Harnessing the Potential of Innovative STEM Education Programs: Stories of Collaboration, Connectedness and Empowerment

Case Studies of STEM Education Projects in Milwaukee and Rural Ohio

The NEA Foundation Report

September 2012
ABOUT THE NEA FOUNDATION

The NEA Foundation is a public charity supported by contributions from educators’ dues, corporate sponsors, and others who support public education initiatives. We support student success by helping public school educators work with key partners to build strong systems of shared responsibility. Visit neafoundation.org to learn more.

ABOUT THE NEA FOUNDATION REPORTS

Reports issued by the NEA Foundation provide in-depth coverage and analysis of innovations designed to increase teaching effectiveness and student achievement. Selected innovations are drawn mainly from the NEA Foundation-funded sites.

ACKNOWLEDGEMENTS

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Dear Colleagues:

With generous support from the AT&T Foundation, the NEA Foundation funded innovative programs, in Milwaukee, Wisconsin and Appalachian Ohio, aimed towards strengthening systemic, instructional efforts to improve high school STEM (Science, Technology, Engineering and Mathematics) achievement. The STEM projects in these communities empowered educators to develop and use proven practices to deliver rigorous, engaging and relevant learning opportunities and curriculum for their students. As a result, we have gained a critical understanding of how we can best ensure that American high school students are prepared for the next level of education.

This case study shares the best practices from each site, and provides examples of how we can work together to improve STEM teaching and learning for all high school students.

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Introduction
The NEA Foundation and The AT&T Foundation
The NEA Foundation and the AT&T Foundation

As demand for the United States to remain competitive on the global stage continues to grow and public school systems and schools face continued budget cuts, the NEA Foundation has emerged as a champion for the critical work of teachers. Among other efforts, by providing the funding necessary for targeted science, technology, engineering and math (STEM) education that provides critical college and career readiness skills, the Foundation has supported the success of two dynamic programs that have had tangible success in and out of the classroom.

The lessons and possibilities presented by the success of these programs have much to offer other sites across the country that are turning focused attention toward effective STEM teacher professional development and innovative instruction for student achievement.

The notion of effective STEM education as a national imperative is driven not only by a desire to remain competitive globally but also to serve existing workforce needs. According to a report released by the U.S. Congress Joint Economic Committee in April 2012, “[despite] the clear demand for STEM talent by domestic employers, the U.S. is failing to produce an ample supply of workers to meet the growing needs of both STEM and non-STEM employers…”1 As we march farther into the digital information age, the need to meet this existing demand for talented and prepared STEM employees will only increase.

Ensuring effective STEM education and engagement, particularly for those educators and students who lack resources and exposure to STEM learning opportunities, is essential not only for our next generation of scientists, engineers and STEM teachers, it is key to our nation’s continued prosperity, security, health and quality of life. The following stories of two innovative STEM education programs in Milwaukee and rural Ohio offer important lessons and insightful possibilities toward the creation of systemic change in STEM education in cities and regions across the United States.

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Core Themes

The successes achieved in both sites demonstrate that dynamic and experiential STEM teaching and learning can have an incredibly positive impact on educators, students, schools, and communities. While the details of project focus and implementation in Milwaukee and Ohio are markedly different, the following themes emerged and remained constant through the process of content discovery:

☑ Experiential Learning: 
The process of making meaning from direct experience
By engaging students in hands-on STEM projects, teachers are facilitating learning beyond core subject matter. In Ohio, students are visiting local outdoor environments to learn about the lasting effects of mining—and what can be done to reverse the damage. They are experiencing what it means to make a difference to their environment through STEM project work, physically collecting samples, tracking changes, and seeing results.

☑ Professional Development: 
Educators having the opportunity to learn more about their work and best practices
Teachers are connecting with each other in order to develop their curricula, share resources and best practices, and learn how to best support each other in this work. In Milwaukee, first-year teachers in the aquaponics program are able to reach out for guidance from veteran teachers who have been through the program. This allows them to create a stronger curriculum with more of an impact for students.

☑ Professional Connections to Local Industry and Academia: 
Building critical relationships for sustainable career-themed teaching
Students and teachers in both Milwaukee and Ohio are connecting with professionals in their respective fields of study. In Milwaukee, students and teachers are being exposed to businesses and community-based organizations that are revitalizing the local environment through urban farming, specifically aquaponics. In Ohio, students are meeting individuals who are on the front lines of the environmental cleanup effort, making the connection to STEM-based careers. In both sites, teachers are afforded the opportunity to engage with local institutes of higher learning and professional subject matter experts.

☑ Access to College and Career Pathways:
Ensuring that students are ready for their respective next steps
In both Milwaukee and Appalachian Ohio, there is a gap between high school graduation rates and college and career success. The programs in both sites are connecting students to local postsecondary institutions through field trips and on-site learning opportunities. These connections are showing students that they can stay in their area and remain connected to their community while successfully pursuing exciting STEM-based careers.

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A Collaborative Opportunity
Project Overview
In 2008, the NEA Foundation received funding from the AT&T Foundation to strengthen systemic, instructional efforts to improve high school STEM achievement. Since then, the partnership has funded dynamic STEM projects across the United States. Grant-funded projects focus on at least two of the following criteria:

- Provide innovative opportunities for teachers to deliver rigorous content to students
- Support teacher knowledge and growth with their colleagues and community partners
- Deliver relevant and engaging instruction through experiential learning opportunities
- Connect community assets and resources in pursuit of increased student achievement

Two project sites have stood out in their dedication to STEM education and the connection of their work to their local communities:

✅ Ohio Appalachian Educators Institute (Ohio)
In rural Appalachia, this project brought together a diverse group of teachers to engage in a STEM education immersion experience unlike any other. As a result, students are empowered to learn about alternative energy, mechanical engineering, and environmental sustainability directly linked to their geographic region and local environment.

✅ Milwaukee Public School System (Milwaukee)
As Milwaukee is emerging as a frontrunner in the urban farming movement, this project involves a select group of teachers that work collaboratively to cultivate a unique aquaponics program in public schools across the city. Through this work, known as the Urban School Aquaponics Initiative (USA), students are learning about safe, local and sustainable food sources and deepening their engagement with the local community.

In both Milwaukee and Ohio, the initial project concepts have grown over time into self-sustaining programs that have had positive unplanned impact and will continue to function once the grant funding has run its course.

The following case studies provide an in-depth exploration of these themes.
Education ‘STEMs’
Community Engagement for Students
Appalachian Ohio
Appalachian Ohio has a rich cultural history of connectedness to its geography and environment. Minerals such as salt, iron ore, clay, and coal are abundant in the area, and mining of these resources has historically been a major source of income. The geographical remoteness of the region, however, has created a sharp disparity in educational access, providing a unique set of challenges and opportunities for implementing an effective STEM education project.

The Ohio Department of Education (ODE) classifies Appalachian schools as rural and high poverty. ‘As a group, they have higher-than-average poverty, the lowest average median income level and the lowest percent population with a post-secondary degree.’

While college attendance rates continue to rise in the state and across the nation, there is an intentional, increased focus on the alignment of STEM education with college and career pathways specifically in the Appalachian region of Ohio. Teachers like Kimberly Lewis of the Buckeye Hills Career Center, a local career and technical training resource, understand that school is the place where many students have the opportunity to engage in STEM education that may lead them to college and a career in that field. In a 2011 interview, Lewis emphasized, “...in rural areas like this one, it’s important that we do these things. We take it for granted that everyone has easy access to the Internet, but I have students who don’t even have computers at home because of poverty and/or remoteness.”

The STEM engagement project in Ohio addresses the disparate access to resources and scarce opportunity for the professional connectedness of teachers by bringing together a diverse group of teachers to engage in a unique STEM education immersion experience. From this initial shared professional development, further supported by the oversight and resources provided by project coordinators, teachers create exceptional experiential STEM learning opportunities that empower students to learn about alternative energy, mechanical engineering, and environmental sustainability directly linked to their geographic region and local environment.

— Access & Success – Appalachian Ohio, 2009 report

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4 OAEI Year Two Progress Report

5 Phone Interview with Kimberly Lewis, 2012
The Ohio Appalachian Educators Institute (OAEI), a key project partner, serves its mission to address disparities in educational access by providing district leaders, principals and teacher leaders the necessary skills to lead desired change at the district, school and classroom level by building capacity for improved instructional practice. As a local hub for educator professional development, OAEI works in partnership with Ohio University, another key project partner. Beyond the initial professional development provided by OAEI, Ohio University facilitates professional development and provides content and logistical support for teachers participating in the project.

Collaborative Professional Development

In August of 2009, OAEI brought together eight math and science teachers from five rural, public high schools, for four days of working with scientists and researchers in the advanced energy laboratories at Ohio University. Teachers learned about the past, present and future of energy use in the region, from coal to natural gas, wind and solar power, and learned how to incorporate these projects into their own curricula. What began as a professional development opportunity for area teachers to make connections and enhance STEM education in their classrooms blossomed into a vibrant, multi-faceted program.

OAEI convened the group of teachers with three distinct goals:

1. **Increase teacher content knowledge in science**
2. **Provide teachers with a direct experience of science application**
3. **Promote the development and delivery of rigorous content to students through experiential learning that is aligned with the Ohio Academic Content Standards**

The initial professional development experience grew into four distinct project implementations in four schools, where in different ways teachers use hands-on STEM projects to engage students, and to create buy-in and connections to the local college and career opportunities. Each teacher has taken resources and networking connections forged through the project and created his or her own unique applications, based on environmental needs, such as better fuel combustion, watershed cleanup efforts, and the re-use of discarded electronics.

Experiential Learning in Robotics

Larry King is a veteran teacher who has experimented with project-based STEM instruction for many years. The focused STEM professional development and project funding afforded him the opportunity to expand this work by providing additional exposure to and interest in the STEM subject he’s most passionate about: Robotics. King’s goal is to help create a foundation for college and career access for his students by connecting them to the elements of fun in STEM education. He has accomplished this through his approach to hands-on experiential classroom learning and unique robotics curriculum, integrated into his existing Physical Science instruction that directly appeals to his students’ curiosity and desire to play while imparting key tenets of physics, engineering and solar power.

It is often the misunderstood kids who find a place to blossom in this program. Kids find an avenue for expression that they haven’t had before. A lot of them have never had any hands-on projects in the STEM area and this opens up their eyes to a whole new world.

—Larry King, Physical Science Teacher, Warren High School

To leverage the excitement King saw in his Physical Science students during the school day, he expanded his Science Builders Club, an afterschool activity for students interested in advancing their mechanical skills and having fun with STEM projects by investigating advanced energy ideas, including how to generate and cook with hydrogen gas created through electrolysis, and creating a solar powered haunted house. This year, Science Builders Club students worked tirelessly with King after school and on weekends to coordinate and execute the first annual Weird Science Carnival, a ‘part-carnival, part-science museum’ that drew more than 200 local children and adults to engage with over 40 interactive projects.

STEM is fun because it builds bridges with problem solving—YOU make the path.

—Student, Warren High School

Exhibited projects were built by students and demonstrated different facets of STEM learning. All projects integrated elements of physics, chemistry and engineering including a hand-built ‘chair of nails’; a BIG BANG Booth demonstrating firsthand evidence of the Universal Background Radiation; a Bird Bomber Booth allowing students to drop a “load” on a target by anticipating Newton’s First Law; and a Theramin stand that encouraged carnival-goers to play an eerie musical instrument without touching it by manipulating electrical fields. These interactive projects, conceived and developed by students, empowered students to show their learning to their families, friends, and communities through something much more tangible than a test score. Further, proceeds from the event will fund Science Builders Club field trips and activities for years to come. King intends on holding this event each year, as the excitement and energy around this event were tremendous for students and the community alike.

Why Students Love STEM: Appalachian Ohio Public Schools Part 1
http://www.youtube.com/watch?v=_Y5CYwW8Blk&feature=youtu.be
## Access to Career Pathways

Kimberly Lewis is a science instructor at the Buckeye Hills Career Center, a non-traditional district wide resource for career and technical training and instruction. Lewis’s project activities focus mainly on alternative energy technology, including the use of waste projects from wood as fuel. Since the structure of Buckeye Hills only allows students to attend classes part time, students choose voluntarily to participate in the activities that Lewis coordinates.

Through the professional development offered by OAEI and Ohio University, Lewis was able to connect with a local engineer, who has become a project mentor for her students, visiting her classes and offering valuable real-life experience to the projects that the students are working on, such as creating wood pellets from sawdust (a local, renewable and low-cost fuel) and combustion chambers to test their effectiveness. This contact meaningfully exposes students to real life local professional experience in a STEM field. Further, students are given the opportunity to explore and understand what it means to be an engineer firsthand, thus gaining insight into a realistic local career path in STEM.

Lewis has also involved her students in SkillsUSA, a national organization that connects students with career opportunities, and their SkillsUSA championships, which encourage creative thinking and healthy competition. Her students are eager to take their projects from her science classes and showcase them in different categories, such as Engineering Technology. They designed a ‘wind cube’, which takes advantage of the roof design of residential buildings to generate wind power. An engineer from Athens, Ohio, served as a consultant to this group, solidifying the real-world professional connections to the work.

### My teaching methods really haven’t changed but what now have are new people to collaborate with and my students also have these people as resources.

—Kimberly Lewis, Science Instructor, Buckeye Hills Career Center

Beyond project activities, as a result of the positive momentum and energy around the project and related connections with other teachers, Lewis is empowered to maintain her dedication to experiential learning and STEM education. In addition to her work in the classroom, she has created a professional development group for other teachers in the area. STEM-STEM (where the second ‘STEM’ stands for Second Tuesday of Every Month) is a collaborative learning environment where teachers meet each month to discuss the STEM work in their classrooms, advancements in the field, and other professional opportunities. Through this opportunity, Lewis has enhanced her classroom environment by creating a self-sustaining designated space for professional learning that allows her to understand and implement the effective ideas of her teacher peers.

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**Why Students Love STEM: Appalachian Ohio Public Schools Part 2**

[http://www.youtube.com/watch?v=od6tQ-bPyRM&feature=relmfu](http://www.youtube.com/watch?v=od6tQ-bPyRM&feature=relmfu)
Connection to Local Industry and Environment

Troy Weaver is the sole chemistry teacher at Vinton County High School. Through the project tapped into local natural resources as a backdrop for his curriculum. At the Raccoon Creek Watershed, his students participate in project-based activities such as fish shocking and water testing. The Raccoon Creek Watershed is an area that has been adversely affected by acid drainage after more than a century of coal mining in the region. Through the project, Weaver has coordinated a series of trips for teachers and students to work with a number of partner organizations dedicated to raising the water quality. Students are learning various methods that scientists and watershed groups utilize to monitor the quality of the watershed, including water chemistry and fish sampling.

The most significant change has been STEM taking hold in my curriculum and in the mindset of being permanent, rather than an optional course or special elective.

—Troy Weaver, Chemistry Teacher, Vinton County High School

In his work, Weaver creates in students a genuine interest in science that will lead to college and career pathways tied into leveraging the geographical context of the Appalachian region. Most of Weaver’s students are at-risk and benefit from knowing that there are local career options in the science field. Weaver has seen these experiences have a profound effect on his students, for as these field trips are changing from ‘optional’ or ‘special elective’ to a permanent part of his curriculum, students are expanding their understanding of STEM education to include hands-on projects. He is teaching them that ‘science is doing’ and connecting them to their local environment at the same time. Students have been introduced to individuals in the field who have made this work their profession. This lets them know that there are careers in this field, that they can continue to work in this area, and eventually make a living in a STEM career.

Impact on Teaching and Learning

The approach to STEM education in Ohio is focused on experiential learning, environmental impact, workforce development and connections to community. Each of the teachers have used the professional development and connections afforded them through the project to provide their students dynamic academic challenges while simultaneously creating pathways to college and career success. Through coordinated and focused professional development opportunities, educators are visiting local colleges where professors are expanding on this work.

The resources, materials and partnerships gained through this project will allow for continued work in STEM education in rural Ohio. Kimberly Lewis’ STEM-STEM group will continue to meet, enabling more and more teachers to have access to the resources and lesson plans needed to proliferate this work. New classes of students, excited to experience what their peers have learned in and out of the classroom, will benefit for years to come.
Urban Farming and the Power of Community Partnerships
Milwaukee, Wisconsin
Urban Farming and the Power of Community Partnerships: Milwaukee, Wisconsin

Milwaukee, known traditionally as a manufacturing powerhouse, is quickly emerging as a frontrunner in the urban farming movement, a multifaceted and growing industry that addresses resource and economic, environmental and food security challenges within a defined urban population. Urban agriculture is a complex system encompassing a spectrum of interests, from a traditional core of activities associated with production, processing, marketing, distribution, and consumption, to a multiplicity of other benefits and services that are less widely acknowledged and documented. These include recreation and leisure; economic vitality and business entrepreneurship; individual health and well-being; community health and well being; landscape beautification; and environmental restoration and remediation. Since urban farming has a stake in every facet of the community it serves, the topic is an ultimate focal point for a project designed to increase local STEM engagement among teachers and students.

This is a science-based kind of learning. When students get involved, they really become passionate about it. For kids to learn about their food systems, it has to be hands-on, and that leads to academic excellence.

—Will Allen, Founder and Chief Executive Officer, Growing Power

The urban agriculture movement demonstrates its impact on the ground through the work of community-based organizations. In Milwaukee, organizations such as Growing Power, and Sweet Water Organics are committed to creating a new job market for the city, while simultaneously lessening their environmental footprint by growing produce and fish for the local market. Growing Power, a key project partner offering site demonstrations and professional development to participating teachers, is a local organization that supports and facilitates the development of community food systems that provide high-quality, safe, healthy, and affordable food. Sweet Water Organics, an urban fish and vegetable farm that strives to become a resource for job creation, is another key project partner providing hands on training and access to project resources for teachers and students.

In their work, both partner organizations utilize aquaponics, the symbiotic cultivation of plants and aquatic animals in a recirculating system, and are connected to the larger urban farming movement through the Great Lakes Water Institute (GLWI). GLWI is a University of Wisconsin System research facility operated by the School of Freshwater Sciences at the University of Wisconsin-Milwaukee that provides a focal point for research, education, and outreach aimed at a thorough understanding of state and local aquatic and environmental resources. Through the STEM project, these partners connect directly with local high schools to empower the development of a future local workforce.

Why Students Love STEM: Milwaukee Public Schools Part 1
http://www.youtube.com/watch?v=yuligbHw998&feature=related

The USA Initiative: Building STEM Competencies Through Aquaponics

Karen Green, curriculum specialist at Milwaukee Public Schools (MPS) and STEM project coordinator, developed the Urban Schools Aquaponics (USA) Initiative in the summer of 2009 after hearing a presentation about urban aquaponics offered by GLWI. Since a number of MPS high schools have an agricultural background and have offered agriculture programs and curriculum in the past, this kind of teaching and learning fit in with existing school and classroom structures. Over the past two years since the project’s inception, the USA Initiative has afforded teachers the ability to learn how to build their own aquaponics systems, design a thorough aquaponics curriculum, and create a self-sustaining educator mentor program. As a result, in addition to actually growing safe, local and sustainable food, students are learning how to build the systems themselves, take care of the animals (fish and turtles, for the most part), and monitor all changes.

In Milwaukee, there are 29 public high schools serving around 22,000 students in grades 9-12. Only 67 percent of high school seniors graduate and 82.6 percent of students qualify as low income. The USA Initiative engages these students in their local community and empowers them to succeed in STEM careers through exposure to and direct experience with aquaponics. Further, the USA Initiative has a singular goal of strengthening systemic, instructional efforts to improve high school STEM achievement.

To achieve this goal, the schools involved with the USA Initiative have seven objectives:

1. Continue to develop and refine a model for implementing aquaponics education in MPS
2. Provide innovative experiential professional development opportunities for teachers through partnerships with community organizations and academic institutions
3. Build a professional learning community of teachers focused on effective instructional practices through urban aquaponics education
4. Support teachers in the development and implementation of rigorous, relevant STEM-based curriculum for students, including experiential learning opportunities
5. Provide coaching professional development to build capacity for urban aquaponics education
6. Conduct action research to evaluate the effectiveness of the USA Initiative in improving student interest and achievement in science and STEM to close the achievement gaps
7. Provide students with service and experiential learning opportunities to ‘green’ their schools and communities, including exploration of careers in related STEM fields

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Collaborative Professional Development

One of the greatest strengths of the USA Initiative is that it connects participating teachers with local businesses, community organizations, and post-secondary institutions. Green, the developer of the USA Initiative, matches first-year teachers with mentors and coordinates dynamic professional development opportunities through local businesses and organizations.

At Growing Power, teachers participated in the From the Ground Up! Workshops, “intensive, hands-on trainings offering diverse groups the opportunity to learn, plan, develop, operate and sustain community food projects. Project participants leave the workshop with improved skills that they can take back into their communities and pass on to others.”9 This opportunity, paired with a graduate-level course from Milwaukee-based Cardinal Stritch University on environmental education, Aquaponics, Sustainable Futures-From the Ground Up, has given teachers the tools necessary to build their own systems, create lesson plans and most importantly, make connections for continued professional development.

Both the highly motivated and less motivated kids love the aquaponics program. There are students who are not at all interested in school, much less in passing my class, and this program was exactly what they needed- to work with their hands, building things and taking care of the animals. The students are incredibly kind to the turtles in my system.

— Mark Enters, Science Chair, Northwestern Secondary

For example, Mark Enters, a former teacher at Custer High School and veteran of the STEM program in Milwaukee, is currently teaching at a school that was not selected to participate in the aquaponics program. Despite this, using the resources and knowledge provided through the project’s professional development, Enters continues to use aquaponics in his classroom. He leverages the relationships he cultivated with other teachers and professionals at organizations like Growing Power to enhance not only his own continued learning, but to heighten the classroom experience for his students through guest speakers and field trips. It is the power of the hands-on learning, coupled with the real-life need for sustainable living that makes this work critical for my students and for me, Enters says.

Part of the sustainability of the STEM/aquaponics work is the professional learning community (PLC), developed as an educator mentor program to familiarize new teachers with the power of building STEM competencies in students through aquaponics. In this context, the PLC serves as a professional development opportunity where teachers new to this curriculum are paired with veteran teachers for the duration of a semester. Mentors and mentees meet twice monthly, affording teachers the opportunity to participate in in-depth, in-person and ongoing dialogue about best practices and challenges associated with achieving success with an aquaponics system and how to effectively engage students in this sort of unique experiential learning.

At MPS, the PLC has afforded a structure for constructive teacher collaboration around STEM learning, and specifically aquaponics, that has helped to create a sanctioned aquaponics curriculum accessible to teachers district wide. And while the STEM aspects of the aquaponics curriculum are only a part of the larger goal of the USA Initiative, which includes teaching sustainability, environmental impact and how to live a ‘green’ life, the demonstrable linkages to community and environment are not only resonating with students, but also affecting how the teachers involved think about their own decisions in and out of the classroom.

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**Students are doing the work, getting dirty and participating in the hands-on projects. I see them work with urgency and excitement. I see students having fun with what they are learning.**

—Thomas Baker, Science Teacher, Morse Marshall School

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For example, Mark Hladilek is a science instructor at Vincent High School. He teaches physical science but has been incorporating the idea of environmental sustainability into his lesson plans. In addition to his students’ involvement in aquaponics and sustainability, Hladilek is learning about how his own behavior affects his environment. His involvement in this program has led him to question his choice of vehicle and personal habits around recycling and sustainability.

**Experiential Learning in Aquaponics**

Richard DePalma, science teacher, is the driving force behind the aquaponics program at Vincent High School, which once had a thriving agricultural program. Founded with a strong focus on career-themed education, the school grounds include a greenhouse, livestock areas and landscaping programs, making the campus an ideal place to house an aquaponics program. Through participation in the USA Initiative, De Palma leveraged the project resources to build and sustain a fully functional aquaponics program at Vincent, including an operational sustainable fishery, reinvigorating a portion of the school’s original identity and raising a substantial number of edible fish, including tilapia and yellow perch, that simultaneously power the aquaponics system, growing lettuce, watercress and other edible plants.

**Hands-on learning is more fun because you’re DOING things, instead of just reading about them.**

—Student, Vincent High School

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Further, DePalma has taken elements of his aquaponics curriculum developed through training with Growing Power and coursework at Cardinal Stritch University and intertwined them into science classes across the discipline at Vincent. Leveraging the excitement and engagement of students who participate directly in the aquaponics program, DePalma’s work has exposed biology, physics, and chemistry students to hands-on projects and experiences and STEM learning.

DePalma has noticed a strong shift in the interest levels of his students as a result of the experiential learning offered by the aquaponics curriculum and peppered through other science courses. This is evidenced by students’ desire to stay after school and contribute on weekends to the care and maintenance of the aquaponics system, and to participate in trips to Growing Power for restocking and maintenance equipment. DePalma feels that involvement in the aquaponics work helps students’ dispositions while simultaneously empowering them to lead projects and experiments themselves.
His students have built the system and come in on a daily basis (during the school year) to monitor water levels, feed the fish and harvest their produce. His students have invested their time and energy into this system, which translates into continued buy-in and increased levels of engagement. Students’ time spent physically building and caring for the system has brought the aquaponics curriculum to life and established it as a foundational element of school identity.

**Access to Career Pathways**

Since the GLWI and organizations like Growing Power and Sweet Water Organics have taken hold in Milwaukee, the USA Initiative’s aquaponics curriculum is integrally tied to new—and growing—careers in the region in sustainable fishing and farming. The project’s ability to tap into local community and business is an advantage not only for the benefits of connectedness and experiential learning for teachers and students, but for MPS to be seen as a cultivator of engaged and career-ready STEM learners.

Further, as a result of the urban farming movement, there is a renewed understanding and willingness among the community to use existing structures to build and maintain aquaponics systems. This is evidenced by the fact that local markets and restaurants are buying their produce and fish from Sweet Water Organics, and that Growing Power supplies healthy, locally-grown afterschool snacks to MPS students.

The USA Initiative and aquaponics curriculum has a direct tie-in to this local industry. Students are seeing this firsthand, making connections and generating enthusiasm about the plethora of career opportunities in their area. In a radio piece that aired on Milwaukee’s NPR affiliate, WUMW, the aquaponics program at Vincent was described. The recorded evidence captures the profound nature of the impact of the aquaponics program on students. As the students excitedly show off their work to the reporter, making sure to explain the functionality of each aspect, it is clear that they are proud of their accomplishments and eager to share what they learned. More importantly, however, the students spoke of going to college in related fields, such as landscaping.

**Impact on Teaching and Learning**

Through the aquaponics work, teachers in Milwaukee have connected their students to a blossoming local industry that is uniquely tied into environmental sustainability. Learning aquaponics is a hands-on endeavor that requires a physical connection to the subject matter, which can make learning easier for some students. Because the students themselves are involved in all aspects of the program, from the design of the system, to the building of the tanks and grow trays, to the raising of the fish and harvesting of the plants, a connection is made to the physical aspects of the systems—the fish in the tanks and the plants that sustain the surrounding ecosystem. As a result, students are directly engaged in and investing in their work, experiencing the impact of their efforts through such simple tasks as routine maintenance where the fish are measured for size and weight. Students celebrate their ability to nurture and grow the fish and plants, and they seek recycled materials to sustain the aquaponics systems. They demonstrate animal husbandry in taking care of the fish and turtles that are part of their systems.

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**Word got around about the aquaponics class. People didn’t know what it was and when we explained it, people were skeptical... I brought people in to show them the fish and they signed up for the class.**

—Student, Morse Marshall High School
Student engagement is further evidenced by the increased numbers of students at MPS participating in the aquaponics curriculum, as well as the unprecedented number of students that participate after school and on the weekends in the care and maintenance of the fish and plants. Students take time after school to check in on the systems, and ultimately they are practicing self-led STEM education. Students are energized by the possibilities, as teachers remark that they have to lock their classroom doors at the end of the day because students will want to come by and check on their work. Through the connections with Growing Power, Sweet Water, and the University of Wisconsin, Milwaukee, students have seen that there is a future in aquaponics and urban farming as a career. They have learned how to build and maintain these ecosystems, while simultaneously taking care of living creatures and ultimately learning how to relate to their environment.

The biggest takeaway for the students is that they get to have something to put their hands on and take ownership of. They are applying the things they learn in the classroom and it gives them a real life experience. It shows them exactly why it’s important to learn these things and how science is applied. There is a huge confidence boost.

— Kevin Hach, Career and Technical Education teacher, Vincent High School

Beyond students, the USA Initiative has had a profound impact on participating teachers, expanding their understanding of sustainability and the possibilities of urban aquaponics for STEM education. The USA Initiative initially brought together six teachers, all veteran teachers with a science or math background from two public high schools in Milwaukee, for a semester-long PLC through which they developed a rigorous and relevant STEM curriculum in urban aquaponics education. Over the past year, this number has grown, and the initial six teachers are continuing this PLC by serving as mentors to a new ‘class’ of six teacher mentees. Each teacher mentor has been through both the Growing Power program, learning about urban food projects, as well as the Cardinal Stritch upper-level course on aquaponics and sustainability, and have set up these systems in their schools. The teacher mentees are learning how to build their own aquaponics setups, involving their students in each step of the process.

As a new class of mentees ‘graduates’, more and more teachers now know how to teach aquaponics, how to train-the-trainer and access the resources on-hand. Teachers, too, are invested in the aquaponics curriculum. In preparation for the introduction of the full aquaponics curriculum to the 2012-2013 school year, this PLC has created a large pool of subject matter experts—teachers who have physically built and maintained these systems—students who are interested in the content and experiential learning, and an academically sustainable program for Milwaukee Public Schools.
Conclusion and Learning for Other Sites
Conclusion and Learning for Other Sites

As a result of the projects in both Appalachian Ohio and Milwaukee, STEM education has become a resource and lever to promote college and career pathways for rural students. The work happening in each school, while disparate in content and form, is continuously building bridges for students to take what they have learned and apply it in post-secondary opportunities. Students are being introduced to a wide range of different subject matter that has rarely been delivered in this way. They are meeting professionals in STEM-related careers who are getting paid to do the kind of work that students are learning about in school. STEM offers hands-on, experiential learning opportunities for students who have not had these kinds of learning experiences in the past. Students are being introduced to STEM through engaging and inspiring applications, both in and out of the classroom.

In a time of increased budget cuts, teachers are continuing to forge pathways to college and career success through various applications of STEM education. Fiscal resources are not the final answer when it comes to making these network connections. Many sites are experiencing positive connections through free programs, volunteer work, and donated time and energy. Teachers must continue to seek out professional development opportunities that could lead to this kind of STEM success.

STEM education is a necessity to the future of sustainability.

—Richard DePalma, Vincent High School, Why Students Love STEM: Milwaukee Public High Schools

As students show marked interest in hands-on, experiential learning—especially in STEM—it is imperative that teachers use existing resources to build their STEM offerings. The students in both Milwaukee and Ohio have responded positively to the new lesson plans and curriculum. They are physically invested in the work, as their hands built the machines, combustion chambers and aquaponics systems, respectively. The students are in the field, and literally in their own backyards in some cases, diving deeper into STEM subjects, meeting professionals in these fields who are encouraging them to attend college or follow a career path in STEM.

For both sites, the underlying message is the same: These projects opened doors to opportunities and partnerships that were previously beyond reach for the communities they impact, and it is ultimately the strong value of the work to students, schools, and communities that will keep it going in the future.