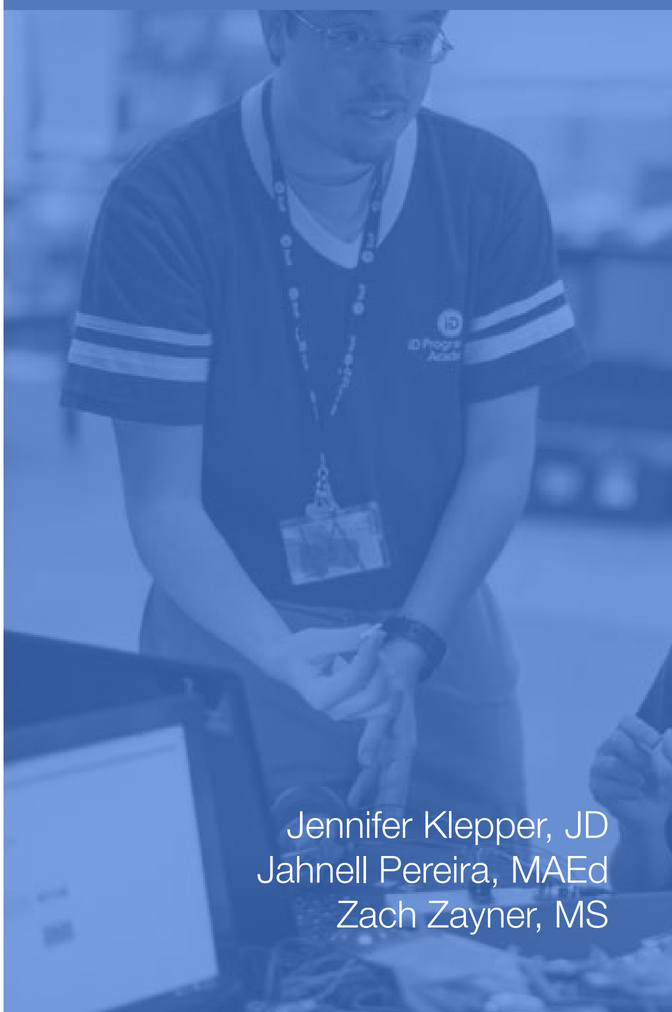
Maker Education

Effective Implementation in 21st Century Classrooms

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Maker Education:
Effective Implementation in 21st Century Classrooms

Maker Education tends to be seen as something that is relegated to superfluous activities that are considered to be “high engagement” but do not contribute to increased rigor in the traditional classroom. This does not have to be so. One core tenet of Maker Education is applying critical thinking skills across a problem through hands-on creation. With properly created problems and projects, Maker Education can be a considerable part of the day-to-day activity in the classroom and can enhance the evaluation process through inclusion of multiple standards and objective assessments in a single, overarching framework. This paper discusses the value of Maker Education, the obstacles to its integration in schools, and the keys to preparing and planning for its successful implementation for the benefit of both teachers and students.

What is Maker Education?

Playfulness, Experimentation, Iteration, Collaboration, and Innovation

Dale Dougherty, the founder of *Make: Magazine,* is frequently credited with helping to start the Maker Movement. Dougherty writes in a chapter titled “The Maker Mindset” (Honey & Kanter, 2013) that the origin of the Maker Movement is “experiential play,” which comprises “trying to take things apart,” trying “to do things that even the manufacturer did not think of doing,” and “giving it a try.”

Trying is risky, and risk can lead to failure but also iteration and innovation. Another core tenet of Maker Education is that all students can be challenged and can grow, and that in pursuit of this goal, we build a safe space where failure is a fundamental possibility. A failed experiment is not an end, as with a standardized assessment, but rather a challenge to try again. Students can make (or attempt to make) a product that accomplishes something they previously thought might not be possible or to modify an existing product in a way that the original product creator never imagined.

The involvement in the creation of a product from concept to reality teaches valuable lessons about resourcefulness and persistence, helps students identify as learners and own their learning, and provides them with the opportunity to demonstrate their mastery of a series of objectives without the traditional summative test assessment. Maker Education stresses this approach — where student choice is front and center — and addresses the "When will I ever use this?" sentiment often expressed by students, particularly in traditional STEM subject areas.

Why does Maker Education matter?

Challenge: Achieving Differentiation and Engagement in Today's Classrooms

To create a nation of successful critical thinkers, we need to give all students the tools to analyze and solve problems in creative, innovative ways. This means redesigning some of the core pieces of our classrooms and asking ourselves, “How do we design a curriculum that works for all students?”

Teachers often have a range of functional grade levels in their classrooms, making it a steep challenge to teach lessons that meet the needs of all students. Couple this with the need to engage all learners and assess them toward pre-set milestones, and suddenly traditional classroom structure appears to demand these goals compete with, rather than complement, one another. To differentiate in our classrooms, we must have a system of evaluation that scales with the variety of students in our classrooms.

Maker Education allows teachers to create hands-on projects that engage students in a variety of social and academic skills, meeting state standards and classroom objectives. Each project can be tailored to the needs of the class. Imagine an art project where students create an electronic light sculpture and then program designs to appear using a state standard for decimals … or a history project where students create a map that lights up key locations and plays a recorded sound file to explain the events that took place there. In each of these activities, students are able to display understanding in more than one way, with organic, cross-curricular connections that may not happen in a more traditional setting.

This is why Maker Education matters. It opens doors for new methods of teaching and learning by combining a range of objectives into a single project. It allows the open-ended creation of a product that gives participants a choice in the execution and shows them that mastery can be demonstrated multiple ways both inside and outside the classroom.

Challenge: Developing College- and Career-Ready Students

It is this connection to the “real world” that further elevates Maker Education. Students' creation of a product can be a more simplified version of the expectations of a team in that career field. Whether using a microprocessor board or a 3D printer, students create products with real materials and learn by making. The implementation of programming, mathematics, building, design, and social process to solve problems and create solutions mirrors situations that students will encounter in their future. Maker Education provides students with authentic experiences while they accomplish set objectives to show mastery.

This approach can transform the traditional classroom mindset from a single summative evaluation to a series of smaller assessments using student-created products that build on one another and culminate in a more substantial final project. This is where Maker Education excels.

What are some of the obstacles for Maker Education?

In many schools there are still barriers to Maker Education's potential for positively impacting academic achievement. For educators, upfront obstacles to implementing educational tools and concepts in the classroom can be categorized into three areas: (1) academic expectations, (2) implementation, and (3) funding. Each area poses unique issues that must be navigated successfully to integrate Maker Education into the traditional classroom.

Academic Expectations

Academic expectations can become a quagmire when coupled with meeting the needs of students. Educators need to be able to provide students with multiple types of opportunities to demonstrate mastery of standards and objectives. The integration of Maker Education supports key academic standards — particularly in terms of making sense of problems and developing solutions; abstract and quantitative reasoning; applying math to everyday life, society, and the workplace; numeracy; measurement and data (including data visualization); and core cross-cutting concepts and skills. In literacy, Maker Education often involves presenting projects and concepts; providing detailed written explanations, describing procedures, or discussing an experiment; and integrating technical information and visuals into written work. Due to this connection to core content, Maker Education is effective at demonstrating mastery, can be used as a formative or summative assessment, and can impact student engagement.

Traditional test-focused curriculum cannot meet student needs and academic expectations on its own through stagnant summative evaluation. Maker Education offers a dynamic, differentiated, project-focused solution. It does not need to replace curriculum already being taught because educators can use Maker Education to modify and redefine lessons to make them substantially more effective (Puentedura, 2014).

Implementation

Implementation of Maker Education still carries a certain mystique. It is circuit diagrams and programming and 3D printing — subjects that are outside the realm of many classroom teachers' experience. Teachers who already feel pressure to complete their mandated curriculum and evaluate student mastery of standards in an efficient and effective way may balk at learning another skill or incorporating a new technology. Fortunately, Maker Education is more accessible than it has ever been, both for educators and students, as we will explain in detail later in this paper.

The key to properly implementing Maker Education is working with the end in mind. What will we achieve with this project, and how can we use an authentic task to create ways for our students to show mastery of several standards so we do not compromise our timeline?

Funding

In the case of Maker Education, many of the necessary materials and equipment can be used across disciplines, grades, and even schools within a district — and are not limited in the way that subject-specific consumables often are. Materials can be reused and recycled, and students can even create robots and other projects out of household "trash."

When an item such as the SparkFun Inventor's Kit (SIK), an introductory Arduino microprocessor kit, is made available to a wide audience of educators in a building, that kit can become many different tools depending on the classroom. In an art classroom, it may be used to create a light sculpture; in a science classroom, a modeling device; and in a technology classroom, a programming platform. This open door is not constrained to programming and microprocessors. Most maker-based platforms lend themselves to this type of flexibility, where they can move fluidly across curricular lines, thus deepening and enriching the impact of targeted funding efforts.

Because Maker Education typically involves not only materials, but professional development and curriculum, several funding sources are available to support schools and districts. Federal funding has been flowing for innovation in schools over the past several years — including Race to the Top (which gave preference to applicants whose efforts included closing the gap for girls in STEM), an increase in NSF grants, and the i3 grants. For Maker Education, several funding streams are available, including 21st Century Community Learning Centers, Ed-Tech State Program Funding, STEM funding, Title I, and Title II (for the professional development component). Additionally, after a multiyear lull, Career Technical Education (CTE) funding seems to be gaining some traction with continued investment in 2016.

How does Maker Education happen successfully?

When adopting a Maker Education program, implementation planning is a critical factor in meeting academic expectations, achieving successful implementation, and validating funding decisions. Three key considerations are professional development, instructional/curriculum support, and selecting the right materials. Each of these pieces works together to culminate in an effective and engaging Maker Education program.

Professional Development & Training:

Preparing Teachers and Administrators for Maker Education

Even for those completely in tune with STEM/STEAM education, electronics, and engineering, Maker Education may be new. Providing professional development for educators — from implementing materials/curriculum to more general topics — can increase confidence, buy-in, and implementation quality.

Overall Technological Literacy (Professional Development)

With the technology landscape constantly growing, building the technological literacy of educators is an ongoing commitment. Ensuring those involved in Maker Education are confident that they know both the how and the why of Maker Education is critical. Typical topics addressed in professional development for Maker Education are:

- What is Maker Education?
- Making a Makerspace
- Code and Hardware
- Internet of Things (IoT)
- E-Sewing/E-Crafting
- Robotics in Schools
- Preparing for Actual Implementation (Training)

Many schools and districts are aggressively working toward technology implementation. All too often, however, training is an undervalued part of implementation. Numerous examples of this can be found across the country as iPads®, Chromebooks, and instructional software go virtually unused because educators have not been trained to use them. Ensuring high-quality implementation training for all educators involved in Maker Education, including the administrators and coaches supporting the implementation, is recommended.

Typically, this type of training occurs prior to implementation and — depending on the implementation type and the educators being trained — can be completed in anywhere from a half-day to two days. The content of the training is usually based directly on how to implement the specific materials/curriculum purchased. Outcomes of this type of training are that participants understand the goals and pedagogy of the content being taught, how to implement/teach the specific materials and curriculum being used, how to measure success, and how to access support materials during the course of implementation. This type of training may also include ongoing support such as refresher sessions, guidance in next steps, classroom observation/coaching, or data analysis meetings.

Support Along the Way

In addition to live professional development, many online resources exist to support educators involved with Maker Education — from video concept libraries that provide multimedia support to help students (and teachers) understand complex concepts to project/tutorial libraries where teachers can get inspired and access hundreds of meaningful maker projects for their students.

Instruction/ Curriculum:

Ensuring Teachers Have Support for Implementation

"Current science curricula fail to frame the relationship between science and technology as a symbiotic relationship and thus fail to understand that technology education creates a space for science education" (Bullock & Sator, 2015). Maker Education brings science and technology together with the flexibility to fit different modes of implementation: as supplemental projects within core content, as part of a makerspace within a school, or as part of a STEM/STEAM curriculum.

The supplemental/project model can infuse any classroom with electronics projects and activities to teach curriculum concepts and standards. This implementation can occur in any classroom — including science, physics, engineering, art, humanities, math, English, and social studies — and supports meeting key academic standards through project-based learning. The lessons and instructional support in this model of implementation involve projects that can last one day to several weeks.

The makerspace model creates a space within a building where students can build independently or where teachers can bring their classes to work on projects. These spaces can vary significantly — from mobile makerspaces, to a corner in a classroom, to space within a library, to an actual lab. The focus of this model is typically to provide a "space" where students can access hands-on learning materials. Usually, there is a "maker expert" on hand to support students and teachers in using these materials.

The curriculum model typically occurs when there is a larger unit or full course that entails the principles of engineering and design. One example would be electronics engineering, in which the main focus is supporting students as they master electronics standards and explore the world of programming hardware. The curriculum associated with these courses mirrors that taught in a core content area — with a scope and sequence, standards alignment, assessments, and day-by-day lesson support.

Materials:

Maker Education Involves Making Things

The initial instinct of many schools starting a Maker Education program is to purchase a 3D printer. Experience shows, however, that a truly beneficial makerspace makes much more available to the school than just this technology. Educators should plan for the makerspace, selecting projects to implement that will help achieve the desired learning outcomes. Problem is, the options can be overwhelming. From programming and robotics to sensors and wearables, there are hundreds of kits and thousands of components geared toward introducing electronics to students with diverse interests and skills. Seeking knowledgeable Maker Education-focused companies who provide professional development and curriculum is a difficult task.

SparkFun Education (www.sparkfuneducation.com) is one such company that can bridge the initial gap for educators. With an experienced staff of engineers and educators, SparkFun Education provides professional development, training, and long-term implementation support through a wealth of ever-evolving content in the online InventorSpace community.

Where do I begin with Maker Education?

To broaden the scope of Maker Education, or to implement it for the first time, educators should look to where they can truly redefine areas of a curriculum that need more engagement. Then comes the planning stage and deciding on an appropriate professional development/training/support strategy.

Public focus on Maker Education often centers on flashy technology, but it is more than just that. Maker Education is about building educational experiences that are based in the real world, that allow student choice, and that achieve multiple objectives. While crafting and monitoring these experiences may sound daunting, today's educators are the beneficiaries of robust digital communities and experienced companies that recognize their products can be used to inspire and educate the next generation of inventors and world changers.

SparkFun is one of those companies building free-to-use platforms where educators can meet and share project-based lessons that are engaging and standards-compliant. These platforms allow remixing of lessons to build custom content that can fit any classroom and inspire student projects that redefine strategies for achieving educational objectives. Perhaps the most exciting thing about Maker Education today is that it is not only students who are being inspired, but also the very educators who are so critical to their development and future success.

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