Exemplary STEM Learning

LESSONS FROM OUTSTANDING NEW YORK SCHOOLS & TEACHERS
Teacher Leader Fellowship Toolkit

Jonathan Eckert, Ed.D
June Teisan, Ph.D

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100KIN10

Biography

LEAD RESEARCHER

JON ECKERT, Ed.D., is Professor of Educational Leadership and Copple Chair at Baylor University. He has taught and coached intermediate and middle school science students outside of Chicago and Nashville for 12 years. After completing his doctorate at Vanderbilt University in 2008, he was selected as a Teaching

Ambassador Fellow at the U.S. Department of Education where he worked in both the Bush and Obama administrations on teaching quality issues. For the past eleven years, he has been preparing educators and leaders.

His research interests include collective leadership, teaching effectiveness, evaluation and strategic compensation to enhance that effectiveness, and science education. Eckert has conducted research for the U.S. Department of Education, the Carnegie Foundation, the National Network of State Teachers of the Year, the National Institute for Excellence in Teaching, and the Center for Teaching Quality.

FELLOWSHIP LEAD

JUNE TEISAN, is a National Board-certified teacher and career STEM educator. Dr. Teisan served as 2008 Michigan Teacher of the Year, Albert Einstein Distinguished Educator Fellow in Washington, D.C. at the National Oceanic and Atmospheric Administration, received the White House Presidential Award for Excellence in Science Teaching and is a National Teacher Hall of Fame Inductee. Dr. Teisan is a visiting lecturer at Oakland University teaching future educators and also coordinates school programs and educator initiatives at Detroit's historic Belle Isle Aquarium, our nation's oldest

aquarium. She serves on the leadership team of the Michigan Teacher of the Year Network and with the National Association of Research in Science Teaching.

Dr. Teisan is actively involved in education policy and advocacy efforts at the state and national level. She is passionately committed to widening opportunities for under-represented and under-served students in the STEM fields and to supporting urban and early-career educators with rich, innovative professional development.

Contents

Research can be a powerful tool in education, but it's an even-more powerful tool when that research is created, implemented, and reflected upon by the education experts themselves—classroom teachers.

That is why we felt that an important and necessary part of this project was to include those who know student learning and pedagogy the best. So we mobilized a cadre of STEM teacher leaders to help us unpack our overarching research question: How does the collective leadership of teachers and administrators facilitate exemplary STEM learning?

At the initial phase of our research, we extended an all-call across New York state to gather master STEM educators. Fifteen STEM teacher leaders were selected, forming our New York 100kin10 STEM Teacher Leader Fellowship.

This Fellowship helped us take this research to a granular level, understanding what best practices actually look like in schools, explained by actual practitioners. These expert educators met monthly for 18 months, examined their practices grounded in our overarching research question, and implemented their own research in their individual contexts. Included you will find two-page summaries of each Fellow's action research, containing findings and links to more detailed explanations. We encourage you to read, share, and implement their ideas, helping you and your colleagues create your own ideal STEM learning system.

CLAIRE GERKEN

Introducing STEM Instruction into Primary Classrooms

In our technology-dominated world, there is a sense of urgency for educators to help prepare students with the skills and knowledge needed to join a future workforce, which will undoubtedly be inundated with STEM jobs.

STEM education in many countries aims to prepare a future workforce to help improve national economies and sustain leadership within an expanding globalized economy (Kelley and Knowles, 2016). There is a global interest in increasing STEM achievement in young learners, which in turn, imparts a huge responsibility on teachers. While STEM has always been present in schools in some capacity, it is becoming more and more visible in schools across the nation; however, not in all.

I am a first grade teacher in Manhattan. Before accepting my job at my current school, I taught first grade in the Bronx for several years. My school was selected as part of a citywide program called "Computer Science for All (CS4All)." I, along with several other teachers, was trained in this initiative and provided with all lesson plans and materials needed to execute the program in my classroom. All teachers trained in this program were allotted two periods a week to teach STEM. This was an exciting time for students and teachers alike: we were sent robots and iPads, and much to the delight of the teachers… paid, monthly professional development! I saw my students benefit greatly from the implementation of STEM. They were engaged, excited, and gained a sense of confidence that I had not previously seen in some of them before.

When I transferred to my current school in Manhattan this September, I was aware that there was no established STEM curriculum for classroom teachers; however, I did know that I wanted to continue STEM instruction in some capacity as I had seen how beneficial it was for my previous students. It quickly became clear that teaching STEM from scratch would be no easy feat. The major obstacles were two that every teacher can relate to: a lack of time (both instructional and planning) and lack of materials. Because my current school is not part of the citywide CS4All initiative, we do not have any robots or class sets of iPads in the building. We are not provided with allotted time in our instructional day to teach STEM, and we are not provided with any opportunities for professional development in the area of STEM.

Throughout the past few months, as I have attempted to implement STEM in my classroom, I have explored the following guiding questions:

- How can STEM instruction be implemented in a school with no established STEM curriculum?
- How can STEM instruction be implemented when no time is provided in our schedule?
- How can STEM instruction be successful with a lack of instructional materials and technology?

Although I am still in the early stages of implementing STEM in my classroom, through a process of trial and error I have discovered that the best way to begin implementing STEM instruction in an early elementary classroom is through integration in other subject areas. I have learned to be creative with both instructional time and with materials available to me.

Elementary classroom teachers are responsible for teaching all subject areas: phonics reading, writing, math, social studies and science. It sometimes seems impossible to get everything done in a day; however, elementary teachers actually have a unique opportunity for integrative approaches to STEM instruction. Teaching using a content integration approach is a great way to develop young learners' interest in STEM, which has potential for increasing the percentage of students who eventually enter STEM fields (Sanders, 2009).

In my experience, I have found that the most effective way to integrate STEM in my first grade classroom has been through literacy-based enrichment activities and through games and challenges during "choice time." In my first grade classroom, I frequently use ScratchJr, an introductory, block-based coding program as an enrichment piece to my literacy program. Students use this program to animate their writing pieces or retell a book they are reading. The platform is user-friendly for young learners who have no previous experience with coding. ScratchJr is now frequently used as a station during my literacy center block.

STEM activities can be easily integrated into writing workshop. I designed STEM challenges for my students as a basis for our "how-to" writing unit (procedural writing). Students engaged in STEM challenges and then wrote to teach others "how-to" complete the challenge. Our first challenge was to have students build a tower with 100 or fewer index cards to support a small stuffed animal. My students worked in teams to plan, design, build, test, redesign and share their results. After completing the challenge, the students went through the writing process and produced a published piece. I have taught this procedural writing unit in first grade classrooms many times. Infusing STEM content into this unit completely changed the learning outcomes for my students: because they were writing about a shared experience, I found that they wrote with more confidence. This content integration activity helped to instill persistence, teamwork, and creativity in my young learners.

In my school, all pre-K - first grade classrooms have "choice time" for 30 minutes a day, where students engage in

constructive play with their peers. During this time, students are allowed to freely choose from a variety of classroom activities, games and art materials. The aim of this period is to help develop social-emotional skills. I have found that this block of time has been instrumental in my implementation of STEM instruction. My students use ScratchJr, Code.org and CodeSpark Academy apps in small groups during choice time. These apps are all free for teachers and developmentally appropriate for young learners who may not be reading yet. After introducing these apps to my students, coding has become one of the most sought after options during choice time.

With flexibility and creativity, primary grade teachers can readily integrate STEM instruction into an already jam-packed schedule. Teachers can be resourceful and even begin to implement STEM instruction without much technology. STEM activities can be executed with everyday classroom objects, such as index cards, tissue boxes or even just paper and pencil. In my first grade classroom, we do many "unplugged" activities. These are STEM-based activities that do not use technology. Although I do have technology available to me in my classroom, I find that these activities are meaningful and help to limit screen time.

As teachers, we want to provide our students with the skills they will need to be successful in the future. It is clear that STEM education is a key component to success. There are obstacles to implementing STEM in the primary classroom, such as lack of curriculum, technology, materials and time. With a sense of creativity, flexibility, and resourcefulness, primary grade teachers can overcome these obstacles and provide their students with meaningful STEM instruction.

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Claire Gerken has been teaching first grade in New York City for the past 7 years. She is part of the second cohort of teachers trained in Computer Science 4 All, a NYCDOE Initiative aiming to provide New York City students with a high-quality CS education at all grade levels. She helped establish the STEM program at her previous elementary school. She is passionate about implementing STEM instruction in the primary grades.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our website.

LIESHA SHERMAN

Creating a Vibrant STEM Community in an Elementary School

"Are we having the Science Fair this year? I already started planning my project."

"My friend and I would like to start a composting program for our Pinewood Peace Garden. Are we allowed to do that?"

"My friends and I had a meeting last night to plan the mini-golf course we are building out of cardboard. Here are our notes and diagrams. We are each building a hole so it will be a 3 hole golf course and each of us is designing it from a different country in the world. My hole is going to have an Egyptian theme with a pyramid. We can't wait to start building!"

This is a sample of the conversations that students come to me with every single day. We have created a vibrant STEM community in our school where students demonstrate creativity, initiative, and a true desire to learn.

Over the past six years, my district has made an investment in STEM and we are reaping the rewards of a lot of hard work. What started out with administrative driven changes has evolved into a student centered model where our students are empowered to take risks, try out their ideas, and make mistakes. Students describe our STEM programs as fun and engaging, and most don't even realize how much they are learning and growing as they engage in voluntarily creating cardboard projects, researching for Science Fair projects, and learning to code. Students ask to work on these activities during recess and their free time. Our students are becoming lifelong learners as they try out new activities and make choices about their learning. We have overcome barriers to create this vibrant STEM community through a supportive administration and a key point person to develop STEM learning opportunities in our school. The key to infusing STEM in a school is to spark student interest and then fan those flames by providing fuel for our teachers through professional development, support with resources, and creative new ideas for STEM learning opportunities.

A review of literature on Elementary Makerspaces and STEM education supports the importance of providing opportunities to young learners. Research shows that integrated STEM education is supported by Next Generation standards, results in positive student outcomes, and is supported by teachers. Susan Whittemore offers support for Makerspaces in her abstract, Makerspaces that Set the Stage for Lifelong Learning. "When young students embrace their own learning and can envision that they own their future, that confidence will carry them through learning experience after learning experience, into post-secondary education, the workforce, and their communities."

The first step in shifting towards a STEM infused curriculum is administrative support and a passionate point person to plan events, rally and entice teachers, students, and parents to participate. As the point person in my school, I am fortunate to have the opportunity to create programming that excites and energizes the students and teachers in my building. Having administrative support is a key component. Our administrative team has been extremely supportive approving the purchase of significant equipment such as robots, Makerspace materials, and science lab equipment. As we develop new science curriculum, our administration invests in the materials necessary to make it successful. We now have

a Pinewood Community garden with a high tunnel, owl pellets for an ecosystem lesson, microscopes to look at plant and animal cells, and materials to build models for an engineering lesson. When I have an idea for a new program like the Hour of Code, Astronomy Club, or the Cardboard Challenge, the answer is always yes. Last summer, my principal approved my request to create a Makerspace in our building. He secured a classroom, bought us a new STEM sign to post outside the room, and has allowed me to promote the program with our faculty. Additionally, our science administrator sent me to a professional development workshop for a new robot called Edison. This level of support makes infusing STEM throughout our school possible and realistic.

Recently, our teachers took a STEM survey and identified training, time, and resources as the biggest obstacles to teaching integrated STEM curriculum. We are working to overcome these challenges. Our district has taken a number of steps to address the challenge of time and resources. Teachers bring their classes to the Science lab once a week where hands on science experiments or engineering lessons are set up. This guarantees that all students in our building have a hands on science experience once a week. Our district recognizes the time it takes for a classroom teacher to set up hands on, often messy science lessons and the materials needed for an engineering experience. Through science lab, all students are able to experience STEM on a consistent basis. In addition, I am able to provide resources to teachers who plan to teach a STEM lesson in their classroom. For example, a 4th grade teacher wanted to teach a lesson on animal adaptation by having her students build a better bird beak. She called me and I was able to send down straws, spoons, masking tape, beans, and macaroni. We know classroom teachers are short on time in their instructional day so most of our STEM special events, such as the Science Fair and Cardboard Challenge, have been designed to require little to no classroom time. Encouraging students to engage in STEM outside of normal classroom time has also increased parent participation as well as the students' personal interaction with me and other teachers. To address teacher training, we established a new program "Spotlight on STEM" where teachers attend a 20 minute professional development workshop before school and are able to take away a simple STEM lesson including the materials to teach it. Teachers also have received training on every new science unit that has been developed as we have transitioned to the Next Generations Science standards to ensure our teachers feel comfortable and confident with the science content. Supporting teachers with resources, honoring

their time, and offering coaching are all ways that we are overcoming these obstacles to STEM education.

While we have accomplished a great deal in the past six years, we are still working to improve and add to the STEM opportunities for our students. It definitely starts with administrative support, but there are things a teacher can do to gain that administrative support. All of the programs we have started began with a program proposal that was linked to Science, Math, and ELA standards. Secondly, there is a certain amount of risk-taking involved. We have created numerous successful programs, but we have also tried a variety of programming that we have abandoned because it didn't reach enough students, it didn't achieve the goal that we set out to, or it was just not sustainable. In addition, I regularly attend Board of Education meetings and share during public privilege of the floor about the amazing things happening at our school in the area of STEM. This helps build support from our senior administrators and Board members. Furthermore, social media is an essential part of building a culture of STEM. I regularly post and tweet about our programs and our STEM instruction. This allows our message to reach our board members, administration, parents, and local businesses. Be loud and advertise STEM accomplishments and this will help to build support. We continue to work to propel our STEM curriculum to support more teachers, reach more students, and to ensure sustainability. If you would like to read more about our journey into creating a vibrant STEM community, please check out my attached article to read about the process, the challenges, and the successes and failures.

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Liesha Sherman teaches science and technology to students in grades 3-5. She spent 8 years in the elementary classroom teaching Kindergarten through 3rd grade and has spent the last 6 years teaching science at Pinewood School in the Mohonasen School District in the upstate NY. Liesha has created a Makerspace in her building, numerous STEM programs for her students, and served as the Instructional Leader for Technology K-5 in her district. Winner of the NEATEC Teacher of the Year for her instruction of Nanotechnology to young students, Liesha is devoted to bringing STEM opportunities to her students.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our underline*website*.

MOLLY McGARRY

Introducing STEM Instruction into Primary Classrooms

How do we keep our students engaged in a culture of immediate feedback and social media distractions? Educators embrace the necessity for active student engagement, but it is not easy to maintain moment-to-moment whole class student engagement for every lesson.

There are many ways to utilize technology to capture our students' attention. Several computer based platforms are tried and true in East Syracuse Elementary School, East Syracuse NY. We are fortunate that our classrooms are equipped with enough Google Chromebooks for every student K-5. However, centers could be used if your school has fewer computers.

Research has demonstrated that engaging students in the learning process increases their attention and focus, motivates them to practice higher-level critical thinking skills, and promotes meaningful learning experiences. Instructors who adopt a student-centered approach to instruction increase opportunities for student engagement, which then helps everyone more successfully achieve the course's learning objectives.

Using computer based response modes allows all students to be heard, as well as express themselves creatively in a platform that is in keeping with 21st Century Learners. It can remove unnecessary barriers for our students with special needs, including the population that needs enrichment within our lessons. Formative and summative assessment is frequent and specific, whether it is delivered by the instructor or peers. Finally, it engages some of the elements of computer science (CS) because it offers ample opportunity for creativity, communication, persistence, and problem solving.

Technology is constantly changing, so it is essential to be aware of the vast current resources offered for teachers. Some districts, such as East Syracuse Minoa Central Schools in Central New York, have instructional technology experts who share new ideas for classroom use, but if your district does not have this resource, there are fellow educators willing to share. For example, Twitter and Facebook provide teachers with current information on released platforms, and fellow teachers post lessons and comments. Also, teachers in your building may be using an engaging platform that you can observe in action.

Currently, one of the most powerful engagement platforms that some of our teachers use is **Pear Deck**. Pear Deck is built by educators and helps teachers create lessons using Google Slides or Microsoft Powerpoint. It promotes 100% student engagement and real-time formative assessment. Teachers can view whole class work in progress, save the work, and export it to student folders. Students may refer to their work for reference and reflection.

Flipgrid, another highly effective source for student engagement, is a website that allows teachers to create "grids" to facilitate video discussions. Each grid is like a message board where teachers can pose questions, called "topics," and their students can post video responses that appear in a tiled grid display. It is a free platform and offers an element of social networking within your classroom community. Student voice can be impressive, and instructor feedback can be given using a rubric within the program!

Seesaw is also a web based platform which actively engages the parents. Teachers can empower students to create, reflect, share, and collaborate. Students "show what they know" using photos, videos, drawings, text, PDFs, and links. It is simple to get student work in one place and share with families, and nothing is shared without teacher approval. In a research study by Seesaw, 92% of 300 teachers reported that their students were more engaged in learning because of Seesaw. Also 92% have seen an increase in parent involvement since using Seesaw.

Although the ever changing world of technology is difficult to maintain, the benefit is the freedom of choice. Educators can choose what works best for engaging and assessing students at a specific time in the year. The attached article goes into deeper detail into how these computer-based forms of student engagement are used at the elementary school level. As you read, think about your objectives and the learning styles of your students. Most importantly, have fun and be creative!

Molly McGarry has been teaching elementary school for 28 years. Molly has been the Math Science Inquiry Support Teacher at East Syracuse Elementary in East Syracuse Minoa Central Schools since September 2014. Molly was a recipient of the Honeywell Space Academy® for Educators scholarship in 2015. Molly co-coaches a robotics club after school for fourth and fifth grade students. She is passionate about infusing computer science and computational thinking into the elementary school curriculum.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our website.

DANIELLE CHIERA

Addressing Challenges to Building Effective STEM Programming in Elementary Grades

As an elementary educator for the past 14 years, I witnessed the emergence of STEM in various classrooms and different districts in two different states. I have observed students grow ideas, concepts, and confidence when involved in STEM lessons.

They discovered ways to push their thinking and make real life connections. I have taught five different grade levels and continue to experience how teaching STEM at the elementary level is challenging. While math and English Language Arts receive ample instructional time and resources as subjects evaluated by mandated testing, many aspects of STEM instruction are not given the same amount of attention in the curriculum or school day. I have found success in addressing these challenges to implementing STEM through teacher collaboration and administrative support - knowing it can be difficult to achieve success on your own.

Some of the specific barriers facing elementary teachers include time constraints and readily accessible effective STEM resources.The National Science Teachers Association and the National Study of Science and Mathematics Education point out that science instruction (including STEM) may receive less instruction daily, if not weekly. How can we find more time for STEM? Time constraints limit teachers from planning, conducting, and reflecting on science instruction including STEM. Furthermore, these limitations add to the challenge of finding relevant and effective STEM resources and opportunities for exploration in the classroom. According to Education Week, 100kin10 Coalition addresses this issue

specifically stating that, "Teachers often don't have sufficient access or funding to quality STEM curriculum.They also rarely have opportunities to collaborate with STEM experts in the classroom and many elementary teachers feel anxious about teaching STEM subjects." These are very real concerns not only regarding the lack of instructional resources, but also the opportunity to collaborate with colleagues and administrators to co-create STEM units grade or district wide.

My district has found a manageable solution that has helped address one roadblock: specifically focusing on teacher voice and time. With supportive leadership, teachers are given an opportunity to co-create STEM units for the entire district. Over the last five years, they have employed teachers in the district (along with the district STEM coordinator) to create STEM specific units for each grade level across the six elementary schools in the district. Each year, they add a new six-day grade specific STEM program that will be co-taught with the STEM coordinator and as the years progress, the classroom teacher transitions into the role of the primary STEM teacher and the STEM coordinator teaches fewer days each year. It started with Roller Coaster Physics in fourth grade,followed by Windmill Design in fifth grade, Scratch Coding in sixth grade, and Seed Dispersal in third grade. The

district is currently developing programs for grades one and two. This worked well because teachers were given paid time over the summer to plan units and then lead professional development throughout the school year for teachers in each grade level.

This has been a great first step in assisting teachers to incorporate a STEM unit into their curriculum. Teachers were able to co-teach with the STEM coordinator and be exposed to new concepts and lessons. They were provided with professional development and resources prior to implementation. These resources were provided in paper and digital form to provide teachers with opportunities to modify or differentiate any of the materials. Students were given time to imagine, create, and explore hands-on discovery and experimentation. They were continuously curious and eager to learn with every lesson. Overall, teachers and students were excited and not anxious to approach scientific methods and science engineering practices.

The chance to build units was a great start, but the challenges of time constraints still hindered progress. Our students wanted more STEM experiences and I felt we could expand on our prior efforts. I know for many teachers, one of the greatest challenges we face is time constraints. Time to plan, time to prepare, and time students spend exploring. Although we have time constraints, we see the joy of learning through the STEM lens and we want to create this more often. We want to be able to provide this type of thinking without overwhelming teachers to add more to their already busy planning periods.

When brainstorming what an effective plan would be, I thought about convenience. I thought about what could be done for more STEM and more consistency. I knew other teachers felt the same way. After surveying colleagues at my school, it was absolutely evident that every teacher who participated agreed that if STEM materials were already prepared for them, they would incorporate consistent time for students to explore STEM in the elementary classroom. I found a resource that bridges the gap from teaching one single unit annually to a more consistent implementation for student engagement while supporting other teachers. It started when I searched for a pre-made resource that would be helpful for my colleagues and me, something that would require little planning but bolster student engagement. It was a weekly "newspaper" for teachers to use in their classroom called The Daily STEM. It is filled with news, puzzles, and much more to engage kids with STEM through literacy. Bingo! Pre-made, short, simple, accessible.

This didn't require a subscription, or a login, or an email. I was able to choose from different issues and the students could differentiate which issue they thought was most interesting. The combination of student choice and STEM was a winner! Not only did the students love it, but the teachers did as well. This really was something that, after careful searching, I was able to implement quickly and share out to colleagues.

After trying this in my school with a few other teachers, the students really seemed motivated to read more and try new challenges. Most students were optimistic to see what the challenges were going to be. When speaking to colleagues, we all felt like we were slowly, but more consistently, finding ways to challenge students in a more manageable way. It is definitely a process that is evolving. I think sometimes as educators we feel new "hot topics" need to be wrapped in a bow and look fancy. After reading the research and adding a pre-made resource to our classrooms, we found it is better to take it slow and make small changes. The fact remains the same, incorporating STEM into the elementary classroom on a consistent basis can be hard, but it is possible with the help of strategies that are already available and not reinventing the wheel.

Danielle Chiera is an elementary teacher with 14 years experience teaching grades 1-5 in Long Island and New Jersey. She has a Master's Degree in Special Education. She has assisted in curriculum writing for elementary STEM and English Language Arts as well as professional development workshops for elementary teachers. Danielle piloted a Makerspace unit for her district and she was also an instructor for Camp Invention where students learn about STEM in the summer. She also coaches high school soccer and middle school track.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our underline website.

TONYA LACKEY

Leading a Successful STEM Program within Your School With and Without Administrative Support

I am a Technology and Engineering Educator at a rural upstate New York public school, Boquet Valley Central School, located on the beautiful Lake Champlain an hour south of the Canadian border. Through my action research I observed the importance of building relationships with classroom teachers and working with the classroom teacher to build his/her confidence in delivering STEM topics.

I have had a unique experience of enacting a STEM program in settings with and without administrative support to the program and have learned strategies to succeed in both situations.

I built an exemplary STEM program in a small K-12 building with the support of my Principal. In recent years my school merged with an equally small neighboring school. As the schools merged the new building principal did not support the K-5 STEM program and at first it did not appear as if it was going to succeed. However, through persistence and a positive "cannot fail" attitude I began to build my relationships with the classroom teachers. The teachers were well on their way to grasping what I could offer to their students and to them in a form of professional development when the principal left the school district and a new principal joined who supported the K-5 STEM program. At that point, my job got a lot easier when it came to "selling" the importance of the STEM program, building the relationships with the teachers, and consequently raising their confidence in delivering STEM topics.

Now that I and the STEM program had the support of a new building principal I had a chance to build the program in the new district. With the support of the administration I observed how the students were benefiting from a highly qualified Technology and Engineering Educator, myself, in the classroom who was leading the students through the Engineering Design Process, teaching them to see the world differently, to think differently, to explore through play, to build and test, to re-design, to fail and then to succeed. The students moved from asking to play computer games to asking "are we going to build a circuit today?", "can we use the robots?", "when do we get to build with Legos?", and "can we take apart a computer?". The students also started to ask more inquisitive questions, such as, "why is the volume greater in this circuit compared to the last circuit?", "why did my robot turn the whole way around, I only wanted it to turn left?", and "how can I make this building taller and still keep it free standing?".

Research from Lesseig, Slavit, Nelson, and Seidel (2016) tells us that inquiry-based learning, peer collaboration, and real-world problem solving not only engages our students in learning but excites them and hooks their interest resulting in improved math and science achievement. I observed the

increased excitement the students brought to class everyday and the classroom teachers observed an improvement in the quality of math and science projects.

The support and buy in from elementary teachers hinges on the teacher's self-confidence level in teaching STEM and ongoing content specific professional development (Robinson, 2014; Shernoff, 2017). In the situation where the building administrator did not support the program, I realized elementary teachers play a significant role in building the future of talented STEM innovators; however, they need meaningful content specific professional development on a regular basis in order to be best equipped and have the confidence to provide stimulating lessons. Without the support of administration regular professional development is not possible. And as a result a successful STEM program is not viable over time. Therefore; I focused on building my relationship with my teachers and helping them build their confidence in teaching STEM topics. I believed that if they were more comfortable with the subject, then they would support me in their classroom and the STEM program I was bringing to their students.

Research states a K-12 STEM program benefits the long term success of the student body (Daugherty, 2014; Clayton, 2019; Mann, 2011); however, it is most effective if there is support from administration, the Board of Education members and K-12 teachers. A review of several scholarly journal articles points to the importance of early exposure to STEM related opportunities and subjects for all students. (Cotabish, Dailey, Robinson, and Hughes, 2014; Daugherty, Carter, and Swagerty, 2014; Mann, Mann, Strutz, Duncan, Yoon, 2011)

I conducted action research to look at the barriers in implementing a STEM program in a K-5 setting and discuss solutions to break down the barriers or simply to work around them. I was curious to know if the buy-in from elementary teachers and administration support was required for success or just an added benefit. The main driving question addressed was:

• Does the success and long term viability of the program require administration support?

Through my research I observed an increase in my students' enthusiasm for hands-on projects and higher order learning activities. At the same time I observed a decrease in requests to participate in lower order thinking activities such as keyboarding and computer games. Parents began providing

feedback on the projects that their K-2 students could describe and explain to them when bringing the project home (i.e. string telephones and wave theory) for the parents to see.

Kennedy and Odell (2014) states, "High quality STEM education programs provide teachers with opportunities to collaborate with one another in unified efforts aimed at integrating the four subjects into one cohesive means of teaching and learning." This was observed to be true and accurate in the first four years of the STEM program when the building principal supported the program and allowed for collaboration. The effects of the lack of support and collaboration were observed this past year when the principal did not provide time for collaboration and did not see the benefit in implementing a STEM program in the K-5 classes. Without the support of the building principal, a STEM program may not be successful nor sustainable. However, do not give up. When faced with a lack of administrative support, focus on building your relationship with the classroom teacher. Peer collaboration can happen in the hallways, at lunch, or before and after school over coffee or a snack. Find the time to collaborate and you will find a way to succeed even without administration.

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Tonya Lackey is a New York Master Teacher with eleven years of teaching 7-12 Math and K-12 Technology and Engineering courses at an upstate rural public school. She has a B.S. in Electrical Engineering and brings over tens years of industry experience into the classroom. She is the Executive Secretary on the New York State Technology and Engineering Educators Association executive board and is a Lead Teacher on the NSF Funded ExCITE (Exploring Computation Integrated into Technology and Engineering) Project through a partnership between ITEEA and Hofstra University.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our website.

JOHN HERRINGTON

Mayor and Superintendent Collaborate on Unique Opportunity to Create Authentic Learning Opportunities for High School Students

Village of Minoa (NY) Mayor Richard Donovan had a vision to incorporate the Waste Water Treatment Plant facility in creating research opportunities for local high school students. After collaborating with East Syracuse Minoa Central School (ESM) Superintendent, Dr. Donna DeSiato, the two of them paved the foundation for authentic hands-on research and the Cleanwater Educational Research Facility (CERF) was born.

Developing this partnership, changing the teacher culture and resulting student experience, has allowed students the opportunity for real-time research and a deep understanding of clean water and alternative energy topics. My wife Pamela and I as co teachers of the research class were tasked with furthering the partnership and leading students and their research visions. The traditional teacher-role required a great deal of flexibility, vulnerability, and humility, as it was nearly impossible to be an expert in all of the student research specialties, nor one-step-ahead of the emerging projects' physical material needs.

A representative sample includes: how constructed wetlands purify water, how a biodigester uses waste water to make biogas, the process in making biofuel from microalgae, how aquaponics and hydroponics systems work, and the ability to heat a greenhouse through the decomposition of a leaf pile. When teachers are allowed to facilitate learning, not dictate facts on an exam, teacher and student interactions are altered in a way that allows for increased collaboration, productivity, and trust; One step closer to the educational system preparing students for the real world after high school.

Research shows that authentic and problem based education are extremely beneficial for the complete development of learners. Multiple studies (Dennis, 2010; Edens, 2000; Flowers, 2016; Millenbah, 2003) outline the importance of authentic hands-on learning experiences leading to improved problem solving and decision making skills. Taking ownership in their learning through authentic education, students increase motivation and are better prepared to succeed not only in school, but in their careers.

Dr. Adam Boddison, Chief Executive at the National Association for Special Educational Needs (n.a.s.e.n.) believes that teachers are pivotal in changing the culture of education. He contends that while the system needs to provide a safe environment for learning, students must be exposed to real world situations.

Feedback from our students is more evidence that we are heading in the right direction with this research program.

"The class allowed me to do hands on projects, think outside the box, and learn completely new things. Global Environment

made me realize that I was extremely interested in the environmental sciences, and gave me clarity on what to study in college."

"Overall this experience was a great introduction to college level learning that allowed me to combine my background knowledge in science with problem solving skills to answer a research question that is applicable to the real world."

"This class is unlike any other high school class. The teachers are phenomenal at being mentors, but allowing students to use their own ideas to create new projects, studies, etc. I loved every second of it. I was the first class to start working with CERF, and it's unbelievable to see how much the program has grown, and what current research the students are doing today. The projects are complex, exciting, and apply to today's world issues."

Critical to the success of CERF were the individuals supporting the vision from all partners. However, there were barriers that are worthy of note. Logistics of transportation, developing feasible research projects, connecting students with appropriate mentors when needed, garnering collegial support from competing electives, and adapting a teaching style to best fit the needs of the learners in this new educational environment. It is also worthy of note that I speak to the integral role played by Dr. DeSiato. Without her encouragement to think outside of the box, constant support both budgetary and professional, or her constant messaging of her belief in multiple measures of student achievement and performance, my wife and I would not have taken the necessary risks to ultimately succeed.

Having this special research opportunity for students also brings some special needs. Obviously having an unlimited budget would be ideal, unfortunately we were on a "shoestring" budget. Some materials are purchased through our traditional science budget but we have gotten good at repurposing items that have been discarded at the DPW by local villagers such as doors, water containers, hoses, pvc piping and wood. Our Superintendent has also provided

additional unforeseen resources. Because we are partnered with our local village, we have access to some of their resources such as tools, lab equipment and most importantly, brain power. Input from the Waste Water Treatment / CERF staff has been invaluable. They work with students advising on project designs, problem solving and lending their expertise when needed. There are times when heavy machinery is needed and the workers are always willing to help. Developing grant writing skills has been an important asset for this "shoestring" budget. We have purchased a greenhouse, water tanks and supplies through grants from NOAA and the ESM Education Foundation.

Creating CERF and evolving our teaching skills and projects, in order to create the best science research learning experience for our students has been a labor of love. We gladly spend time thinking about all-things-CERF in the small hours, summers and school vacations, and long after the students have moved on to their next chapters, because as teachers, we have been called to prepare the next generation of scientists.

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John Herrington has been teaching science at East Syracuse Minoa High School (East Syracuse, NY) for the past 22 years. During his tenure he has developed curriculum and partnerships, including the Cleanwater Educational Research Facility (CERF) with the Village of Minoa and SUNY ESF. CERF provides a real-life learning laboratory for student lead scientific research. John was the 2019 recipient of the Technology Alliance of Central New York (TACNY) Teacher of the Year, recognized for his outstanding contributions in high school STEM Education in Central New York. He also was recognized by NOAA in 2019 as a Planet Steward, a distinction that is accompanied by professional learning opportunities and seed money to implement student projects.

To learn more about his journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our website.

NATALIE HURLEY

Overcoming Barriers to Demonstrating Excellence in STEM Education Through Looping

It's no news to anyone in academia that building relationships with students is paramount when it comes to student achievement. For most, the best way to build a relationship with a student is to spend more time with them.

At Indian River High School (IRHS) in upstate New York, student/teacher relationships are a number one priority and one way of ensuring they're built is through "looping". Looping in primary and secondary education is when a teacher teaches sequential courses for at least two years with the same students. How this looks varies by grade level and subject area. Although more often implemented at the primary grade levels, my experience with looping is at the secondary level specifically in mathematics. At IRHS PreCalculus and Calculus have been linked with a single teacher for approximately 15 years through three different teachers.

The Case for Looping
Research by Cistone and Shneydermann (2004) found the value of looping to extend beyond student achievement and can be found in student attendance, retention rates and instructional outcomes. Multiple studies show that looping saves instructional time (Cistone and Shneyderman, 2004) and provides students with more time to build relationships that are important to the development of social skills (Checkley, 1995). In addition, research by Sterling (2011) found higher academic achievement on standardized tests in mathematics among groups of students who were in a looping situation. Therefore, a successful looping practice has demonstrated advantages to students, classrooms, and districts as a whole.

Brief Background
In the first years of my career I ascended from 8th grade teaching math to my current course-load of PreCalculus and Calculus. On the way up the grade levels, I also taught Pre Algebra, Algebra, and Algebra II. This gave me a solid fundamental knowledge of the Common Core Learning Standards across several grade levels and the vertical alignment from 8th grade through Calculus. During my ascension year after year students were moving with me until I landed as the only Calculus and PreCalculus teacher in the school.

Teacher Understanding of Content
By looping with students, teachers are given the opportunity to teach content over the course of multiple years, mastering knowledge of learning standards and also building necessary foundational skills in students needed for the next year which is particularly valuable in studying mathematics. Understanding what the students come to class having been taught as well as what they need to be proficient in for success the following year, drives course development and instruction in a positive manner. A teacher who loops has a vested interest in ensuring content is committed to long term memory and firm foundational skills are built.

Focus of Instructional Time

In my Calculus class the age old remark for students trying to stall instruction, "My teacher never taught that!" is never uttered. Furthermore, the first days aren't filled with review of PreCalculus. The beginning of the course starts with limits- the first unit in most Calculus classes. There's no need to familiarize students with my own unique way of adding fractions or factoring polynomials- they already know it right along with all of my class routines and expectations. We jump right into the good stuff, feet first, with all the PreCalculus prior knowledge needed for particular lessons sprinkled into bellringers and spiraled homework assignments. The time saved, approximately two weeks, is available for end-of-year review, enrichment opportunities, and activities to dive deeper into understanding content- all the things teachers often say they "don't have time for".

What makes looping easily accessible is that it literally comes at no financial cost for districts. They utilize labor resources already employed. The cost then lies in that of the teacher to buy-in to switching their preparations. Developing a culture and climate in the classroom conducive to promoting an environment of mutual respect and rapport becomes a vested interest of both teachers and students who know they will spend multiple years together. A successful loop grouping can serve as a model for teacher/student relationships districtwide and those who stand to gain the most are our students. When teachers and students are mutually invested in learning, exemplary things happen.

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Natalie Hurley is a high school mathematics teacher at Indian River High School in upstate NY with eight years of experience spanning from middle school through Calculus. She is a fellow in the New York State Master Teacher Program, facilitates professional development for utilizing instructional technology in her region, and proudly serves her community as Vice President of the Board of Education for the General Brown Central School District.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our <u>website</u>.

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JASON FAHY

Creating Unique Transdisciplinary Project Based Learning Opportunities

Teachers in traditional public schools around the country often struggle to implement effective Project Based Learning (PBL) focusing on Science Technology Engineering and Mathematics (STEM). Many of these educators attempting to employ these strategies soon encounter a long list of common obstacles that often stand in the way of sustainable practice.

For over 10 years our transdisciplinary team (consisting of a Science, Math, ELA, Social Studies and Special Education teacher) at Pine Grove Middle School in East Syracuse, New York has managed to peel away many traditional constraints to create unique PBL to support STEM education. This initiative has not only opened up possibilities for other teams in our building, but has served as a template for several middle schools around the state to provide students with innovative learning opportunities. It is important to note that our administrative culture fosters a permission to take risks which allows teachers to experiment with best practices.

Many educators make an honest effort to incorporate some degree of project based learning opportunities in the classroom, but have reported encountering similar constraints that threaten sustainability. One of the seemingly most insurmountable of these is lack of time (Cingtang et al, 2018) and the accountability to State curriculum (Thomas, 2000). Teachers often feel forced by these constraints to make decisions that are not necessarily in the best interest of students causing best practice to fall by the wayside. It is important to recognize that student feedback suggests

that immersion in engaging PBL and the design processes can motivate them to learn difficult content better than mere repetitive practice. (Remijan, 2017). Our 8th grade middle school team has made a concerted effort over the last several years to challenge these constraints and with our combined effort, shift the student experience toward one rich in STEM PBL through the use of transdisciplinary teaching, collaboration with STEM community partners, flexible scheduling and dynamic student groups.

School is inherently divided into silos. Whether it is by subject area or grade level, ability or need, period or room, students experience learning in isolation. Inspired by a learning tour of exemplary STEM schools around the country, our group of open minded teachers was assembled. As a pilot team, we started by looking at the continuity of the student experience both in systems and content. We examined each of our courses and searched for commonality in structure. Where similar elements presented themselves, we exploited them, deconstructing our silos and synthesized a new system comprised of the best aspects of each. We also combed content for overlapping themes, realigning our units to set the

stage for transdisciplinary instruction, not just between math and science, but all subject areas to create a more coherent package for students.

Teachers often find themselves rushing to get through whatever curriculum they are teaching and rarely find the time to dedicate to fully integrated STEM experiences. This can make it difficult for them to imagine adding project-based units to their otherwise full planning calendar. Our team has recognized this obstacle as a formidable foe. A more efficient use of time, space and student grouping needed to be developed to maximize the school day, allowing the INSTRUCTION TO DRIVE THE TIME FRAME rather than having time dictate the instruction as so often is the case. Through analysis of our existing schedule, we quickly identified inefficiencies in roster configuration and redundancy, unlocking dozens of opportunities to flex within the confines of a traditionally built and scheduled middle school with little impact on the master schedule. By reconfiguring a group of teachers to share common rosters of students and simply shifting periods so that these classes were being taught at the same time, teachers now had the autonomy to reimagine what the instructional day looks like. This new found flexibility to rearrange students into virtually any group size and time frame using the criterion of the task at hand, created the framework to support full implementation of transdisciplinary STEM based project based learning in conjunction with our community partnerships.

Over the last several years our model has evolved. Schedules and student groupings have become more dynamic with the advent of technology that is able to produce targeted skill-based data for each student. Our framework is nimble and ready to adapt to new district initiatives and mandates as well as the natural fluctuations in the master schedule due to elements outside of our control. We have seen our physical space change to support our work. A cafeteria/auditorium and an oversized hallway that used to sit empty for a large portion of the day were now viewed as instructional spaces and accordion room dividers that had been closed for decades were once again open to allow for large group instruction. A recent building project has further enhanced our flexibility with additional rooms that can open up and multiple small group instruction areas. While every year brings new challenges, we have managed to keep the problem solving mindset intact which, ultimately, is a cornerstone of STEM PBL.

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Jason Fahy has been teaching science at Pine Grove Middle School in East Syracuse, NY for over 25 years where he has worked to develop award winning transdisciplinary STEM learning opportunities through dynamic use of time, space and student grouping. Within this framework, his team has drawn national attention from organizations such as NASA and PBS for their project work. Jason was a recipient of the 2013 Technology Alliance of Central New York Outstanding Teacher Award and has been recently featured in a STEM Innovation Spotlight Video by the U.S. Department of Education. He currently serves on the Teacher Advisory Council for Colgate University.

To learn more about his journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our underline.

BRANDIE HAYES

Overcoming Barriers to STEM with Leadership, Increased Access, and Training

My school has slowly, and with good success, been on the path to strengthening STEM instruction over the past decade or so. In retrospect it's almost as if we've focused on one STEM discipline at a time, allowing each discipline its own period of focus and development, in which we assessed our needs and wants and then made some sort of significant shift in order to accomplish our goals.

We began with math, switching to a curriculum that offered strong conceptual understanding and flexible thinking. With notable improvement in math performance, we focused on science. Our school used to have a science class that the students visited once a week for science instruction but we abandoned that structure so that science was taught by every classroom teacher. This change in structure allowed science instruction to be taught with greater frequency and with more interdisciplinary connections.

Technology has not been a singular discipline of focus for my school, but it has always been important to me. Since I was a child I've always marveled at all of society's advancements due to technology, so when I became a teacher it didn't take me long to begin wondering about the ways that technology could provide incredible benefits within my classroom. My review of literature on the benefits of technology use in educational settings show that technology has many positive outcomes, such as increasing engagement, providing differentiated and personalized learning, helping to close achievements gaps, supporting English language learners, and providing assistive technology for all learners. As the field of educational

technology continues to advance, the benefits of using technology to support teaching and learning will only continue to grow.

When I started teaching 15 years ago, I was thrilled to start exploring how technology integration could benefit my students and myself personally, but there was a problem: my school only had one cart of 30 laptops for student use, to be shared across all upper grade classes. Limited access to laptops and the rapid decline in their condition due to overuse, made using technology nearly impossible. Something had to be done and it appeared that the only way it would happen was if I stepped up, so I did. My first goal was to increase technology access for myself and my staff and then explore how the technology could be used to support and enrich teaching and learning. Getting administrative support was the first step.

Administrative Support

Principals are busy people with a tremendous workload, many objectives to accomplish, and a limited budget, so although my priorities were set, I was nervous about whether I would receive support from my principal. I've learned that one of

the best ways to gain administrative support is to highlight the significance of a problem (or improvement) and have a clearly outlined and manageable plan already prepared for how to address it. When I spoke to my principal, I highlighted our laptop supply and demand crisis, suggested that we get Chromebooks (which would allow us to significantly increase our volume of laptops for cheaper than we could with regular laptops), and volunteered to maintain them. Although technology was not a high priority for my school, it was valued enough for my principal to invest in 96 Chromebooks as well as a Smartboard and projector for every classroom! This acquisition of new technology was our first leap over a major hurdle in our STEM journey and was the beginning of my secondary role as "tech person" in the building, but having tech doesn't mean that it will be used or used well. My role as a tech leader was going to be more significant than I imagined.

Tech Support and Training for Teachers
After we received our new Chromebooks, there was an extensive need for tech management and support in order to get the carts organized and circulating. As a full-time classroom teacher working in my own time to create management systems and training, there was a gradual roll-out of the Chromebooks for the first year or so. In order to provide more substantive learning experiences for the Chromebooks and the Smartboards, my principal allowed me to attend professional developments, which I used to create in-house learning opportunities that were responsive to the needs of teachers with different levels of skills and interests. Teachers eventually became more comfortable with using Smart Notebook with their students, and discovered that our Google Apps for Education suite of apps was increasingly beneficial for staff collaboration and organization, as well as student tasks. Considering how to get teachers interested in and knowledgeable enough to feel comfortable using the technology was a significant hurdle that I worked to overcome as a result of increasing my professional development and sharing my knowledge with others.

It was happening! We had tech, which was being used across the building, and it was feeling great to discover its benefits as teachers. Teachers were reporting that students were so much more engaged, and sometimes even more productive, when technology was used but I still hadn't hit MY mark. I wanted the students to be active and intentional tech users, knowledgeable enough to use tech in ways that supported their growth as learners, so I've continued to further my learning to accomplish that goal and share with others.

Goal: Transform Teaching with Tech
Over the past few years, I've been focusing myself more on how to increase student agency with tech. It's been very experimental, but also successful. I have created more structured time to learn new digital education tools with my students and have found more areas within my curriculum to integrate tech learning so that students have opportunities to apply what the tech skills they are learning to their work.

This year, I started working towards International Standards for Technology (ISTE) certification, which has been a game changer!! ISTE studies how technology can be used to enhance and transform teaching and learning. Aligning my practices to ISTE's technology standards has made me more intentional and reflective about the uses, benefits, and outcomes of technology integration in my classroom. As my students repertoire of tech skills have grown, they are using technology with increased ease and creativity, in more collaborative ways, and in ways that serve their learning needs, goals, and interests.

Like myself, there are a few other teachers in my school who are experimenting with high impact technology usage. I've started preliminary research to determine how other teachers have been using technology with students and how we can support each other to improve the quality of our tech usage. My journey to STEM excellence is far from over and has been challenging, but has been one of the most rewarding and exciting aspects of my career.

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Brandie Hayes is a 5th grade math and science teacher at P.S. 8 Robert Fulton School in Brooklyn, NY, where she has worked for the past 15 years. For the majority of her career, Brandie has been her school's technology SPOC (Single Point of Contact) for the DOE and the unofficial technology lead teacher in her building. Brandie is also the head coach of the P.S.8 robotics team, which participates in the First Lego League robotics competition annually. This school year, Brandie has taken on the role as P.S. 8's lead teacher for the NYC Computer Science for All program and is also a proud Math for America fellow.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our website.

CATHY SCHAEFER

Our Journey to Change:
A District-Wide Shift to STEM Learning

Our seven-year journey to district-wide STEM education started with one person reaching out to a colleague with a great idea. The benefits of STEM education are known, which was the initial impetus for considering the shift to STEM learning.

Through our work, we were able to identify some important components of a successful and comprehensive program. These include administrative leadership and support, a clearly articulated vision, targeted professional development with ongoing support, faculty access to best practices for STEM teaching and learning, ample opportunities for collegial collaboration and curriculum development, and resource management that prioritizes STEM learning.

Research informed our initial planning and ongoing work. We began with two driving questions. "How do we overcome District inertia to begin the process of implementing this change?," and, "How do we chart a course and stay the course, despite challenges, until we reach our goals for comprehensive STEM instruction?"

To answer the first question, we researched institutional change as a foundational component of our process. We formed an ad-hoc committee of all stakeholders and articulated a clear mission to give us direction, as well as a vision that people could get excited about and coalesce around. We needed to network broadly to determine what would motivate, energize, and engage people. Our change efforts were fueled from the grassroots up to administration,

rather than the other way around. To gain traction, our process had to be different. We wanted everyone to feel like they were a part of the process. Our goal was to build something greater than individuals that would endure independently from any particular person. It would be a new paradigm and part of the fabric of our school community. It felt a lot like building a broad coalition of support for a platform in a political campaign.

While we worked, we were mindful of institutional systems theory. We knew that even small changes in complex systems can have far-reaching effects. When we considered making changes, we looked at all the moving and interacting parts of the school community. We personally reached out to anyone who would be impacted to get their thoughts and to invite them to be a part of the planning. Personal contacts and relationships were as important as providing information and resources in developing a coalition of support for the initiative. We discovered that there is no substitute for one-to-one conversations and no shortcut to thoughtful consideration of the impacts of proposed changes.

We learned a lot about the answer to our second question from each other. We began with goals that we were extremely

committed to achieving. That was our North Star. On the other hand, we are human, so there were times when the journey to our destination took detours that discouraged and frustrated us. It was then that we relied on each other. We chose our core Committee group thoughtfully. Even though it might seem counterintuitive to choose core group members with very different work and leadership styles, this was actually an advantage. A leadership team benefits from different perspectives and approaches. Our personalities and unique skill sets complemented each other very well, which contributed to our success as a group. We had individuals who were better at writing and planning, others who were more skilled at networking and communicating in person. We had those who were detail-oriented and others who were better at seeing the big picture. We relied on optimists to encourage us to continue and pragmatists to keep our goals realistic and achievable.

Patience and persistence from everyone involved was paramount, even though it was sometimes difficult. Most research on meaningful institutional change reflects timelines on the order of years, rather than weeks or months. Many organizational strategic plans are written with a five-year window, but most of us want to see more rapid progress than that. Keeping momentum going when progress is slow requires effort. One of the things we did was to set short-term goals, so that we could see some progress, even when we still had a long way to go to accomplish all that we had set out to do. At the end of each year, we celebrated our accomplishments. At the beginning of each year, we noted everything we had achieved, using that as a springboard to set goals for the future. Looking back at our overall accomplishments was like checking the steps on an activity tracker and seeing that you covered a lot more distance than you thought.

We helped interested teachers to create lessons as templates for others to follow. We successfully advocated for formal support from the Board of Education, with a Board liaison to our Committee, which gave our work more visibility. There were new courses and enrichment activities, and a bond to build a new Design and Engineering lab. To promote STEM, we wrote newsletter articles and held school-wide events. We provided the architects with ideas and feedback as our new lab took shape. We began to plan ways to maximize the utilization of the new space through curriculum development and scheduling changes. The community had put their faith in us. We were committed not to disappoint them by making

our program unequivocally worth their investment.

Curriculum development began with training in problem-based learning (PBL), which has natural connections to STEM learning. This was coupled with more site visits to schools with successful STEM programs to focus on curriculum. Currently, our stakeholders are not in agreement on what curriculum should look like. Should we purchase an off-the-shelf program or should we create a custom program using the expertise of current faculty and administration? There are pros and cons to both approaches. We are weighing our options. We know that our priorities may change over time and that things that initially work, may not always work as the program evolves. Flexibility will be key.

Our challenges can be summarized by noting what has been expressed through Committee observations and teacher feedback. These included frequent changes in administration and lack of administrative vision, paper policies that were not implemented, inconsistent and fragmented professional development, scheduling that limits collaboration, and adherence to patterns of teaching and learning in which successful outcomes are measured only by standardized testing.

Program assets included high teacher capacity, openness to new teaching strategies and broad support for STEM. These led to District successes such as the creation of K-12 STEM benchmarks, bonding and construction of a Design and Engineering lab, K-12 course work in robotics and engineering, new high school course sequences in engineering and computer science, and adoption of block scheduling to facilitate STEM instruction and collaboration.

Foundations that facilitated our successes included the formation of an ad-hoc committee of stakeholders, the development of K-12 STEM benchmark skills, reaching out to community organizations, schools, and businesses for partnerships, writing grants, studying effective leadership and institutional change, and acknowledging that change takes time. Having patience and persistence, being flexible, and keeping a sense of humor all contributed to our success. Credit is also due to my colleague, Steven Giglio, Middle School technology teacher, who was the initial catalyst and provided steady support for the initiative from the very beginning.

The full report includes a detailed description of our grassroots efforts to create both a dedicated space for

innovative learning and a curriculum that provides access to STEM learning for the greatest number of students. Growing pains and challenges remain, but there is also cause for celebration as the District looks back at what has been accomplished during the past seven years since STEM in the District was just an idea. Though challenging at times, this has been worthwhile and exciting work.

Cathy Schaefer has worked as a registered nurse, science museum docent, outdoor educator, and store manager. For the past nineteen years, she has enjoyed teaching middle school science. As a STEM facilitator in the middle school, she has collaborated with faculty, school administrators, parents, and community members to develop STEM learning opportunities for students in grades 5-12. She is currently working on developing a middle level STEM curriculum aligned with the new science standards. She is also working with colleagues in non-STEM disciplines to facilitate interdisciplinary instruction.

To learn more about her journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our website.

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JASON HYATT

Permission and Commission to Step into STEM Teacher Leadership

In the district in which I teach, we have been engaged in high-quality STEM education for more than a decade and we have seen incredible growth and student success. Much of our success is due to teacher training, professional development, and staffing decisions to support STEM.

In addition, we have made significant investments in tools, machines, materials, computer software and hardware, and curriculum. We have been focused on high-quality teaching in the classroom with high-quality supporting resources. And yet, we want to improve and continue to grow.

Many of our students are interested in STEM and intrinsically motivated to engage with related learning opportunities when they begin high school. Throughout elementary and middle school they are exposed to many STEM learning opportunities. Many of these opportunities are expanding and growing. More clubs, camps, and spaces are being offered during these formative years. We are certainly on the right path. At the high school, students continue their trajectory by taking Math and Science courses and they can also begin to take elective courses within our Career and Technical Education (CTE) department. This is where our breadth and depth grows to support high-quality STEM education. This is where the static and abstract becomes dynamic and takes shape. We engage students and allow their creativity to grow and flourish. We provide them with hands-on experiences and empower and support them to go further, learn more, and create. We communicate to parents about our successful programs, use social media to get the word out about our programs, and we engage with our community. These are all the things we know about why we have been successful. But what comes next?

My story will follow, but it is important to note that this is where I embraced being a STEM teacher leader. To satisfy that desire to improve and continue to grow and determine what comes next, I focused on how we could increase access and interest in STEM programming offered in our high school. This has become my STEM mission. I found that I needed to be intentional and creative with my approach, which just happens to be exactly what we teach our students in our classrooms. I believe that the key to success is understanding that interest and motivation increases when students are challenged, given responsibility, given real-world problems, the solutions they create impact others positively (peers, teachers, community, world), and they are recognized and valued for their achievements and work. This is also true for the educators that lead this work. I also want to work toward creating a culture of collaboration among students, teachers, and our community to provide more STEM learning opportunities for our students.

Barriers are a natural part of moving forward. Institutional barriers, teacher barriers, and student barriers all exist and must be addressed in order to grow. Our biggest institutional

barrier is our school daily schedule. Many districts have an activity period, enrichment, advisement or club time built into their daily schedule but ours does not. In addition, many of our students participate in performing arts and many of those classes or ensembles are scheduled during lunch periods. Our school currently uses block-scheduling built within a nine period-a-day structure. This leads to scheduling barriers for individual students during the school day. Many students who take advanced courses and/or performing arts have little or no room in their schedule for anything else and oftentimes have no lunch scheduled. In addition to school scheduling, many of our students participate in sports and extracurricular activities and therefore their time is limited to do more outside the school day. Teacher scheduling is a barrier as teachers have time constraints with contractual stipulations to follow and whenever they have open times in their schedule, they are assigned duties like study halls, monitoring common areas, in-school detention, etc. By focusing on these barriers it is often easy to become discouraged and give up any attempt at creating positive change or growth. However, I am confident that each of these barriers can be overcome by embracing a teacher leader role and using creativity, seeking administrative support, allowing for flexibility, and aligning what we want to do in STEM with district initiatives.

I didn't always think this way. My confidence in being able to tackle this goal of increasing access and interest in STEM was lackluster at best. As a teacher, I knew I could make a difference in my classroom but that's kind of where it all stopped. All my grandiose ideas, and trust me, I've had a bunch, they would all stall here. I didn't really believe that I had the power to affect change or step outside the boundaries of my classroom walls and go in a new direction. This was the work of our administrators or my department leader. I needed permission for that kind of stuff, to be asked or commissioned to do it! Not to mention, a lot of hand-holding and pats on the back along the way. This is how it was done. Perhaps it would start with some fancy ceremony where I would be knighted with the sword of the school board or approved by a majority vote by a selection committee. Right? Well, no, not really. That fancy ceremony never happened and apparently never does. Instead, I found myself signing up for some STEM Teacher Fellowship through the National Network of State Teachers of the Year (NNSTOY). That sounded fancy enough! I really had no idea what I had gotten myself into when we first started but after I was accepted (was this my commissioning?), I began to network with various STEM teachers from all over New York State. I heard their stories and we heard other educator

stories. My classroom walls were either expanding or starting to come down. We read a book about teacher leadership and shared our struggles. We met regularly and our time was valued. This was not only accomplished through providing us a stipend but through trust and understanding that we are professionals with full lives and things come up. There was flexibility and freedom to work without strict oversight that encouraged and allowed us to accomplish our goals. We were given time to process, reflect, and consider new directions as STEM educators. And we were given mentoring opportunities and leadership that made themselves available to us whenever we needed it. We took a long view and met together regularly over the course of 18 months. Our final goal was to create a STEM toolkit to share with other educators. In this toolkit our stories, research, and successes were to be shared. My colleagues in this fellowship have great stories to share and I hope you take the time to consider them. My story took a little bit of a different turn and I was inspired to take a step into STEM teacher leadership. That is my contribution to this toolkit. I have dreamt a little and decided to take some action because I knew I already had the permission to do that.

I created a plan and I'm currently making it a reality. I began by sharing my story about my participation with this STEM fellowship with my department leader and then my building principal. I asked for time and space to leverage our existing resources to create additional opportunities for students to participate in STEM related projects and programs at our school. I decided that I want to provide open lab time, in some ways like a makerspace for our students. They begin by coming in during lunches, study halls or activity periods (our school is considering creating more of these). When time allows, students will begin to work on various maker-focussed certifications. I'm currently calling it the Maker Apprenticeship Program (MAP) where students will be receiving instruction on and certification in using various machines, tools, and equipment. As students receive a certification, they will be rewarded with a physical plaque, badge, or certificate of sorts to recognize their achievement. Students will collect or pursue these certifications based on their interests and choice. Once a certification or collection of certifications is achieved, students will begin to choose various projects to work on where they demonstrate their mastery of that craft. Students who pursue and achieve all available certifications would be rewarded with a Master MAP certificate. I also want to develop a "creative collaborative" where students who have achieved the certifications or their Master MAP certification, have a menu of projects to work on that benefit the school and/or the

community. Other students working toward their MAP may assist them and I want to build in a mentorship type of aspect to the program. I want to see more experienced students teaching other students. I want them to partner and work together to create together. One of the best things about this plan is that I am using existing technology, machines, tools, and equipment within our school. Raw materials can be up-cycled from leftover materials from class work and community groups may offer raw materials for projects as well. No new investments need to be made in order for this to become a reality. It all begins with me being intentional, creative, and stepping out and making it happen. It won't happen by itself and an administrator may never ask me to do it. Through this approach, I know some of the existing barriers can be overcome and perhaps we can achieve our goal of growing our STEM programming in our school.

My STEM teacher leader story is still playing out. The experience I have had in being part of a group of STEM educators, being brought together to share and collaborate has motivated me to take that next step. I've learned a lot. I've been challenged. I have been inspired. I have developed a vision and I feel empowered to accomplish it. I'd love to encourage other teachers to step outside their walls. Perhaps my story could give you some tips and tricks for increasing access and interest in STEM for your situation and how to navigate some of the barriers along the way. Or perhaps, you could connect with my story as an educator who has all the tools and resources available to them but just needs to take that next step and get that permission or commision to do something creative and blow those walls down. I invite you to do just that.

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Jason Hyatt teaches technology at his alma mater, Cazenovia High School, where he has taught for his entire 16 year career. He is a Project Lead The Way teacher and has taught Design and Drawing for Production and Gateway courses Design & Modeling and Automation & Robotics to both 7th and 8th graders as well as various other technology electives over the years. He is also the Boys Varsity Cross Country coach and serves as a Friends Of Rachel Club advisor. Jason's passion around teaching STEM has centered around the maker movement and he loves helping students develop their creativity using various tools, materials, and systems.

To learn more about his journey, access the full toolkit and the NNSTOY report on Exemplary STEM Learning on our website.