Journey to Change: A District-Wide Shift to STEM Teaching and Learning

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- "How do we overcome District inertia to begin the process of implementing this change?"

- "How do we chart a course and stay the course, despite challenges, until we reach our goals for comprehensive STEM instruction?"

The information included in this summary provides additional details on some of our challenges and successes, with the hope that it may assist others in reaching their goals. Our driving questions provided both a focus and a roadmap for our work in much the same way that essential questions guide instruction. We chose to work in ways that we thought would provide answers and solutions to those questions. We began by studying institutional change, systems theory, and conflict resolution, which gave us the framework for overcoming institutional inertia and developing consensus. Peter Senge's, *The Fifth Discipline*, Michael Fullan's, *Leading in a Culture of Change*, and William Ury's, *Getting Past No*, were some of the important resources in facilitating our process.[1] We focused on gradual, reasonable tasks that were initiated and supported by the grass roots to both inform and gain enthusiasm for the work from the broader community.

We felt that the most successful program for us would be one that was adapted from other successful programs, but unique to the needs or our school community. We did not want to simply copy what others had done. We felt that customizing a program to our needs would result in the most successful outcomes. While we recognized that every school community is different, we also identified some common threads from successful programs through our review of literature, networking efforts, and visits to successful programs at other schools.

1. A supportive administration that takes the lead
2. A clearly articulated vision
3. Targeted professional development, ongoing support, and access to exemplars for STEM teaching and learning
4. Ample opportunities for collaboration and curriculum development with colleagues
5. Resource management that prioritizes STEM learning

Our ad-hoc committee of interested stakeholders started with one teacher asking another teacher to work on STEM. We got our early start by creating a robotics course at the middle school and getting administrative support to put resources and scheduling behind it. During this process, we had informal conversations with parents with whom we had developed relationships from working with their children as teachers. We approached individuals who we thought would be interested in participating in an informal school committee. This "core four" of two teachers and two parents recruited a

few others to participate, including high school students and teachers from multiple disciplines.

We clearly outlined time commitments and worked hard to be respectful of everyone's time. We felt that this was key. It is unlikely that people will stay on committees if they feel that their time is not valued. Within the identified time constraints, we tried to make sure that we had month-to-month, reasonable, short-term goals. It was important that the Committee be able to see successes, even small ones, to keep the energy and motivation going. Several people mentioned that being part of our evolving STEAM committee was more rewarding than their participation in other school or district committees. They appreciated seeing evidence of progress toward our goals as opposed to talking around a table month after month without tangible accomplishments. No one wants to waste their time. We did not want to lose any of our talented members. We had succeeded in recruiting not only teachers with varied backgrounds, but parents as well. We had representatives from business, accounting, science, and the arts. We benefited greatly from this broad range of ideas and expertise.

After several meetings setting a foundation for the work, we approached the middle school principal with our ideas. As teachers and parents, we knew our reach was limited. We needed an administrator. He joined the committee and the work continued. The involvement of administration was a necessity, since all decisions regarding staffing, scheduling, and resource management for the school are theirs to make. It is the administration that identifies the priorities for action. We were happy to do the research and make recommendations as long as we felt that there was a possibility that our ideas could come to fruition once they left the committee.

We refined our mission and vision.[2] We met monthly to discuss our findings and to brainstorm infrastructure and course work that would mesh with the Committee mission and vision, school district culture and resources, and the mission and vision of the school district as a whole. We reviewed curriculum maps, identified areas for collaboration, and created lessons with interested faculty to provide successful examples and spark interest in the initiative.

We successfully advocated for new STEM courses and course sequences by meeting with administrators and department coordinators. We worked with teachers, administrators and the school superintendent to plan a STEM summer camp for upper elementary and middle school, after school programs in engineering, elementary STEM enrichment courses, and an evening community event dedicated to showcasing STEM projects. Much of this work was facilitated by a teacher leader who was given release time from teaching to coordinate expansion of the program. Having a point person with time allocated to focus on the work was a significant generator for our early success.

Our work and presentation[3] to the Board of Education resulted in recruiting a Board liaison for the STEM Committee and the community passing a construction bond for a design and engineering lab. This expanded our community reach and added momentum to the work.

With the construction of a new space and new equipment dedicated to STEM teaching and learning, a new challenge became apparent. We needed to develop a plan for teaching and learning that would maximize the utilization of the new space. Our vision was that every student in grades 6-12 would have the opportunity to use it.

Our problem-based learning initiative was determined to be a good entry point for STEM learning, as well as for providing an opportunity for all faculty to participate in STEM. We did not want teachers of non-STEM disciplines to have the perception that the initiative was an exclusive club reserved for a chosen few. We wanted to maximize use of the lab with a broad umbrella for both students and faculty. When we broadened the umbrella for inclusion, the capacity of our faculty to be innovative and flexible became a visible asset. As an example, one of our high school English teachers asked students to imagine a 3D representation of themes and emotions in a book that students were reading. The visual expressions of themes, symbols and emotions that resulted were a clear demonstration that STEM can successfully include other disciplines when a teacher is willing to experiment with pedagogy and collaborate in lesson-planning across disciplines.

Through this process, several students reported increased engagement and greater understanding of the themes they were reading. They also noted that it provided an alternate way to show their understanding. Students whose writing skills were weaker really appreciated the opportunity to show their reflection and analysis in other ways--especially those that had ideas they often struggle to express in writing. In this case, the teacher needed a little encouragement from a Committee member and a willingness of the technology teacher to collaborate. Most of the participants reported that this was a meaningful experience. Students built models, 3D printed elements of their design, wrote summaries of their work and presented their ideas. The teacher had the opportunity to do something new and work with her students a bit differently.

Since we recognized that having a designated point person was one of the keys to build on our early successes, the committee successfully advocated for a curriculum director to help move us towards a comprehensive K-12 STEM program. The initial position was approved as part-time, but we hoped to expand that role to full time at some point in the near future. We are in year one of this aspect of our work.

Program Barriers

During this journey, we experienced several challenges that could have derailed our progress. These challenges, as well as our strategies for overcoming them, are based on committee observations and teacher feedback from both anonymous surveys and personal interviews.

Frequent changes in administration stalled our progress. Since there was no dedicated person responsible for the initiative, changes in building and district-level leadership were especially problematic. Each new hire required an orientation to the ongoing work before any progress could be made. As an additional barrier, different administrators

had different levels of commitment to the program. If the STEM initiative was not a priority, progress stalled or went in a direction that was not consistent with the Committee's vision. Lack of administrative commitment to the vision sometimes allowed it to get lost in the day-to-day stressors of running a school. For progress to happen, it is important to keep focused on the vision. That support also needs to be more than a paper commitment. Schools have lots of policies that sound really good on paper, but they do not translate into action without a commitment from those with decision-making authority.

Different administrators also had different views of what leadership looks like and whether or not it should be shared. A top-down leadership style discouraged the team effort that had been so effective. On the other hand, supportive top-down leadership could allocate time and resources, as well as promote the initiative to faculty. We found that a commitment to shared leadership yielded more progress toward our goals. Administration must be willing to trust the professionalism of faculty to take leadership roles as part of the initiative and be committed to follow-up on reasonable, achievable ideas for implementation.

Lack of a strategic plan that was future-oriented caused delays in beginning curriculum work. A proposed pilot program to develop curriculum in advance of the new facility being built was not approved for two consecutive years due to stated budget constraints. During this same time, resources were allocated to other initiatives. It was not made a priority.

This resulted in a situation in which the facility work was ahead of the curriculum plan. Long-term planning helps to maintain progress toward goals. This was also partly as a result of failure to reach consensus among stakeholders, since committee membership had changed from the core group over the years. While these changes brought new and valuable perspectives to the work, the new composition of the group sometimes slowed progress. There were delays in curriculum planning and failure to implement a pilot program or sample available curricula. Several teachers mentioned the lack of examples as one of the barriers to their trying something new. They were not really sure what it was they were trying to accomplish. They reported that examples of successful work and practice from effective lessons that had been tried by others would help them.

While some efforts were made to try new ways of teaching, inconsistent and fragmented professional development hampered its effectiveness. Scheduling limited opportunities for collaboration among colleagues, which also significantly stalled progress. Teachers who were initially excited about developing new lessons or units reported frustration in not having the time to work on them or collaborate with colleagues. Adherence to long standing patterns of teaching and learning that only measured successful outcomes by standardized testing also posed barriers. Many teachers are evaluated according to how well their students perform on standardized tests. They reported reservations about trying new teaching strategies that may not result in traditional success, even if they believed that STEM teaching and learning would improve their practice.

Pragmatism often triumphs over enthusiasm and progress in this area, so clearly-communicated administrative support can go a long way toward successful outcomes. People need to understand that just because the status quo is working, it does not mean that there are no alternatives that would be better. The skills of critical thinking and problem-solving, for example, can be taught through a variety of strategies. STEM learning is one one of those very successful strategies with significant rewards if participants are willing to go through a few growing pains.

Program Assets

An extremely capable faculty open to intellectual growth is a great asset to the school community. Professional growth has been largely supported by administration, both with release time and budgets. On the other hand, the teachers reported that they wished they had more consistent and meaningful professional development in STEM. They wanted to gain more clarity on its benefits to students, as well as best practices for implementation in the classroom. With so many different opportunities for professional development available, they would have liked more guidance from administration on which ones would be most useful and which were priorities. They also wanted assurances, before devoting too much energy to it, that STEM was a long term commitment for the District, as opposed to another new idea in a revolving door of new ideas that would quickly fade. On the plus side, teachers routinely participate in professional development activities and bring new expertise into the classroom, so they can be expected to continue to do so. There is also community and student support for STEM. Student interest in courses such as robotics, computer science, engineering, and science research have also been significant drivers of the initiative.

District Successes

Despite the challenges, there have been significant successes. We formed a dedicated committee and clearly articulated a mission and vision. We developed an elementary STEM enrichment program that began with only grade five, but has since expanded to include all grades K-5. New course work in robotics and engineering K-12 has also been developed along with new high school course sequences in engineering and computer science. A separate committee researched alternate scheduling models with the goal of adopting a schedule they felt would have many benefits for the District including being more conducive to implementation of STEM. A new block schedule was adopted. Faculty cohorts were trained in PBL. We successfully financed and built a design and engineering lab modeled after the MIT Fab Lab.

Moving forward

While we have experienced significant successes, there is still more work to be done. We want to have maximum utilization of the new facility and are charting a course to achieve that. We recognize the need for a comprehensive and relevant curriculum. We are working on the development of STEM benchmarks as a guide. Faculty surveys and interviews revealed a desire for ongoing professional development, as well as dedicated time for collaboration with colleagues to brainstorm ideas and develop curriculum. Faculty also expressed their desire to see examples of excellent teaching and to learn how to use digital and traditional tools. A core group of faculty and administrators are

focusing on developing additional exemplars of units and lessons consistent with STEM. Training sessions for using the tools have also been planned.

To calm apprehension about evaluations based on testing, faculty would like administration and parents to decrease the focus on high stakes testing in favor of focusing on the critical-thinking and problem-solving skills that are key benchmarks of effective STEM instructional experiences. To further District support for teachers in non-STEM disciplines and to build teacher capacity, inclusion of non-STEM disciplines in curriculum planning and targeted professional development should also be a part of the planning.

Looking into the future beyond our district, increasing the requirements for math and science education for preservice teachers would increase capacity for teachers entering the teaching profession. Actively working to establish community partners in business, industry, and higher education is also desirable to broaden STEM experiences for students and provide them with opportunities to gain firsthand experience in careers through workshops, college courses, and internships.

We have learned a great deal on this journey and are very optimistic about the future of our program. We know that there will continue to be challenges, but have proven that most obstacles can be overcome with perseverance, flexibility, collaboration, a sense of humor, and a positive attitude.

Resources:[1]

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Chiu, Ashely, M.S., C. Aaron Price, Ph.D, Elsie Ovrahim, M.Ed, *Supporting Elementary and Middle School STEM Education at the Whole-School Level: A Review of the Literature, Museum of Science and Industry Paper* presented at NARST 2015 Annual Conference, April 11-14 2015, Chicago, IL

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Kelley, Todd R. and J. Geoff Knowles, A conceptual framework for integrated STEM education, International Journal of STEM Education (2016) 3:11 DOI 10.1186/s40594-016-0046-z

Fullan, Michael, *Leading in a Culture of Change,* Jossey-Bass: San Francisco. 2001

Lesseig, Kristin, et al, *Supporting Middle School Teachers' Implementation of STEM Design Challenges*, Washington State University, 2016

Salami, Mubarak, et al, *Assessing changes in teachers' attitudes toward interdisciplinary STEM teaching*, *International Journal of Technology & Design Education*, 23 October 2015 / Published online: 3 November 2015

Senge, Peter M., *The Fifth Discipline: The Art and Practice of the Learning Organization*, Random House, 2006

Shernoff , David J. and Suparna Sinha , Denise M. Bressler and Lynda Ginsburg, *Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education*, International *Journal of STEM Education* (2017) 4:13 DOI 10.1186/s40594-017-0068-1

Stubbs, Eric and Brian E. Myers, *Part of What We Do: Teacher Perceptions of STEM Integration, Journal of Agricultural Education*, 57(3), 87-100. Doi: 10.5032/jae.2016.03087

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[2] STEAM Mission and Vision: This document was created by Cathy Schaefer in collaboration with the STEAM Committee

OUR VISION FOR STEAM

We believe that all students should have the opportunity, from early in their academic experiences, to be exposed to Science, Technology, Engineering, the Arts (including the humanities), and Mathematics (STEAM) instruction as both discrete areas of study and as integrated disciplines. To this end, our vision is to provide integrated project-, problem-, and place-based instruction in all grades for all students.

STEAM MISSION STATEMENT

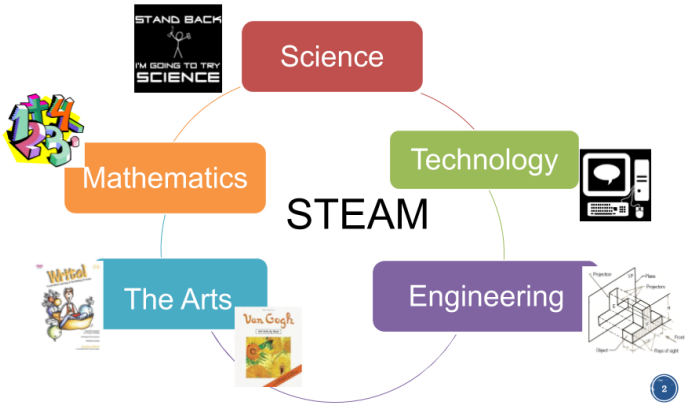
The mission of the STEAM program is:

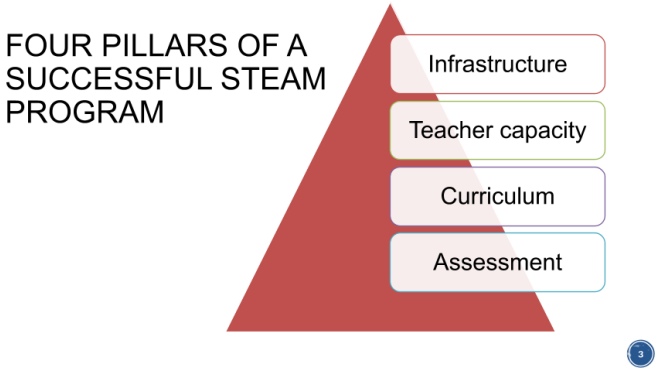
- To provide a K-12 integrated program of Science, Technology, Engineering, the Arts, and Mathematics that consists of engaging learning and enrichment experiences.
- To provide students with opportunities to fully engage with innovation, research, systems thinking, and creative problem solving using core content knowledge.
- To provide students with opportunities for intellectual risk-taking in a safe environment.
- To provide students with opportunities for team building through collaboration with peers, teachers, and community mentors.
- To help students to develop insights into how science, technology, engineering, the arts, and mathematics are an integral part of today's complex society.
- To prepare students for college level studies and careers in a rapidly changing world.
- To encourage the participation of all students across demographic groups and learning styles.

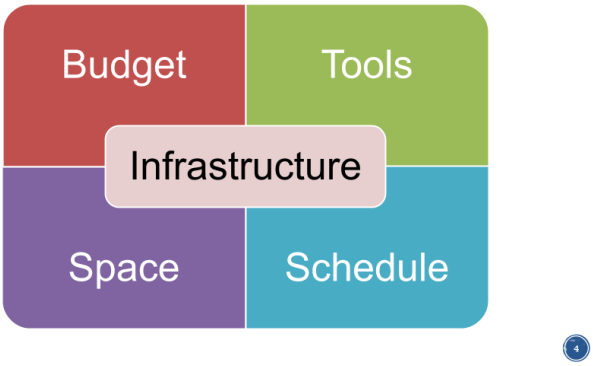
[3] STEAM Presentation:
This presentation was created by Cathy Schaefer in collaboration with the STEAM Committee.

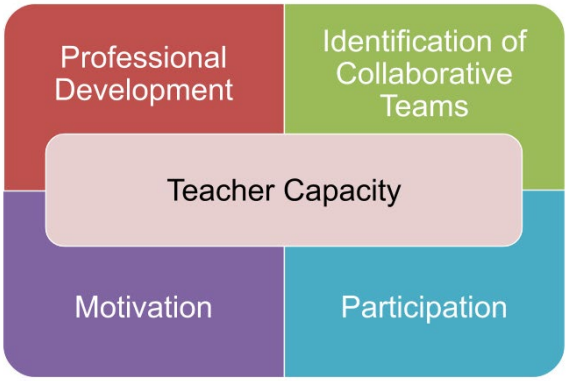
STEAM:

STRATEGIC PLANNING AND VISION FOR A SUCCESSFUL PROGRAM








Professional Development
Identification of Collaborative Teams
Teacher Capacity
Motivation
Participation

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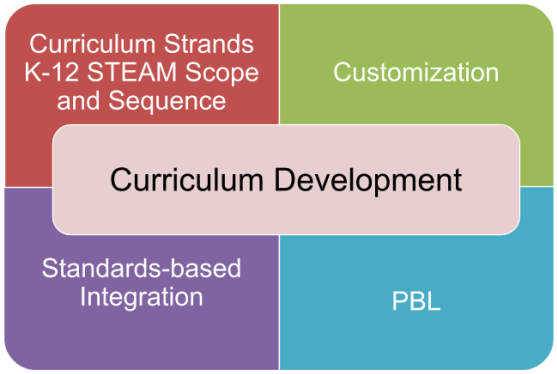
Curriculum Strands K-12 STEAM Scope and Sequence
Customization
Curriculum Development
Standards-based Integration
PBL

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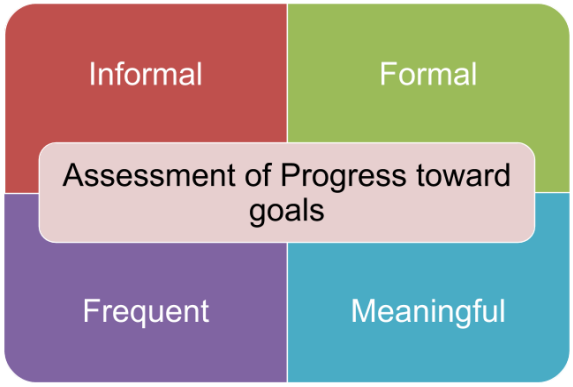
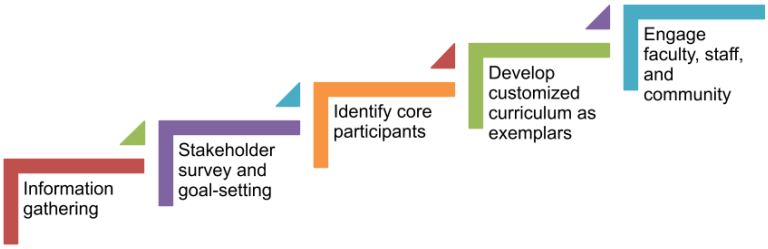

Informal
Formal
Assessment of Progress toward goals
Frequent
Meaningful

7

BUILDING FROM THE GRASSROOTS



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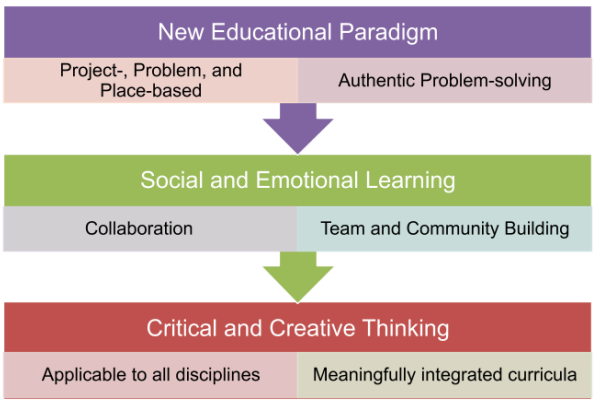
Student- centered vision



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STEAM: Important components of A Four Year Plan

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First steps

Information Gathering	• What elements of our current STEAM program can be used for our evolving program?
Goal-setting	• Stakeholder survey • Faculty and staff interviews
Gap Analysis and Strategic Planning	• What must be done to transform our current program to reflect our vision?

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Next Steps

Identify Core Teams	•Who will most effectively carry out the STEAM vision? •Teams meet regularly to plan and assess
Frequent Communication	•Monthly meetings, email, newsletters, website, community forums
Community Connections	•Establish and/or enhance communication and cooperation of local community

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CURRICULUM DEVELOPMENT

Engineering	• Engineering and Robotics
Computer Science	• Digital Media and Programming
Applied Sciences	• Biology, Chemistry, Physics, Environmental, Forensics
Arts	• Digital photography, architecture, stage design, kinetic art
Enrichment	• After school and summer programs, contests and competitions

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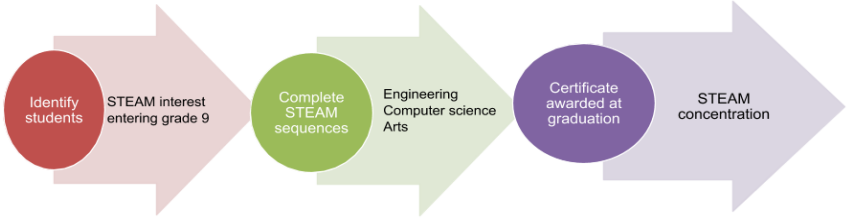
NYS HIGH SCHOOL STEAM PATHWAY TO GRADUATION



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STUDENTS SUCCESSFULLY PREPARED FOR COLLEGE AND CAREERS!

- Meteorology
- Medicine
- Robots science
- Engineering
- Architecture
- Photography
- Video game design
- Full STEAM Ahead!

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