

## Video Transcript

### The Power of Creative Constraints by Brandon Rodriguez

Imagine you're asked to invent something new. It could be whatever you want made from anything you choose in any shape or size. That kind of creative freedom sounds so liberating, doesn't it? Or does it? If you're like most people, you'd probably be paralyzed by this task. Without more guidance, where would you even begin? As it turns out, boundless freedom isn't always helpful.

In reality, any project is restricted by many factors, such as the cost, what materials you have at your disposal, and unbreakable laws of physics. These factors are called creative constraints, and they're the requirements and limitations we have to address in order to accomplish a goal. Creative constraints apply across professions, to architects and artists, writers, engineers, and scientists. In many fields, constraints play a special role as drivers of discovery and invention. During the scientific process in particular, constraints are an essential part of experimental design. For instance, a scientist studying a new virus would consider, "How can I use the tools and techniques at hand to create an experiment that tells me how this virus infects the body's cells? And what are the limits of my knowledge that prevent me from understanding this new viral pathway?" In engineering, constraints have us apply our scientific discoveries to invent something new and useful. Take, for example, the landers Viking 1 and 2, which relied on thrusters to arrive safely on the surface of Mars. The problem? Those thrusters left foreign chemicals on the ground, contaminating soil samples. So, a new constraint was introduced. How can we land a probe on Mars without introducing chemicals from Earth? The next Pathfinder mission used an airbag system to allow the rover to bounce and roll to a halt without burning contaminating fuel. Years later, we wanted to send a much larger rover: Curiosity. However, it was too large for the airbag design, so another constraint was defined. How can we land a large rover while still keeping rocket fuel away from the Martian soil? In response, engineers had a wild idea. They designed a sky crane. Similar to the claw machine at toy stores, it would lower the rover from high above the surface. With each invention, the engineers demonstrated an essential habit of scientific thinking - that solutions must recognize the limitations of current technology in order to advance it. Sometimes this progress is iterative, as in, "How can I make a better parachute to land my rover?" And sometimes, it's innovative, like how to reach our goal when the best possible parachute isn't going to work. In both cases, the constraints guide decision-making to ensure we reach each objective.

Here's another Mars problem yet to be solved. Say we want to send astronauts who will need water. They'd rely on a filtration system that keeps the water very clean and enables 100% recovery. Those are some pretty tough constraints, and we may not have the technology for it now. But in the process of trying to meet these objectives, we might discover other applications of any inventions that result. Building an innovative water filtration system could provide a

solution for farmers working in drought-stricken regions, or a way to clean municipal water in polluted cities. In fact, many scientific advances have occurred when serendipitous failures in one field address the constraints of another. When scientist Alexander Fleming mistakenly contaminated a Petri dish in the lab, it led to the discovery of the first antibiotic, penicillin. The same is true of synthetic dye, plastic, and gunpowder. All were created mistakenly, but went on to address the constraints of other problems. Understanding constraints guides scientific progress, and what's true in science is also true in many other fields. Constraints aren't the boundaries of creativity, but the foundation of it.