Makers 3D Learning Platform Curriculum

Overview

At the MakersFactory, our primary mission is to provide 3D fabrication and learning solutions. The **Makers 3D Learning Platform** provides Fab Lab and Game-Based Learning (GBL) as a 3D platform to teach 21st Century skills to students. Our platform includes professional development for teachers; project-based lessons; and technical support - all the materials needed to successfully integrate new technology in the classroom. We instruct teachers how to use innovative technologies - to give teachers the skills and tools needed to integrate curriculum where students are engaged and inspired. With the hands-on, learn by doing, iterative process of Fab Lab and Game-Based Learning, students gain a better understanding of concepts and skills, develop and communicate complex forms and processes in the fields of STEM and design (or STEAM) and Common Core Standards.

Learning Objectives Include:

- Increase Student Engagement
- Develop Higher Order Thinking Skills
- Enhance Self-Efficacy
- Strengthen Resilience
- Improve School Attendance
- Strengthen Social Skills through Collaboration and Dynamic Learning Environment

makers FACTORY

Integrated Technology Skill Scaffolding

Tools to Create Successful Learners & Communicators

STUDENT SKILLS

- SELF-DIRECTION
- ITERITIVE PROCESS
- SIMULATION
- DIGITAL LITERACY
- CRITICAL THINKING
- CREATIVITY
- COLLABORATION
- COMMUNICATION

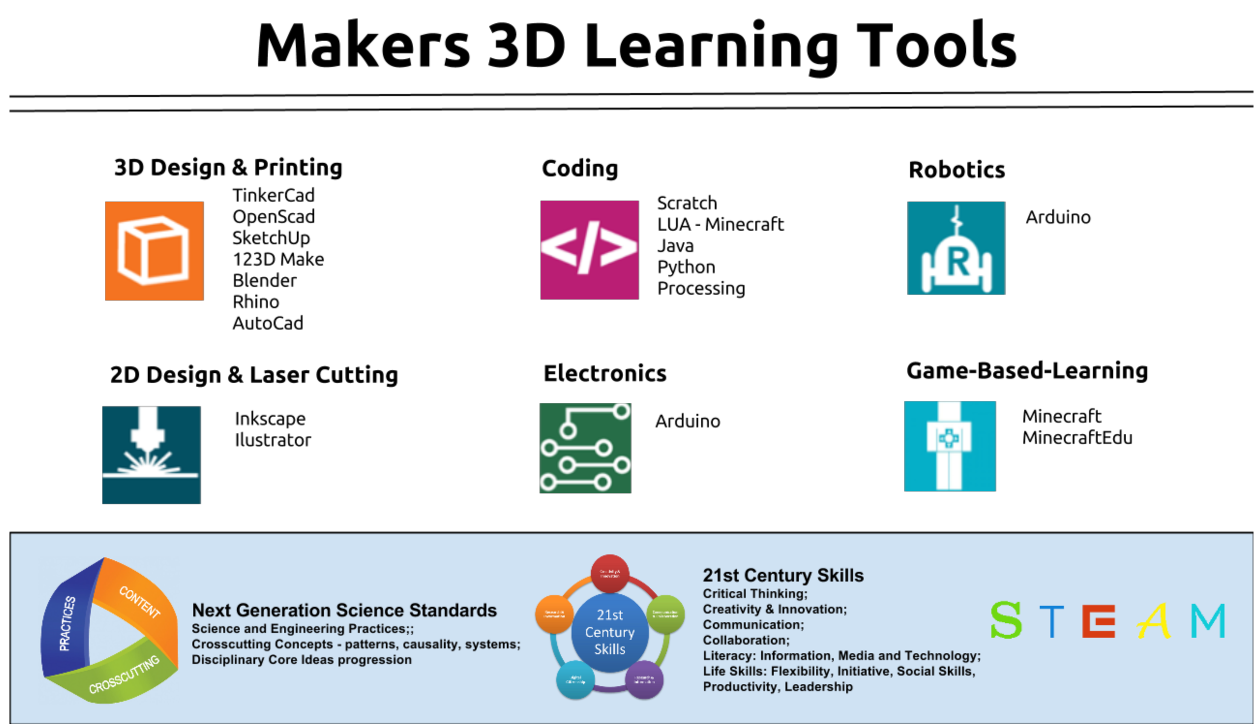
GRADE LEVELS

	hardware	programs	skills
K-1	Tablets Computers Craft Supplies	ABCKey MiniMouse Daisy Dinosaur	Keyboarding Mouse Skills Programming
2-3	Computers Tablets 3D Printer Vinyl Cutter Lego Robotics	Google Chrome Hopscotch & Scratch iMovie Minecraft 123Design Inkscape Google Docs	Information Literacy Programming Movie Making Virtual Building 3D Modeling 2D Design Document Creation
4-5	Computers Tablets 3D Printer Laser Cutter Lego Robotics Green Screen Ink Jet Printer	Weebly & Google Sites Prezi Game Maker HTML & Python Blender Gimp Sketchup	Web Site Creation Presentation Game Design Programming 3D Animation Photo Editor 3D Modeling
6-8	Computers Arduino 3D Printer Laser Cutter Lego Robotics	Blender Minecraft Hacking & Java Arduino Blender GIMP Sculptris	3D Modeling Programming Microcontrollers 3D Modeling Photo editor Digital Sculpting
9-12	Computers Arduino 3D Printer Laser Cutter CNC Router Vacuum Former	AutoCad Adobe Suite JavaScript Raspberry Pi Rhinocerous	2D/3D Drafting Digital Design Programming Computer Science 3D Modeling

makers FACTORY

For more information, contact MakersFactory.com | 831.621.0801 | 877 Cedar Street, #122, downtown Santa Cruz

Makers 3D Learning Tools:
Students use 3D tools, applications and technology to complete their Fab Lab and GBL project-based lessons. The processes used to complete these lessons build proficiency in accordance with Next Generation Science Standards, 21st Century Skills and CCSS.



Fab Lab Learning

Overview

With the shift to Common Core-based standards in education, the use of Fab Lab tools in schools has become a natural approach to meet the new requirements. It is also a sophisticated means to address Information and Communication Technology (ICT) goals, while providing opportunities for collaboration, critical-thinking, and creative problem-solving. Educators can incorporate one of the subjects covered under the Fab Lab Bundle in their curriculum or employ them all — the possibilities are limitless.

Benefits of Using Fab Lab Tools in the classroom

- *Cross-Discipline* -- Many Fab Lab projects require students to apply skills and knowledge from multiple subject areas. For example, in creating even a basic robot, a student employs 2D design, 3D design, electronics, and programming.

- *Communication & Collaboration* -- Fab Lab projects often call for group work over individual work, given all the components and subject areas that can be involved in a single project.
- *Critical Thinking & Problem Solving* -- Students must solve a challenge in physical space by designing and iterating in digital space. Many subject areas must interact and cooperate in a Fab Lab project, using designs from many different kinds of software and hardware.
- *Creativity* -- Fab Lab projects aren't just for developing proficiency in high technology; they are also creative outlets. Students take both form and function into consideration in most Fab Lab projects.
- *Engineering Design* -- Fab Labs use effective tools for teaching science in the context of engineering design while integrating math and technology skills.

3D Design & Printing

Whenever a student plans and designs a 3-dimensional creation in a digital modeling program, they are exercising the kind of complex problem solving that's been identified as a key 21st Century skill. They are using a tool in the digital world to solve a problem in the physical world, a challenge that builds critical thinking skills and the ability to innovate.

2D Design & Laser Cutting

With a laser cutter, students can use vector images created in programs like Adobe Illustrator and Inkscape to cut highly precise pieces out of a sheet of material. This versatile machine can handle a wide range of materials, thus allowing a wide range of design challenges. Though the students are working with 2-dimensional sheets of material, they can use techniques like slot-together designs to produce 3-dimensional physical objects.

Coding

It's easy to see that computer programs are now a part of just about every area of the modern world. Teaching computer science allows students to gain understanding of and control over all these technologies. Furthermore, computer science develops rational and logical problem-solving processes and methods of thought.

Electronics & Robotics

Electronics and robotics often utilize and integrate the tools discussed above. Using electronics like the Arduino microprocessor to connect computer code to 3D-printed or laser-cut robots challenges students to understand and master a complex system of software and hardware.

Fab Lab Lessons

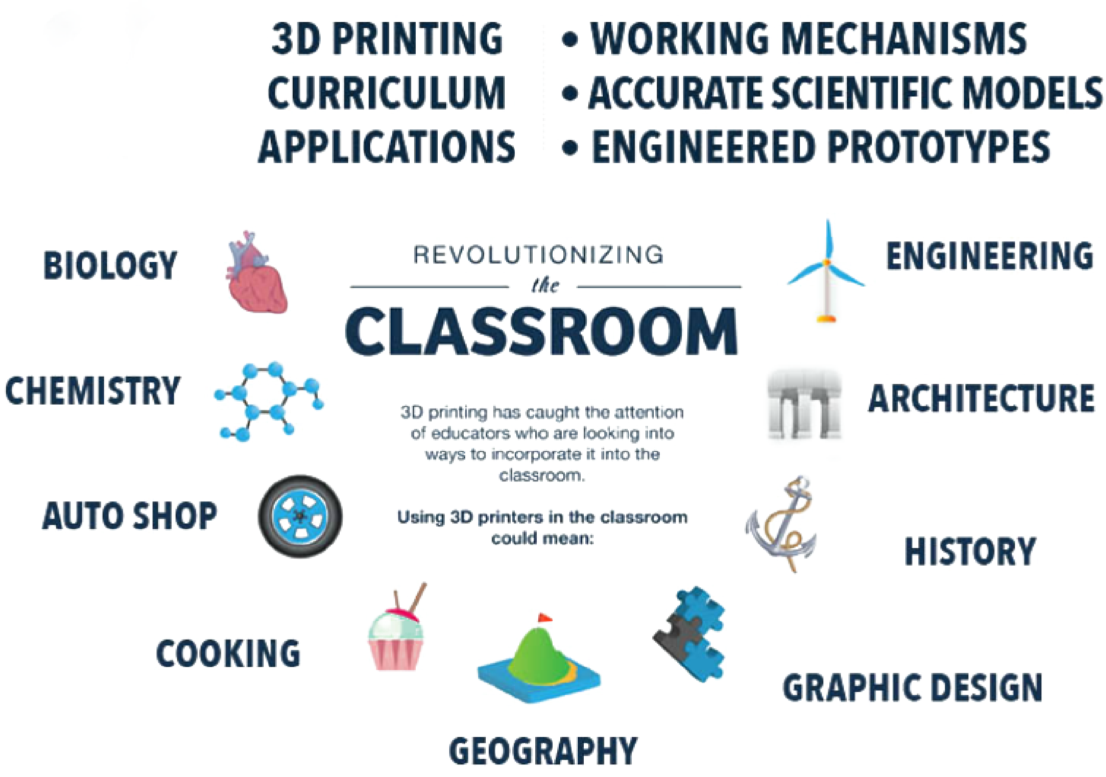
CCSS: In each lesson, students will use new terms and knowledge to analyze and describe processes, concepts and skills used to complete the assignment. They will identify what they learned and how they expanded their knowledge from previous lessons.

MakersFactory Fab Lab lessons integrate Common Core State Standards for Math, as well as Language Arts & Literacy. They also implement the Next Generation Science Standards for California in a variety of content areas.

Sub Category	Lesson	CCSS & NGSS
GameMaker	RPG -- Creating a New Room	Math, Language Arts & Literacy, Engineering
GameMaker	RPG -- Creating a New Item	Math, Language Arts & Literacy, Engineering
GameMaker	RPG -- Creating a New Enemy	Math, Language Arts & Literacy, Engineering
GameMaker	RPG -- Creating New Music	Math, Language Arts & Literacy, Engineering
GameMaker	RPG -- Adding a Bombs Item	Math, Language Arts & Literacy, Engineering
GameMaker	RPG -- Adding a Companion or Pet	Math, Language Arts & Literacy, Engineering
GameMaker	RPG -- Full-Hearts Powerup	Math, Language Arts & Literacy, Engineering
Blender	Modeling -- "Box Man"	Math, Language Arts & Literacy
Blender	Animation -- Intro	Math, Language Arts & Literacy
Blender	Animation -- Basic Rigging	Math, Language Arts & Literacy
Rhino	Design Tools	Rhino is a tool used for engineering. We teach Rhino one on one, class lessons under development.
Inkscape	Design — Intro	Math, Language Arts & Literacy
Inkscape	Design - Clock	Math, Language Arts & Literacy, Engineering
Programming	Processing -- Basics of Drawing	Math, Language Arts & Literacy, Engineering
Programming	Processing -- Intro to Variables	Math, Language Arts & Literacy, Engineering
Programming	Processing -- Functions	Math, Language Arts & Literacy, Engineering
Programming	Processing -- Objects	Math, Language Arts & Literacy, Engineering
Programming	Python -- Hello Turtles	Math, Language Arts & Literacy, Engineering
Programming	Python -- Objects	Math, Language Arts & Literacy, Engineering
Programming	Arduino - Binaryclock	Math, Language Arts & Literacy, Engineering
Programming	Arduino - PlusPlus	Math, Language Arts & Literacy, Engineering
Programming	Arduino - Primefactors	Math, Language Arts & Literacy, Engineering
Programming	Scratch - Intro	Math, Language Arts & Literacy, Engineering
Programming	Scratch - Instrument Sprite	Math, Language Arts & Literacy, Engineering
Electronics	Electronics - Intro	Math, Language Arts & Literacy, Engineering, Physics
Electronics	Electronics - Breadboard	Math, Language Arts & Literacy, Engineering, Physics

Electronics	Electronics - Microcontrollers	Math, Language Arts & Literacy, Engineering, Physics
Electronics	Electronics - Motors	Math, Language Arts & Literacy, Engineering, Physics
Electronics/Robotics/Arduino	Robotics Arm - Engineering and Design	Math, Language Arts & Literacy, Engineering, Physics
NXT Robotics	Mission Sheets	Math, Language Arts & Literacy, Engineering
NXT Robotics	Draw Bot	Math, Language Arts & Literacy, Engineering
NXT Robotics	Racecar Bot	Math, Language Arts & Literacy, Engineering
NXT Robotics	Claw Bot	Math, Language Arts & Literacy, Engineering

Example Applications: Once students learn how to use the 3D tools, they can use them in project-based cross-curricular lessons. See examples listed below.



Chemistry: Use Blender to design models of molecules, including the accurate geometric placement of atoms. Develop 3D visualization skills and design more complicated molecules, such as DNA, proteins, etc.

Earth and Physics Sciences: Use Blender to design a windmill, evaluate how changes in windmill location and blade size affects speed. Import 3-dimensional topographical data and evaluate geological features.

Physics: Combine laser-cutting and 3D-printing to construct a Rube Goldberg machine (a mechanical "roller-coaster" for a marble), utilizing knowledge of energy and forces to break its functioning down into smaller segments and keep the machine running as long as possible. Visualize 2 and 3-dimensional vector fields.

Mathematics: Construct physical and virtual models of mathematical problems and use them to solve larger and more complicated multi-step problems. Explore 2D/3D geometry via computational modeling, or 3D-print graphs of functions.

Planetary Sciences: Build a scale model of the solar system, or program an orbital dynamics simulator.

Biology: Program an ecological simulation using digital life forms to demonstrate how populations of organisms can change over time or due to external forces.

Game-Based Learning

Overview

The central premise of Game-Based Learning (GBL) revolves around four core concepts in education: *engagement, iteration, simulation, and agency*.

That games offer an *engaging* learning environment should be self-evident; computer games captivate millions of users across dozens of genres, and have grown to be become a permanent fixture in modern society. One important assumption of GBL is that this engagement is not to be dismissed lightly as “just for fun.” The goal of using games in educational applications is to leverage their engaging nature to involve and immerse the student in real and productive learning.

Another key feature of games is that they offer environments where rapid *iteration* and experimentation is possible. In games, when a player fails at a task, they receive immediate feedback (“Game Over,” for example), and are allowed to re-try that task immediately. This stands in comparison to the feedback loop of traditional education, where students must wait for assignments to be graded before they can receive any meaningful feedback.

The third relevant feature of games is their ability to *simulate* real systems and allow students to experience and interact with these systems. It might not be clear what Pong is attempting to simulate (Table tennis? Air hockey?), but as computer games have matured, they have become increasingly capable of accurately simulating complicated systems. Games like Kerbal Space Program, a physics-based game where players build and launch rockets, demonstrate this concept perfectly.

The last reason games deserve a place in the classroom is their ability to provide students with increased “*agency*,” or an ability to affect their environment and make meaningful decisions. Games, at their core, operate on player input, and *good* games do so in empowering ways. For under-served student populations, who experience reduced agency in school environments, this is a crucial advantage of Game-Based Learning.

Offerings

Currently, MakersFactory offers Game-Based Learning using the computer game Minecraft, an immensely successful and popular game which is uniquely suited to educational environments. Minecraft is a “sandbox game,” a newer kind of game with no pre-defined goal or end, where players interact with and manipulate their environment by collecting resources and building with cube-shaped “blocks.” By allowing players to determine their own purpose and presenting only tools and materials, it invites comparison to “digital LEGOs.”

Features of Minecraft

- Minecraft is expandable with “mods” which anyone can create and use, and that can add extra features (items, blocks, etc.) into the game to serve a variety of purposes.
- Minecraft is a multi-player game, meaning that an entire class of students can all interact with each other in the same game world, allowing them to collaborate and work in groups or as a class.
- Minecraft’s “content-agnostic” design (unlike many educational games, Minecraft has no particular academic subject in mind) is not a weakness but a strength, as it lends itself well to a variety of topics.

Subject Applications

- **Mathematics -** Minecraft’s cube-based construction is perfect for discussion of area, surface area, and volume, as well as 2-dimensional and 3-dimensional coordinate systems.
- **Physics -** Minecraft’s physics allows for exploration of gravity, velocity, potential energy, and projectile motion.
- **Biology -** Larger-than-life 3D models of biological systems and processes can give students hands-on experience with systems small and large.
- **Computer Science / Computer Engineering -** Using the ComputerCraft mod, players can program robots to perform a variety of tasks, or construct complicated electronic circuits using “redstone,” blocks which can transmit and manipulate power.
- **Languages -** Minecraft provides an authentic social context for language learning, where students can interact in a non-native language to develop fluency naturally.
- **Civics / Social Studies -** Players naturally develop methods of managing resources, which can lead to an exploration of historical systems of government.
- **Earth Sciences -** Minecraft’s naturally-generated landscapes include biomes and can be used to model real-world geographical features.
- **History -** Use Minecraft to re-enact historical events or explore historical structures and landscapes.

MinecraftEdu Lessons:

CCSS: In each lesson, students will use new terms and knowledge to analyze and describe processes, concepts and skills used to complete the assignment. They will identify what they learned and how they expanded their knowledge from previous lessons.

Design	Category	Lesson	CCSS & NGSS
MakersFactory	MC Math	Perimeter and Area	Math, Language Arts & Literacy
MakersFactory	MC Math	Volumes	Math, Language Arts & Literacy
MakersFactory	MC Math	Fraction House	Math, Language Arts & Literacy

MakersFactory	MC Math	X, Y, Z Coordinates	Math, Language Arts & Literacy
MakersFactory	MC Math	Contour Maps	Math, Language Arts & Literacy, Geography
MakersFactory	MC Hacking	Custom Armor	Math, Language Arts & Literacy, Engineering
MakersFactory	MC Hacking	Custom Tools	
MakersFactory	MC Hacking	Food with Potion Effects	
MakersFactory	MC Hacking	Forge Events -- Intro	
MakersFactory	MC Hacking	Forge Events -- Mob Drops	
MakersFactory	MC Hacking	Forge Events -- Explosive Hammer	
MakersFactory	ComputerCraft	Programming - BasicTraining	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - FirstSteps	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - ToandFro	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - Wall-Scaling	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - GoingtheDistance	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - GuardThatBlock	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - TunnelTurtle	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - BridgeBuilder	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - SkyStairway	Math, Language Arts & Literacy, Engineering
MakersFactory	ComputerCraft	Programming - HiwayBuilder	Math, Language Arts & Literacy, Engineering
MinecraftEdu	Game of 4 Bridges	Programming - Build a Bridge	Math, Language Arts & Literacy, Engineering
MinecraftEdu	World of Humanities	Exploring the Ancient, Virtual World: Engagement and Enrichment Within a Virtual Historical Learning Environment	Humanities, History
MinecraftEdu	QCraft	qCraft mod, in which students explore three fundamental principles of quantum physics: Observational Dependency,	Physics, Language Arts & Literacy

		Superposition, and Entanglement	
MinecraftEdu	Fair Trade Rainforest	Establish the farm, get it up and running by harvesting and crafting goods to sell to Fair Trade Foundation and collect gold coins.	Math, Language Arts & Literacy, Civics, Agro Science, Economics
MinecraftEdu	Paleontology	Start digging to uncover the fossil and try to determine what kind of dinosaur it is.	Math, Language Arts & Literacy,Earth Science - Dinosaurs, fossils, paleontology
MinecraftEdu	El Camino	Journey Through California Missions	Math, Language Arts & Literacy,Social Studies - History - el camino, missions, california
MinecraftEdu	Pixel Art Coding	Students will invent their own programming language and use it to encode and decode pixel art	Math, Language Arts & Literacy, Engineering,Programming
MinecraftEdu	Graphing Table	Students will use a variety of data collection methods including fishing, archery, and wood chopping. Once they have collected data, they will complete graphs ranging from picture graphs to bar graphs to line plots.	Math - Measurement and Data - Graphing, Language Arts & Literacy
MinecraftEdu	GCF and LCM	Teaching students about Greatest Common Factor and Least Common Multilple while participating in common camp activities like swimming, diving, high ropes, and archery.	Math - Numeracy and Operations - GCF and LCM, Language Arts & Literacy
MinecraftEdu	Number Sentences	Teams collect number and symbol blocks to build number sentences in this tutorial world	Math - Numeracy and Operations - addition, subtraction, multiplication, Language Arts & Literacy
MinecraftEdu	Sky Tree Farm	Students will visit the fabled Sky Tree Farm and use measurement skills, building skills, and cooperation to complete a tree farm. They will then harvest the wood from the tree farm to solve the final quest.	Math - Measurement and Data - Metric Linear Conversions, Language Arts & Literacy

MinecraftEdu	Water Challenge	With few resources for food available, participants must set up a farming operation and feed themselves. To do so they must creatively transport, conserve, and build around the limited supply.	Science - Engineering - Water Conservation, Language Arts & Literacy
MinecraftEdu	Basics of Motion	Students will use three different tasks to calculate speed or components of speed. They will use the mechanics of the game to experience varying situations with moving objects.	Math, Physics - Speed and Motion, Language Arts & Literacy
MinecraftEdu	Hunger Craft	An exploration of Inequity and Social Justice based on Suzanne Collins' Hunger Games.	Language Arts & Literacy, Social Studies - Justice, Humanities
MinecraftEdu	Model Division	The farm is broken up into several sections. Each has many chores for you to complete. Head on over and see who needs your help.	Math- Numeracy and Operations - Division, Language Arts & Literacy
MinecraftEdu	Animal Cell Tour	Explore a massive replica of an animal cell.	Biology, Language Arts & Literacy

Fab Lab Case Studies/Articles

Learning and Leading with Tech

The Maker Movement: A Learning Revolution

By Sylvia Libow Martinez and Gary S. Stager - May 2014

Give your students access to the latest hands-on technologies and permission to invent something that interests them. Then stand back while they transform from passive receivers of knowledge to real-world makers who are empowered to design, build, and share their own amazing artifacts.

Making in the Classroom

Fortunately for educators, making overlaps with the natural inclination of children to learn by doing. The maker movement values human passion, capability, and the ability to make things happen and solve problems anywhere, anytime. Classrooms that celebrate the process of design and making, which includes overcoming challenges, produce students who start to believe they can solve any problem. Students learn to trust themselves as competent problem solvers who don't need to be told what to do next. This stance can be a crucial change for children who are used to getting explicit directions every minute of every day. It can also illuminate for teachers how authentic assessment can really work in the classroom.

The learning-by-doing approach also has precedents in education: project-based learning, Jean Piaget's constructivism, and Seymour Papert's constructionism. These theories explain the remarkable accomplishments of young makers and remind educators that every classroom needs to be a place where, as Piaget taught, "knowledge is a consequence of experience."

Constructionism. Papert's theory of learning provides the theoretical basis for making, which is a stance toward learning that is predicated on the active construction of a shareableartifact. Making asks teachers to create settings where students are, for example, mathematicians rather than passive receivers of math instruction. Papert also introduced the metaphor of "computer as material," part of a continuum of materials used to make tangible artifacts and ideas. This continuum spans everything from common arts-and-craft supplies to cuttingedge technology. Indeed, teachers in our Invent to Learn workshops often begin the day working with cardboard construction to house microcontrollers they'll program later in the day.

Project-based learning. Some of the time-honored practices that were common in classrooms a generation ago—art, music, drama, woodshop, sewing, cooking, playing with and using real tools and craft materials— need to return to the daily experience of children trapped in schools with no time for anything but test prep. For too long, schools have undervalued learning with one's hands. Schools must stop sorting kids into academic or vocational tracks because such distinctions no longer make sense. Many of the same technologies, process skills, and conceptual understandings are found in the physics lab, art studio, and auto shop.

The key to making is using authentic tools to create meaningful projects. It is a natural fit for the STEM subjects or the arts, but historical research, producing documentaries, and writing for an audience are also forms of making. Computers are not required, but they supercharge project development by expanding the breadth, depth, and sophistication of what's possible.

For the first time, students can use their own powerful ideas to create real things, not just make-believe models. Kids can solve real problems with their own inventions. And we can focus technology instruction on providing authentic interdisciplinary experiences rather than isolated tech skills.

Game-Changing Technologies

Our book, Invent to Learn—Making, Tinkering, and Engineering in the Classroom, identifies three technological game changers that are transforming learning and everyday life in the digital age. These tools allow students to solve real-world problems and should be on every educator's radar.

Personal fabrication.

Until recently, the only things you could make with a computer resided on the screen or paper. Today, additive (3D printers) and subtractive (laser cutters, vinyl cutters, computer-controlled mills and lathes) technologies allow users to design an object on the computer and “print” it out in a variety of materials. Websites such as thingiverse.com are teeming with STL files that are compatible with most 3D printers and allow users to “remix” physical objects. 3D scanners can also turn existing objects into computer files that you can then modify and print out into new objects. Kids can print replacement parts for their bikes, limbs for their dolls, or that Lego piece they wish existed. You can already print many of the parts to build a 3D printer on a 3D printer. And soon you will be able to print circuitry with conductive ink that you can turn into objects with embedded microcontrollers. The most significant development in personal fabrication may be 3D design software. Once too complex for most users, now software like cloud-based

TinkerCAD and SketchUp put 3D design within students’ reach. Among other things, this will allow us to concretize mathematics instruction: Instead of having to memorize an abstract formula to calculate the volume of a pyramid, for example, you’ll be able to learn it while creating a pyramid that you can hold in your hand. Physical computing. The ability to embed interactivity or intelligence into everyday objects is another aspect of the maker trend. Robotics may be the bestknown form of this. Robotics kits, like those made by Lego and Vex, hide all the messy electronics and limit you to already set projects and materials. But microcontrollers like the Arduino make circuitry more transparent, increasing students’ understanding of electronics.

They also expand the range of possible projects because you can combine them with items from your environment, such as broken toys, craft materials, or appliance parts, to construct inventions that interact with their surroundings. The community is continually inventing new shields, which are small boards that piggyback on the Arduino to add new functionality, such as wireless connectivity or radio control. If you are a kid armed with downloadable plans, sufficient motivation, and a number of broken refrigerators, you can even build your own Arduino.

Microcontrollers are also surprisingly affordable. They continually increase in power and functionality while the cost remains low—about $25 for the most popular Arduino standard board. The web is also full of free “sketches,” short programs you can use as is or modify to control your projects. To be able to assist students, teachers will need to have a good conceptual understanding of how homemade “squishy circuit dough” to make electrified sculptures. They can create wearable projects by sewing the machine-washable Lilypad Arduino into fabric. And with the MaKey MaKey, they can turn Play-Doh into a keyboard and mouse, create a drum set out of bananas or a piano out of the school’s stairs, and control a Power-Point presentation with a croissant.

Computer programming.

Every child needs experience programming computers, and not just for their future careers. This important skill plays a major role in many other disciplines,and it can give students control over their increasingly technological world. Computer programming even prepares students to be better citizens in an age dominated by debates over privacy, intellectual property, polling, and investment in the computer-based modeling that’s central to scientific inquiry. Advocacy events like the Hour of Code represent progress, but the truth is, an hour of anything is insufficient. Programming is a skill developed over long periods of time. It is like learning to write, paint, or dance. You become a better programmer by programming, and access to a teacher with expertise doesn’t hurt.

A Maker Option for School Computing

The ed tech community is engaged in a seemingly endless battle over what device provides the most bang for your district’s buck—laptops, iPads, or Chromebooks. Yet there is now another option: microcomputers.

Eben Upton was a computer science professor at Cambridge when he grew concerned that computer science majors had little experience making things with computers. He imagined producing a computer so inexpensive that universities could give it away to potential students and ask them to show what they made with it when they visited campus for the interview. This idea gave birth to the Raspberry Pi, a baseball-card-sized $35 Linux computer with USB, composite video, Ethernet, and HDMI ports. Unlike a microcontroller, the Raspberry Pi is a complete computer. You can use it to program microcontroller or interface with them. Connect an old keyboard, mouse, and display, and you're all set to run OpenOffice, Scratch, and other software. You can use it to power your home entertainment system, or you can ask a fifth grader to build a Minecraft server with it. New hardware, like the Arduino Yun and Intel Galileo, combine both computer and microcontroller in the same small package.

The maker movement treats children as if they were competent. Too many schools do not.

Makerspaces for All

Classrooms should embrace the joyful approach of Maker Faires by creating space for kids to engage in complex, personally meaningful projects. But some schools seem more willing to spend a lot of money building special makerspaces or Fab Labs (fabrication labs) to house professional-grade hardware than they are to change classroom practice. The lessons from three decades of computer labs should dissuade us from building a special bunker that kids visit once a week. This is not to say that you should not have a killer makerspace filled with state-of-the-art technology, proper ventilation, and comfy working conditions. But you should keep in mind that every classroom can be a makerspace where kids have the materials, time, flexibility, and support to learn by doing. Educators need to create space for making in their heads as well as in their classrooms. They also need to drop any preconceived biases about who can be a maker. The range of potential projects and constructions available to makers supports a diversity of activities, genders, and learning styles. When presented with multiple activity centers featuring a variety of materials, boys may gravitate to Arduino and girls to wearable computing/e-textiles. Both activities require engineering, circuitry, microcontroller programming, and debugging, and although there may be surface differences in the product, the process is the same. For example, the Flora wearable microcontroller system includes a sewable GPS element that lets your clothing determine your location. Designing a shirt or necklace that warns you of an approaching friend or arrival at your favorite classroom may include more complex engineering and computing challenges than your standard robotics competition, and it may appeal to children who would otherwise miss out on such learning opportunities. Our colleague, Sylvia Todd, age 12, has done as much as anyone to inspire girls to engage in engineering projects through her popular website, Super Awesome Sylvia's Super Awesome Maker Show (makershow.com; see Student Profile, L&L, December/ January 2013–14). Millions of viewers have learned about the joy and power of making from her since she produced her first video at age 8. Scratch (scratch.mit.edu) users have also shared more than 4 million projects online—a testament to the creativity of kids. Much of what is presented as school technology is concerned with doing work more efficiently. But when educators embrace a more expansive view of computing, provide access to a variety of high- and low-tech construction materials, and encourage choice in project selection, a larger population of children will enjoy rewarding computing experiences. These experiences may not result in more professional computer programmers, but they will produce more adults who are capable of understanding and mastering their increasingly technological world. If you care about equity or closing the digital divide, you will advocate for all children to have rich computer programming experiences with a competent teacher.

Time for Change

Schools usually do not consider the worldview of their new kindergartners. Before they start school, many children have already used Skype or FaceTime to communicate with others over great distances. They already know that when they have a question, an answer is just a click away. A kid who has had the ability to Google anything since she was a toddler has a different sense of herself as a learner. Unfortunately, this image of learning as an active personal process may be in stark opposition to what she will experience in a “standards-based” school, where the teacher and textbook are the limits of allowed expertise. When a child can 3D print and program her toys at home, school as it currently exists will feel like an episode of “Land of the Lost.” The maker movement treats children as if they were competent. Too many schools do not. Making builds on each child’s passion by connecting their whole being with constructive materials in a flow that results in fantastic artifacts that almost always exceed our expectations. We want our kids so engaged in projects that they lose track of time or wake up in the middle of the night counting the minutes until they get to return to school. Never before have there been more exciting materials and technology for children to use as intellectual laboratories or vehicles for self-expression. You can empower your students while preparing them to solve problems their teachers never anticipated by embracing the tools, passion, and projects of the maker movement.

GBL Case Studies/Articles

Why Minecraft in the Classroom Matters - By Dave in Home February 16, 2014

From setting up quest missions to explore ancient worlds in social studies to using the game to enable students to recreate famous settings from literature in English, Minecraft is certainly gaining attention as a supplemental tool for classroom teaching and learning.

Don Bloom, a 9th grade science teacher from New York, outlined how he approached using Minecraft to help his biology students understand the DNA extraction process in an article for Edutopia. “I created a student handout to serve as a guide in focusing their exploration. In addition to providing setup instructions to start that exploration, the handout included a checklist for exploring the cell, and questions for students to answer as they interacted with the different chemical tools in the cell.”

Elaborating on the design of his DNA extraction learning experience, Bloom explained, “The questions on the handout provided me a way to assess students. I was able to see if they could make connections back to course content while also getting a clear picture of whether they were able to meet the learning goal and identify the chemicals needed for the lab.”

As a result of supplementing the curriculum with Minecraft, Bloom stated that, “By the end of the activity, [the students] had a clear understanding of the changes the cell goes through during the DNA extraction lab, and when we actually completed the lab, the students felt comfortable talking about it and could successfully explain why we used each chemical.”

Contrast that statistic with how often a student is willing to make errors and persevere in the classroom. Games like Minecraft provide a safe place for experimentation and exploration in learning that isn’t found as frequently when tackling an academic challenge in the off-line company of peers. When we fail in Minecraft, the perceived costs are far less than when we stumble in the physical classroom. Simultaneously, when we learn in a virtual space like the one that Minecraft has to offer, we are able to do so at an achievable challenge level. What this means is that thirty kids can be working with the same software tool that will automatically differentiate instruction for them. And at the end of a given lesson, those same thirty kids will be able to walk away having approached a subject in a manner that felt comfortable for them.

Educators like Levin and Bloom aren’t just using Minecraft with their students because of its popularity and cult following. Instead, they’re using it for the same reasons that others have used promising educational tools and approaches in the past, because it provides students with greater access to learning; immersive, contextualized learning.

Education Technology Success Stories - Darrell M. West and Joshua Bleiberg March 2013

Minecraft

The Internet revolutionized how teachers and students share information. It placed teaching standards, lesson plans, and supplementary materials at the fingertips of teachers. Despite the enormity of this change the technology of instruction has remained static. The Internet has facilitated but not changed the standard teaching techniques: lecture, group work, individual reading, and slide presentation. New technologies have created new media for teachers to instruct students. The computer game Minecraft is the first step in that direction. Minecraft is a dynamic game that has nearly inexhaustible flexibility.

Minecraft is a highly successful “sandbox” computer game. It is open-ended with no defined narrative or game play objectives. Players approach the game similar to the way children play with Legos or blocks. The game play of Minecraft is deceptively simple. On its face players gather resources and build things with those resources. The worlds that Minecraft generates for players are unique and very large. The cubic volume of a Minecraft world is two hundred sixty-two quadrillion, one hundred and forty-four trillion “blocks.” If each block had sides one meter long then a Minecraft world would have a greater surface area than Neptune. 34

The computer-generated worlds of Minecraft reflect many of the same features as Earth. Minecraft has over a dozen biomes including forest, desert, plains, swamp, jungle, ice plains, taiga, mountain, and ocean. Each biome has climate specific weather and the entire planet has a normal day/ night cycle. The world properly simulates gravity and watersheds. Everything in the world consists of blocks, which include different types of dirt, wood, minerals, precious metals, water, and many others. Physics and chemistry adhere to basic principles. Players can gather natural resources to build nearly anything their imagination can conjure. With the proper resources it’s possible to build functional electrical circuits or coal-powered engines. The game creates a reasonable facsimile of Earth with its bountiful resources and laws of nature. 35

Minecraft has several features that allow it to serve as a teaching tool. The game has a modification or mod called MinecraftEdu. MinecraftEdu gives teachers the tools to conduct a lesson in a virtual world. The mod allows teachers to place text around the world and control the location of students. 36 A community of teachers and educators has grown to support teaching on the Minecraft platform. They have created a dedicated Minecraft teaching wiki including lesson plans and research. 37

As a teaching platform Minecraft has tremendous potential. In social studies, students could build their own pyramid and during the process encounter the same engineering challenges as the Egyptians. Students could recreate scenes from literature. Teachers could demo the principles of biology, physics, and chemistry in real time. Minecraft enables students to engage in constructivist learning. According to constructivist theory, students that engage their environment gain trustworthy information through their own exploration. The Minecraft simulations provide an intellectual playground that encourages authentic learning. MinecraftEdu provides a brand new instructional media.

Jeffrey Adams is a middle school science teacher at the Crescent School in Toronto. Adams used Minecraft to teach a lesson on sustainable planning. Students were asked to create a model of a sustainable city that used little energy. Many of the students chose to build their models virtually in Minecraft. Students were able to build their cities as they saw fit and were given a particular role of farmer, builder, or miner. Adams wanted to find if using Minecraft would increase engagement and performance. Towards that end he administered a survey before and after the unit. Eighty-six percent of students reported they wanted to use the game again in school. Eighty percent believed that gaming allowed them to be more creative and do things they couldn’t have done otherwise. Overall the students found the Minecraft format liberating. 38

Karen Yager and Andrew Weeding are teachers at the Know Grammar School in Sydney, Australia. They used Minecraft in her classroom to teach 12-13 year old boys in a science class. Students were asked to create a model of a city that used little energy. Students were free to choose their presentation format and nearly all (ninety-six percent) chose Minecraft. They had five days to build their virtual cities and had daily challenges in English, mathematics, science and foreign language to ensure the project was multidisciplinary and to keep the students focused. Students then presented their virtual cities at the end of the unit. They found that the boys enjoyed the freedom to explore and take risks within a structured environment. 39

Professor Jessica Bayliss used Minecraft as a teaching platform in her class Game Artificial Intelligence at the Rochester Institute of Technology. Students in the class had to create new terrains and non-player characters in addition to other tasks. College and graduate students were able customize the game extensively. The source code for the game is in Java which is a common programming language. In addition, the extensive modding community provided creativity and support. Bayliss had taught the course using other software platforms in the past but found that students responded better to Minecraft. 40 Bayliss found that using Minecraft increased student motivation for artificial intelligence through modding. 41 She notes that a higher number of students asked to complete AI-related independent studies than in past years. Students were able to engage the Minecraft platform and their own creativity.

Minecraft succeeds as a game for the same reason that it succeeds as an instructional tool. It builds upon a context familiar to everyone or the rules of nature. Keeping the game simple allows for players to engage in authentic learning. The constructivist base allows individuals of varying skill levels including elementary school and graduate students to learn from the game. This dynamic classroom will provide teachers a new instructional technology. As MinecraftEdu matures the opportunities for learning will only increase.
