Polycraft World teaches science through an endlessly expansive universe of virtual gaming

https://polycraft.utdallas.edu

By Tim Palucka

Welcome to Polycraft World. As the game begins, your virtual character comes to life ("is spawned") near the trellis on the campus of The University of Texas at Dallas (UT Dallas)—the university's prime meeting place and a logical starting point for a game that was created there. You have a 20-minute day (10 minutes of daylight, 10 of darkness) during which you should work feverishly to find food and build a shelter to protect yourself from the spiders, witches, creepers, and endermen (two-legged creatures who are peaceful until you look them in the eye) that could steal your possessions or bring about your demise during the night. Tomorrow you might think about finding some iron ore and building a furnace so you can make a sword and armor to defend yourself against these monsters.

As your adventure progresses, you may soon find yourself pumping oil from the ground, separating it into hydrocarbon fractions in the distillation unit you have built, converting these hydrocarbons into polymers, and using them to build parts for flamethrowers, scuba gear, smartphones, or one of many other useful objects that expand your capabilities and make for countless hours of compelling game play.

And, if Walter Voit and his Polycraft World team have anything to say about it, you will learn a lot about materials science along the way.

Voit, associate professor of mechanical engineering/materials science and engineering at UT Dallas, conceived the idea of Polycraft World in 2013 with his programmer friends Chris Wahlen and James McAndrew after years of playing Minecraft, one of the most popular video games in the world. They loved the game, but were beginning to find it limiting. Minecraft lets you explore a virtual world, mine iron ore, build a furnace to melt the ore to make weapons, shovels, and pickaxes, among many other activities. But an experienced player can work through all the possibilities of the game in about 10 hours. So, with co-creators Ron Smaldone, an assistant professor of chemistry, and Christina Thompson, a lecturer in chemistry, they set off to expand the game's scope.

(Clockwise from top right): Christina Thompson, Walter Voit, James McAndrew, and Ron Smaldone, co-creators of Polycraft World, a Minecraft Mod from The University of Texas at Dallas.

As a polymer scientist, Voit knew there was a whole world of other elements and material types—rubbers, petrochemicals, catalysts, Kevlar, carbon fibers—that could transform Minecraft into an endlessly expansive universe of virtual gaming. "Polycraft evolved from two different things: Walter's love of Minecraft and his desire to expand it from an engineering standpoint to get the polymer chemistry and materials science across," says Shelbi Parker, a senior in biomedical engineering at UT Dallas and a longtime member of the Polycraft team. "It developed from something that was just really fun to something that we can use as a teaching tool. From there it just expanded exponentially to what it is today."

What it is today is a module (or "mod") of Minecraft that you can download for free to greatly extend the game's capabilities. And that's putting it modestly. Minecraft contains just over 600 unique blocks and items such as wood, rock, iron ore, and diamonds. Since 2013, the small Polycraft team of dedicated volunteer faculty and students has added over 4000 items, including 118 polymers, 325 compounds, 26 unique inventories (e.g., distillation column, steam cracker, and injection molder), and 84 custom objects (such as jetpacks, ham radios, and running shoes), along with most metals in the periodic table. To conform to the real world, elements are available in the quantities that exist in the earth's crust, so a player cannot just decide to use large quantities of a rare element.

The success of Polycraft World is evident in the usage statistics for the

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(Top) A flamethrower built in Polycraft World destroys some of the creatures bent on your destruction. (Bottom) Meeting a colleague in the corridor of a science building on the UT Dallas campus.

university's dedicated game servers. More than a quarter million page views of the polycraftworld.com and polycraft.utdallas.edu websites; 23,000 repeat visitors; and 100–150 unique users per day show that Minecrafters are turning to Polycraft World to extend their enjoyment of the game.

John Will, a junior in biomedical engineering at the university and a Polycraft team member, attributes a lot of this success to Voit's choice of a starting point. "Beginning with this really popular video game like Minecraft, which has millions of daily users, was a critical choice for an educational video game like Polycraft World," Will says. "Using the compelling underlying game mechanism of Minecraft really helps to educate people about materials science. The tripping point of a lot of educational games is that they try to reinvent the wheel and fail to create an interesting gaming environment."

Starting with Minecraft also gave the team the basic mechanism for constructing new, useful items and storing them in a player's inventory. Minecraft has a crafting bench made of four blocks of wood. Clicking the bench opens a crafting recipe grid, which consists of a three-by-three square grid in its most basic form. Dropping materials into this grid in a pattern creates a variety of tools you need in the game. For instance, placing three iron ingots across the top row of the grid and two wooden sticks under this in the middle column produces an iron pickaxe. A furnace can be made with eight cobblestones around the perimeter of the grid and an empty space in the middle, into which coal can be inserted for burning, and metal ore for smelting. In this way, players can craft and smelt Minecraft's various items and tools.

The complexity quickly increases in Polycraft World. For example, you might decide that wearing running shoes would help you to cover more ground in your 20-minute day, and to outrun monsters intent on stealing your possessions. But you have to build your own running shoes. Starting with five blocks of wood in a V-shape and one wooden stick in the three-by-three grid, you create a tree tap to harvest sap from rubber trees. The harvested rubber gives you pellets of (poly)isoprene to make the sole of your shoe. Next, you need to build a machining mill from one of the many metal ores available, and use the mill to create a mold for a running shoe. You are halfway there. Now you must build an injection molder, and use it to inject the melted poly(isoprene) into your mold to make a pair of running shoes. When that pair wears out, you can start again or use more advanced polymers to craft shoes that will go farther and faster.

"When you go through the steps of crafting the milling machine and the injection molder, you get a feel for how they actually work based on the configuration of the crafting table," Parker says. You need a chisel tip that can grind out metal to make a mold for the shoe, and a piston to push the melted rubber into the mold. "We try to make the manufacturing processes reasonable, so the game player learns how form leads to function."

Recipes for all the items you can possibly create in Polycraft World are available in the Polycraft Wiki, which runs to several thousand pages, so you do not have to keep them all in your head. Fueled by the team's collective imagination, the list of items now includes a jetpack, flamethrower, pogo stick, freeze-ray gun, scuba gear, radios, smartphones, three-dimensional printers, and so much more. The inventory expanded greatly when the team changed their approach from a "why include this item in the game?" to "why not?" according to Parker.

Up until now, the team has focused on the macroscale aspects of materials science because they fit more into the spirit and flow of the game, and they were easier to implement. But Will says that is eventually going to change. "As we get down the road and have time to do it, one of our thoughts was to implement synthesis on the molecular level where you could actually go in and build a molecule using elements," he says. "While this may not be the most scientifically relevant approach from a laboratory perspective, it would be scientifically relevant from an education perspective."

Education, in the form of fun and compelling game playing, is what Polycraft World is all about. Parker spends a lot of time teaching people how to play the game. While she mostly finds herself showing elementary school students how to build some of the many cool objects available, she has taught people in their 80s how to have fun and learn some science while playing Polycraft World. It is especially satisfying for her when a young student "immediately takes to the game and runs with it—there's no stopping them," Parker says. Perhaps she is witnessing the birth of a future engineer who will continue the mission of adding items and processes to Polycraft World 10 or 20 years from now. No doubt this infinitely expandable virtual universe will still be growing far into the future. □

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