MiSTEM Advisory Council

March 1, 2016

Introduction

Michigan has the necessary components to be the world leader in STEM as a result of our strong talent, educational institutions and industry. Michigan's labor supply is strong with 16.7% of all degree completers in STEM degrees, which is slightly higher than the national average of 14.2%[1]. Michigan is home to some of the finest higher education institutions in the world, including some of the largest public research universities in the nation. And since 2010, STEM employment opportunities have continued to grow and have outpaced overall occupational growth in the state. STEM job opportunities are expected to grow by 11.8% through 2020 compared with 8.5% for all occupations. More than 75% of U.S. automotive research and development occurs in Michigan. Our largest metro area, Detroit, is ranked 3rd in the U.S. as a prime source for technology jobs[2] and is still in the top ten metro areas for patent applications - a standard in measuring innovation[3]. However, these components are disconnected and our edge may be slipping as a result.

There is tremendous demand for greater emphasis on STEM from business and education across the state. Michigan businesses are struggling to find talented employees. Indeed, there are nearly 100,000 open positions on mitalent.org that employers are struggling to fill. Our dedicated teachers are searching for better ways to teach STEM to engage their students. And most importantly, all of our students need to see how STEM education is a powerful tool for navigating the dynamic and complex world they live in.

The MiSTEM Advisory Council consists of business, higher education, K-12 education, and philanthropic leaders and was created by the Michigan Legislature to help make Michigan a world leader in STEM education.

The Council has found that Michigan is full of "random acts of STEM". These uncoordinated efforts are proof of pent up demand for a better way to do STEM in Michigan. This report represents a first step in creating a statewide direction for STEM.

We must recognize what makes Michigan great and seize on the opportunity that Michigan represents. Michigan was once the center of the world for technology and Michigan pioneered the nation's, if not the world's, environmental protection policies. The MiSTEM Advisory Council believes that Michigan can again create the talent that leads the world in the development of 21st century mobility technology and addresses the world's climate, energy, and resource challenges.

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[1] DTMB, Bureau of Labor Market Information and Strategic Initiatives

[2] http://www.crainsdetroit.com/article/20150622/BLOG007/150619807/oregon-economist-says-detroit-is-hotbed-of-tech-jobs

[3] US Patent and Trade Office, 2013

A Vision for STEM in Michigan

The MiSTEM Advisory Council envisions that every K-12 student in Michigan has access and exposure to outstanding STEM programs in order to become STEM equipped. In order to do this, there must exist a cohesive approach to STEM in the State. There are four pillars to this approach:

1. Michigan must create a new culture of STEM.
2. The educator pipeline must be strengthened.
3. Business and educators must be integrated.
4. Michigan must ensure quality STEM experiences.

Much like the new Michigan Science Standards, these pillars feature crosscutting concepts. For example, the teacher pipeline must be filled with quality professional development, preferably in partnership with local businesses, in order to drive a culture of STEM education in the classroom to increase student proficiency with the Michigan Science Standards.

A New Culture of STEM

The National Academy of Engineering has identified fourteen grand challenges that the next generation will need to address if we are to advance our quality of life[4]. Many of these problems cut across energy, health, sustainability, security, and even learning itself. Addressing these national and global challenges requires a workforce equipped with advanced STEM-based skills and talents, and at one time, Michigan was at the center of solving these problems. Talents of the likes of Walter Chrysler, Herbert Dow, Thomas Edison, Henry Ford, Daniel Gerber, W.K. Kellogg and William Upjohn have called the Wolverine State home. If Michiganders bring our existing pieces together, we can once again be the world's center for innovation and technology.

Although institutions of higher education in Michigan are already recognized worldwide for their STEM degree programs, industry is still starved for talent and additional growth in numbers can be realized only if pipeline issues are addressed. Industry is dependent on access to talent for its growth and institutions of learning need to be engaged in nurturing those talents to create the next generation scholars, designers, and innovators. Each of these sectors has to commit to a STEM culture and vision in order for Michigan to again be the world center of innovation.

It is an innate human desire to want to innovate to create a better future. STEM is an answer to that desire. Whether you work with your hands or your mind, whether you're the architect or the foreman, STEM engages students at an intrinsic level. In fact, STEM is better thought of as a mindset than a set of careers. It is a mental toolbox that allows for a collaborative approach to tomorrow's novel problems. It is students being able to cultivate intellectual fearlessness and curiosity. It is treating

4http://www.engineeringchallenges.org/challenges.aspx

failure as enrichment. These tenants cut across all topics, from art to construction, from design to soldering.

This allows STEM to truly unlock the potential hidden in Michigan's students by creating students who think creatively and remain engaged in their learning. This mental toolbox can be applied to whatever interests a student, including fields like graphic and video game design, where students are able to express themselves with current or future real-world, employable skills. Artists today use 3D printers, electronic textiles, tablets, and digital animation just as much as they use paint, clay, and paper. All students, no matter their field of interest, can benefit from a hands-on, interest-driven learning process.

STEM also can provide focus and hope to struggling and disadvantaged communities as both a way to keep students engaged in school and as an economic development mechanism. STEM is a bridge that will allow communities to celebrate a more diverse set of student talents and interests. Some schools focus on the athletic aspect in creating individual students, and similarly STEM highlights academic success and hands on experiences that students bring to the community. By celebrating these types of students, communities will be able to embrace the culture that these individuals have set in place, allowing for a culture of STEM to create a rallying point and ray of hope for struggling communities. STEM can help young talent become involved in their neighborhoods and participate in their revitalization in a meaningful way.

Perhaps the highest hope of parents is to see their children go into a successful career. In Michigan there is no better path to a great career than through the acquisition of STEM skills. From 2010 to 2013, employment in STEM occupations in Michigan grew by 12.8%, compared to only 2.1% for all occupations. Further, STEM jobs earn 60% more on average; Michigan's average wage in 2013 was $21.40 an hour, compared to STEM occupations that earned $34.40 an hour[5]. Fields once thought of as dirty, grimy, and unsafe are now the opposite. Today's factories have replaced soot with clean rooms, heavy tools with precision robots, and dirt with immaculate factory floors. Of course, STEM is not only present in manufacturing. One need only to hear hospital advertisements bragging about robotic surgery departments to see proof of how STEM is fueling the meteoric growth of the healthcare industry. Parents, students, and teachers need to be exposed to the careers of the 21st century.

Creating an effective culture is important if we are to inspire our youth to develop a passion for STEM. We want them to become aware of what it means to have a STEM career, to get them to desire to seek STEM experiences both inside and

[5]http://milmi.org/admin/uploadedPublications/2317_A_Look_at_STEM_Talent_in_Michigan.pdf

outside of school, and to help all students feel prepared to continue on to college or career in STEM.

Empowering STEM Teachers

The adoption of the new Michigan Science Standards represents a new era of teaching in Michigan. The strength of the new Michigan Science Standards is that they integrate content knowledge with the practices used in real world careers to make use of this content knowledge. While the standards represent the separate disciplines of earth and space science, life science, and physical science in the core ideas, these disciplines are united through concepts that cut across all science disciplines. These cross cutting concepts such as patterns, cause and effect, scale, systems, energy, structure and function, and stability and change, all address important interdisciplinary themes.

In addition, science educators are encouraged to integrate science and engineering (as engineering, technology and applications of science) with mathematics and technology, promoting a true "STEM" focus for instruction in our state. And most importantly, the standards are no longer represented as static expressions of facts, but instead use dynamic performance expectations to ensure that students learn how to integrate meaningful content in problem solving experiences through experiential and applied learning of real-world practices. The focus on the *application* of content is an important attribute that characterizes a STEM focus for instruction in that the new standards provide a framework for integrating important content into real life problem solving settings that support both academic and career preparation[6].

According to a recent National Academy of Science Study on Science teacher preparation[7], there are many factors that contribute to a potential disparity between the vision afforded by the new Michigan Science Standards and the realities for how teachers will implement them.

> *"At the elementary level, science is not taught much. With double periods of mathematics and language arts, there simply is not room in the school day for teaching science. At the middle and elementary school levels, teachers are underprepared to teach deep content and to focus on core ideas—they may not understand these ideas themselves. In high school, teachers too often are 'siloed' in their own*

[6]Wang, H. H., Moore, T. J., Roehrig, G. H., & Park, M. S. (2011). STEM integration: Teacher perceptions and practice. Journal of Pre-College Engineering Education Research (J-PEER), 1(2), 2.

[7]National Academies of Sciences, Engineering, and Medicine. (2015). Science Teachers Learning: Enhancing Opportunities, Creating Supportive Contexts. Committee on Strengthening Science Education through a Teacher Learning Continuum. Board on Science Education and Teacher Advisory Council, Division of Behavioral and Social Science and Education. Washington, DC: The National Academies Press.

> *classrooms and certainly in their own departments—an arrangement that again is antithetical to the notion of core ideas and of one learning experience serving as the basis for the next." (NAS, 2015 pp. 63-64).*

To ensure that our state will have educators who can support the implementation of integrated STEM instruction we need to have educators who are skilled at teaching using STEM integration that focuses on content knowledge and addresses problem-solving skills and inquiry-based instruction using technology and computational thinking to address meaningful real life problems. Unfortunately, *"… available evidence suggests that many science teachers have not had sufficiently rich experiences with the content relevant to the science courses they currently teach, let alone a substantially redesigned science curriculum… Within the current science teacher workforce, preparation in science, whether through a disciplinary major or coursework, is especially weak among elementary teachers and not strong among middle school teachers" (NAS, 2015 p. 87).*

> *"It is critical, however, to resist the temptation to blame teachers for the current state of science teaching practices, which reflect the varied and under-conceptualized support teachers receive from schools and districts. In addition to being prepared as generalists, elementary teachers have very limited time to plan and deliver science instruction, while teachers at all levels receive little time, structure, and support for their own learning, whether through traditional professional workshops or through teacher study groups or one-on-one coaching. Finally, resources for science are limited, and many teachers, especially at the elementary level, view the available equipment, supplies, facilities, and instructional technology as inadequate" (NAS, 2015 p. 66).*

Teachers want to teach this way, but many are not sure how to best make this happen. Further, the Council has found that many teachers do not know what opportunities exist in the state. As stated earlier, Michigan already has the pieces necessary to create world-class STEM experiences. All teachers should have a one-stop-shop place to support them in the classroom, discover resources, and network with STEM organizations and other STEM teachers. This would allow teachers to access externships, professional development opportunities, STEM projects, philanthropic funding, and any other resource in their region or the state.

Integrating Employers and Educators

Too frequently educators lament the lack of business interest in education while at the same time business leaders search for ways to get involved. It's time to create a formal mechanism to connect Michigan's education and business sectors. This will not only help connect students to future employment, it will also expose teachers to real world methods and practices that they can then bring back to the classroom and help businesses better understand how educators can assist in creating the talent they need. And like with the new Michigan Science Standards, businesses

aren't just looking for content experts. They are also looking for teamwork, leadership, and a mental toolbox that can cut across content areas to solve tomorrow's problems.

Logically, this should be done on a regional level using frameworks that already exist in the state. With a regional focus, students will get more relevant experiences, businesses will see a clearer talent pipeline, educators will have easier access to employers, and regional needs can be addressed with regional strengths.

Every teacher (and probably parent) has heard a student ask the question, "How will I ever use this in my life?" This is a real concern that students rightly have regarding their education. If what they are learning is not relevant to them they will not be intrinsically motivated to learn. But if the content in the classroom can be tied to relevant local needs and/or employment opportunities that they see every day, for instance to windmills in Mid-Michigan, students will connect with their academic career in a deeper way. Students need their education to be relevant to them, and creating regional STEM connections is one way to do that.

Today's economy moves very quickly and businesses cannot wait in order to remain competitive. This has resulted in many STEM opportunities in the state existing at the high school level is because it's a quicker return on talent investment for businesses. However, in regions with mature partnerships, businesses are quickly realizing that high school is simply too late to get students interested in STEM. Many educators, with business partners who recognize the value in starting early, are beginning to reach into middle and elementary schools to begin cultivating student interest in STEM.

Many of the "random acts of STEM" in the state are happy accidents that resulted from coincidental relationships between educators and businesses. These regional partnerships have been successful for a variety of practical and logistical reasons, not the least of which is that it allows for educators to have easy access to employers that are relevant to students and their associated talent needs. This allows for teachers to customize instruction based on the needs of employers and for students to see a clear pathway to future employment through that instruction.

All of the pieces for regional integration already exist, including data, a regional framework, and networks. Michigan's Labor Market Information office already publishes regional employment forecasts and some regions have done more in-depth research into future employment needs. Several regional frameworks, including the state's Regional Prosperity Initiatives, are already up and running, and the Math Science Centers provide a network of STEM-focused staff.

The example and priority of business and education integration through STEM can offer a model for finding solutions and more understanding about other challenges in Michigan education. When schools and businesses collaborate, our students will achieve more.

Quality Matters

Every teacher wants to deliver high-quality instruction. Unfortunately in STEM, due to a variety of reasons, it's difficult for teachers to know what programs are high-quality. Many in the state struggle with this same challenge, and the Council will begin laying the groundwork to answer this question. Starting this year, the Council will begin examining criteria for high-quality STEM experiences for students. However, we all agree that high-quality programs:

1. are hands-on, problem-based, authentic, engaging, and experiential,
2. increase proficiency in the Michigan Science Standards,
3. go beyond content knowledge and teach life skills like communication, teamwork, leadership, critical thinking, and gracious professionalism,
4. utilize industry partners,
5. create value for educators, students, and businesses, and
6. provide an atmosphere for students to express themselves and have fun applying STEM skills and interests to creatively solve personally relevant problems.

The Council would recommend the state seek a set of metrics to monitor progress and success, including, but not limited to:

- Grades 4 math and science proficiency
- Grade 8 math and science proficiency
- STEM education degree attainment
- Apprenticeship completion

Metrics should be both quantitative and qualitative and align with the Council's and state's new vision for STEM success in Michigan. That is, measuring beyond test scores alone but also numeracy, literacy and scientific knowledge and project-based learning indicators and measurements.

Recommendations

Math Science Center Network

MCL 388.1699s requires that the Council "work with directors of mathematics and science centers… to connect educators with businesses, workforce developers, economic developers, community colleges, and universities." To that end, we recommend to the Michigan Legislature, Department of Education, and Governor, that the Math Science Centers become the engine that drives regional STEM integration. Specifically, we recommend the following:

1. Rebrand the Michigan Math Science Centers as Michigan STEM Centers.
2. Require all STEM Centers to facilitate the creation of a regional strategic plan for STEM education with local employers, educators, government organizations, students, and relevant community organizations.

3. Empower STEM Centers to facilitate STEM events, such as educator/employer networking and STEM career and university recruitment fairs to raise STEM awareness.
4. Allow STEM Centers to connect educators and employers to support a culture of intern/externships and apprenticeships for *both* teachers *and* students.
5. Empower STEM Centers to bring together regional employers and educators to create guided pathways for regional STEM careers.
6. Allow STEM Centers to create a one-stop-shop website whereby teachers can network with each other, access regional and state events, explore professional development and externship opportunities, and engage in other functions to further the mission of STEM in Michigan.

State-Funded Activities

MCL 388.1699s further requires that the Council "make funding recommendations to the governor, legislature, and department for funding programs…" To that end, we have identified the following criteria by which state-funded programs under section 99s should be measured:

Any activity must:

1. be project-based,
2. demonstrably enhance proficiency in the Michigan Science Standards,
3. be aligned to the regional strategic plan developed by the regional STEM Center,
4. have a business partner (or multiple partners) who agree, supported with relevant data relating to market demand and skill gaps, that the program will result in students acquiring skills that the employer will need in at least the next 5 years,
5. collect and report data to the state that can be used to examine individual student outcomes.

Further, activities will ideally:

1. be accessible to every student during normal school hours at no cost to the student,
2. contain a teamwork component that is applicable to in-class activities,
3. be able to be started in middle school or, more ideally, in elementary school,
4. be paired with a regional higher education and/or business supported professional development component that supports the integration of the Michigan Science Standards
5. promote soft skills that enhance career and college readiness,
6. leverage state funds by demonstrating strong partnership with local businesses or philanthropy through donations of funds or other in-kind support.

CTE Equipment

The Council has also become aware of a discussion regarding state funding for Career and Technical Education (CTE) equipment. The state should direct funding for this equipment to activities that:

Must

1. be hands-on and delivered through comprehensive programs and curriculum designs that build upon foundational academic expectations as they relate to STEM,
2. be aligned to the regional strategic plan developed by the regional STEM Center,
3. have a business partner (or multiple partners) who agree, supported with relevant data relating to market demand and skill gaps, that the program will result in students acquiring skills that the employer will need in at least the next 5 years,
4. be able to lead to (but not necessarily result in) an industry-recognized credential in technical skills that are desired in fields such as building trades, engineering, and entrepreneurship,
5. demonstrate a strong partnership between educators and employers through business donations of labor, teacher professional development, equipment maintenance and upkeep, or the equipment itself.

Ideally

1. integrate with a curriculum that increases proficiency with the relevant Michigan Science Standards,
2. result in an industry-recognized credential.

Further, the state should consider including maintenance and upkeep of equipment funded under this policy as an allowable use in future years. This could be a cost-effective way to keep high-quality programs running. And finally, the Council would recommend that the state begin a discussion regarding CTE credentials and skills assessment such that education and industry are in alignment.

State policy recommendations

MCL 388.1699s further asks the Council to provide "recommendations designed to improve and promote innovation in STEM education and prepare students for careers in science, technology, engineering, and mathematics." The following are recommendations on state policy that will further the Council's vision for STEM in Michigan:

1. Senate Bills 169 and 170 create the opportunity for students to receive a STEM endorsement on their high school diploma. The Council strongly supports the concept of recognizing students who have engaged in high-

quality STEM activities. We commit to partnering with the legislature to discuss, create, and implement a meaningful credential for students.

2. Senate Resolution 146 encourages Michigan communities to provide for incentives for young STEM professionals. If communities or the legislature wish to pursue this, the regional framework recommended in this document may provide a possible avenue.
3. Encourage educators to engage in STEM-related work experiences that support long-term engagement with real world practices. One way to do this is to allow for teacher "externships" with regional businesses to count for continuing education credits, professional development hours, or other relevant professional credentials.
4. Support educators with high-quality professional development to implement the new Michigan Science Standards that focuses on using science and engineering practices to engage students with learning disciplinary core ideas and crosscutting concepts.
5. Create a model whereby properly vetted and qualified STEM practitioners can participate in teaching, particularly in CTE fields. One possible method is a "teaching internship" or "teaching residency" model with a certified mentor teacher to be able to lead to a certification for the practitioner should they choose to pursue one.
6. Begin recording student participation in registered apprenticeships.
7. Provide educators with opportunities for practicing and receiving feedback using teaching that engages students with using technology and computational thinking to address meaningful real life problems.
8. Develop and implement meaningful assessment tools and practices that document STEM learning for college or career readiness.

The MiSTEM Advisory Council was created in 2015 under MCL 388.1699s and is made up of 11 voting members serving at the pleasure of the Governor and 4 ex-officio legislators appointed from the House of Representatives and Senate.

Voting members:

- Co-Chair: Kathleen Bushnell Owsley, Executive Director, Bosch Community Fund
- Co-Chair: Christian Velasquez, Marketing Director, Dow Corning Corporation
- R. Charles Dershimer, Ph.D., Clinical Assistant Professor, School of Education, University of Michigan
- Harrison Ford, Student, Kettering University
- Lee Graham, Training Coordinator, Operating Engineers
- Jim Heath, President, Stryker Instruments (Retired)
- Kenneth Kelzer, Vice President Global Vehicle Components and Subsystems, General Motors
- Jay Kulbertis, Ed.D., Superintendent, Gladstone Area Schools
- Josh Nichols, STEM Teacher, Stockbridge Community Schools
- Satish Udpa, Ph.D., Executive Vice President, Michigan State University
- Carolyn Wierda, Executive Director of STEM@SVSU, Saginaw Valley State University

Legislative Appointees:

- Representative Leslie Love, 10th District (Detroit, Redford)
- Representative Jim Tedder, 43rd District (Waterford Township, Lake Angelus, Clarkston, Independence Township)
- Senator Hoon-Yung Hopgood, 6th District (Belleville, Romulus, Taylor, Westland)
- Senator John Proos, 21st District (Berrien, Cass, and St. Joseph Counties)

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