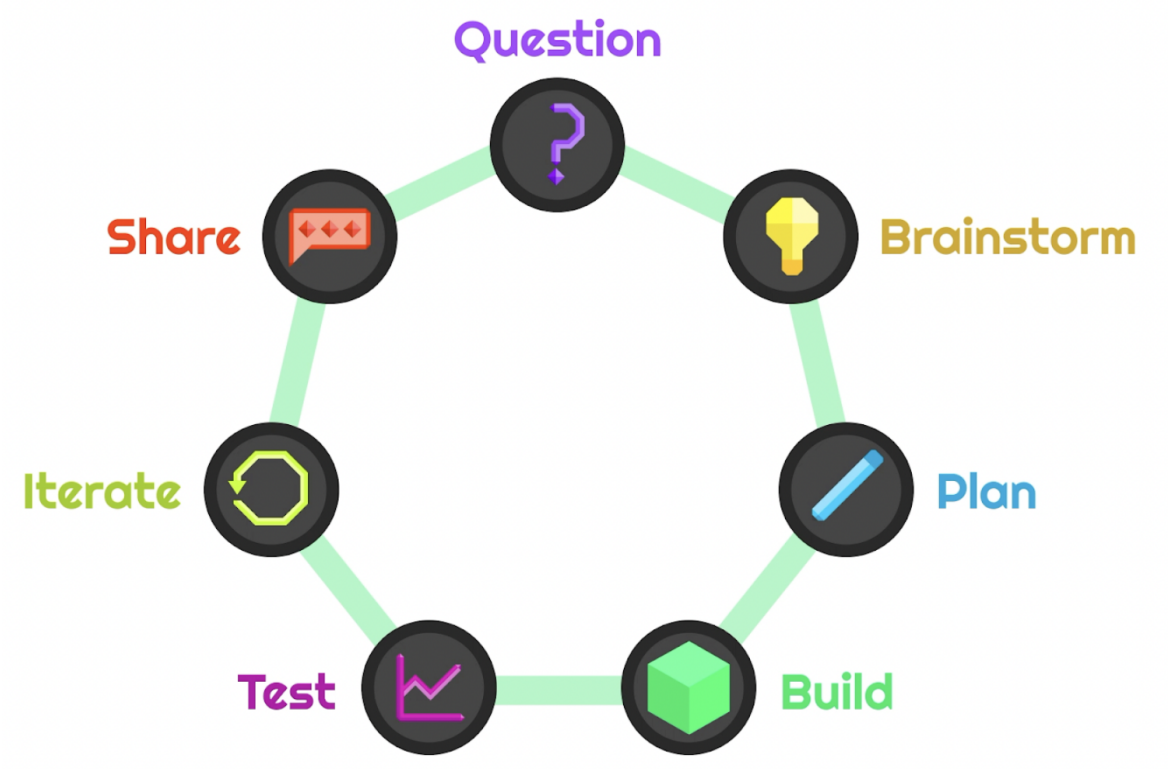
On their website, Google explains their mission: "Our mission is to organize the world's information and make it universally accessible and useful." But with so much information out there, how could any company possibly organize all of it? Google's former Senior Vice President of People Operations Laszlo Bock writes in his book "Work Rules!" that the impossibility is intentional because the mission is meant as "a moral rather than a business goal." By developing an ideal to strive towards,

the mission "creates motivation to constantly innovate and push into new areas." Google's workplace reflects those ideals: A Business Insider article reported that Google encourages its employees to work on passion projects and coach each other.

Google's environment is perfect for students who love VEX Robotics. Like employees at Google, VEX students learn from each other: we discuss on the VEX Forums and share robot reveal videos. Each season, we use the engineering design process to create innovative designs for the games.

Our team was fortunate to interview Xin Guan, a software engineer from Google, about how she uses the engineering design process in her work.

The Engineering Design Process



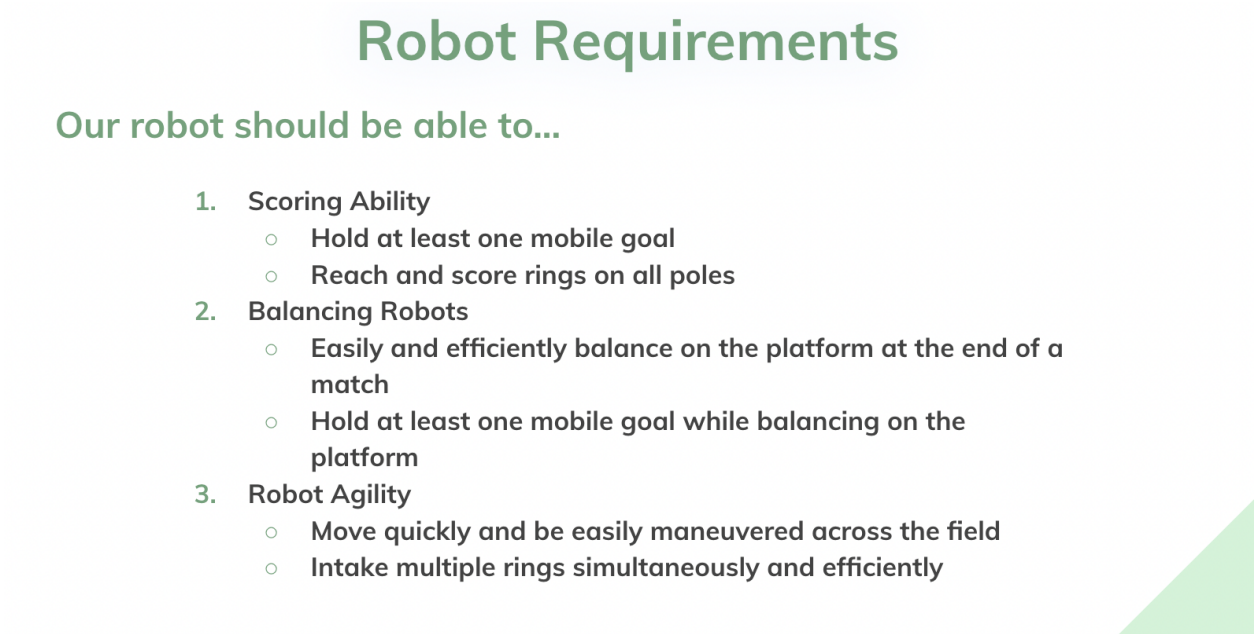
Team 62X's engineering design process (graphic by Eric Yoon)

Our team uses a seven-step engineering design process in order to streamline our collaboration process. When we talked with Xin Guan, she told us that engineers at Google also use a design process for developing new software features.

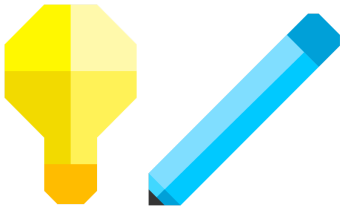
1. Software Requirements Document

The first step in both Google's and our team's process is clearly understanding the objectives. Not only does the Software Requirements Document explain the specifications for the features, but it also assigns priorities to features.

In our team's "Question" step, we collaborate on a System Requirements Review (SRR). We review gameplay and technical constraints on the robot (such as sizing). Given that information, we determine features we want our robot to have.



A slide from team 62X's SRR (graphic by Audrey Engman, Anika Iyer, Kensuke Shimojo, Karen Wu, and Eric Yoon)



2. Software Architecture Document

This document outlines how the requirements determined in the previous step will be accomplished. Engineers at Google estimate the effort required for different features and then plan based on return of investment (ROI). They list alternatives and explain why they're going forwards with the option they chose. Finally, they set milestones and make future plans for testing, release, and evaluation.

Our team has a "Brainstorm" and a "Plan" step in our process. To plan the implementation of the required features, we design 3D models of our robot with AutoCAD. We create design matrices to explore alternatives for each subsystem and mark future tournaments on Google Calendar.

In both processes, there is a planning phase where engineers explore possibilities and figure out how to realize the features they want.

Chassis

	X-Drive	H-Drive	Tank Drive	Mecanum
Forward Speed	Somewhat slower	Comparable to tank drive	Faster than X-drive	Generally on the slower side
Strafe Speed	As good at strafing as going forwards	Only has one motor powering strafe	N/A	Strafing isn't as accurate
Motor Count	4	5	4	4
Motor Force	Trades off torque for increased speed	Trades off speed for strafing	Efficient with motor force	Trades off speed for increased force

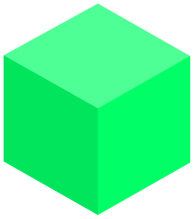
Lift

	4-bar	6-bar	Scissor Lift	Double Reverse 4-bar
Height	Standard	Higher than 4-bar	Varies	Higher than 6-bar
Lift Capability	Depends on gear ratio	Depends on gear ratio	Depends on gear ratio	Depends on gear ratio
Motor Count	2	2	2	2

Team 62X's design matrices (graphic by Audrey Engman, Anika Iyer, Kensuke Shimojo, Karen Wu, and Eric Yoon)

3. Review Process

The Software Architecture Document goes through an internal team review, an external team review, and finally a stakeholder review. Xin Guan told us that getting stakeholder approval is an important part of the process— unlike VEX students, Google engineers aim for real-world impact.



4. Minimal Variable Product (MVP)

Without considering reliability or scaling, software engineers at Google develop prototypes to demonstrate features. This is similar to the "build" step of our design process, where we construct a preliminary prototype of our robot.

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5. Demo

Software engineers at Google need to demo their MVP before they can turn it into a final product. If their coworkers and stakeholders approve, then engineers can start working towards their milestones. After each milestone, they do another demo.

Our team uses two presentations, the Preliminary Design Review (PDR) and Competition Readiness Review (CDR), to review our robot. We do the PDR after prototyping our robot and we do the CDR before competitions. Like software engineers at Google, communicating with our teammates is vital.

6. Testing, Release, Evaluation

After creating a new feature, Google can't immediately roll it out for everyone in the world— they need to first analyze its efficacy through tests like the A/B test. Xin Guan gave us the example of adding a button to YouTube: first, 10% of the users will be given that button. Then, after a period of time, engineers will analyze whether the button has boosted the increase of traffic or revenue.

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7. Iterating

Like VEX students, software engineers at Google won't make a perfect product on the first try. That's why both our team and Google have a step dedicated to improvement.

One of Google's offices (photo courtesy of Sundry Photography)

Why VEX Robotics?

The engineering design process used by VEX students is remarkably similar to the one Google uses: engineers determine system requirements, plan their work, develop and test prototypes, and finally improve their work. Along the way, they communicate their progress.

VEX students learn valuable project management skills to streamline the design process. When Xin Guan told us about tools that engineers at Google use, we realized that our team uses similar tools:

	GOOGLE	VEX STUDENTS
WORKFLOW	Kanban boards	Kanban boards, engineering notebook
TIMELINE	Google Calendar	Google Calendar, Gantt charts
COMMUNICATION	Google Hangout, Google Meet	Slack, Google Meet, Zoom, VEX Forums
PRESENTATION	Google Slides	Google Slides
CODE REPOSITORY	Internal Google repository	GitHub
DOCUMENT REPOSITORY	Google Drive	Google Drive

A comparison of tools used by software engineers at Google and VEX students (graphic by Karen Wu)

Finally, although women are underrepresented in the STEM field, VEX Robotics empowers girls through Girl Powered workshops supported by Google. Not only does VEX Robotics give us the technical skills needed for a career at Google, but it also supports students of all backgrounds and inspires a love for engineering that will push us to keep innovating.

A Girl Powered workshop in Bakersfield, California (photo courtesy of VEX Robotics)