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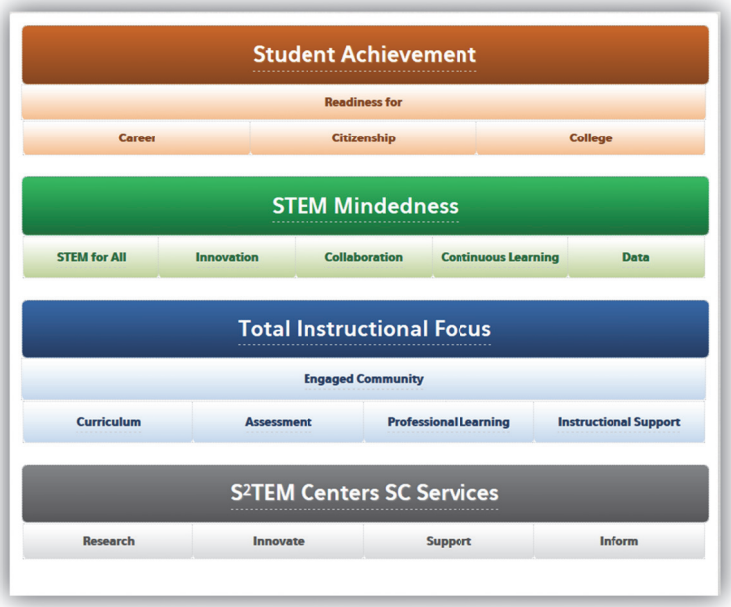
Theory of Action for STEM Success



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STEM MINDEDNESS: STEM for ALL (INCLUSIVE PRACTICES)

Inclusive practices in a STEM school ensure gate-keeping processes are fair, course offerings are comprehensive and all students receive support to achieve success in STEM.

At one time, the "pinnacle" STEM careers, such as engineers, researchers or physicians, belonged to a select few. Today, STEM-minded schools practice multidimensional inclusion. These schools promote all students as being STEM-capable citizens, competent for success in college and careers.

Supports All Students

One dimension of inclusion is that STEM schools encourage and support all students equally in their pursuit of STEM careers. This type of inclusion is most prominent at open-access schools—programs that service all students without restrictions. These types of STEM schools should be acutely aware of their underserved and at-risk students, providing them with equal opportunities to succeed.

Fairness in "Gate-Keeping"

A second dimension of inclusion in STEM education is fairness in "gate-keeping." Elite STEM schools accepting only highly motivated students with a record of high achievement should have an unbiased assessment process in place to select students using multiple measures of assessment. In the same way, other STEM schools offering gifted and advanced courses should have a similar system in place to ensure student selection into those courses is inclusive.

Comprehensive Offerings

A third dimension of inclusion in STEM education is comprehensive STEM offerings. Georgetown University's Center on Education and the Workforce STEM Report states, "The STEM supply problem goes beyond the need for more professional scientists, engineers and mathematicians." The authors of the report note that the demand for STEM knowledge, skills and abilities is growing rapidly across workforce clusters. The reality of the job marketplace is that there are millions of jobs for STEM-capable people in manufacturing, finance, technical fields, agriculture and other industries.

STEM schools are inclusive by providing a broad vision for the world of STEM career opportunities. Schools should consider job trends and offer not only classes serving those students striving for "pinnacle" STEM careers, but also those in historically "vocational" fields.

STEM-Capable Citizens

Finally, inclusion is as much about citizenship as it is about college and careers. Every individual ought to be STEM-capable enough to make good decisions in life and in the voting booth. Further, all students should possess 21st Century skills, be computer literate and comfortable with a certain degree of technology.

Honor Inclusion
While schools may offer specialty learning opportunities or focus on specific kinds of learners, all STEM-minded schools can honor the inclusion principle by ensuring opportunities for college, careers and citizenship are equitable and appropriately STEM-focused.

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Inclusive practices in a STEM school ensure gate-keeping processes are fair, course offerings are comprehensive and all students receive support to achieve success in STEM.

Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Supports All Students

- In what ways is your school encouraging and supporting all students equally in their pursuit of STEM careers?
- What are some strategies you are using to promote STEM careers with your underserved and at-risk students?

Fairness in "Gate-Keeping"

- For schools using a competitive application process for admission, what assessment measures are you using to ensure that your selection process and acceptance decisions are unbiased?

Comprehensive Offerings

- What are some of the current STEM related job trends in your area?
- What are you doing to ensure that all students—those seeking the "pinnacle" STEM careers and those seeking historically "vocational' fields—are provided learning opportunities aligned to these STEM trends in your area?

STEM Capable Citizens

- How is your school ensuring that every student is STEM capable enough to make good decisions in life and in the voting booth?
- In what ways are you ensuring that all students possess 21st Century skills, be computer literate, and be comfortable with technology?

Honor Inclusion

- What are you doing to ensure that opportunities for college, careers, and citizenship are equitable and appropriately STEM focused?

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STEM MINDEDNESS: CULTURE INSPIRING INNOVATION

A culture that inspires innovation motivates school leaders, teachers, students and community alliances to think, dream and do in an atmosphere that has been thoughtfully created to embody a spirit of American ingenuity and inquiry.

Atmosphere

In a STEM school, the community is keenly aware of the importance of American ingenuity in maintaining our country's position as a global leader. The atmosphere is alive with the excitement of possibility thinking. Could this school be educating the developer of the next device demanded around the world, or the creator of the concept that eradicates world hunger? In this environment, self-directed individuals work interdependently to generate and test new ideas. Stakeholders are encouraged to question the status quo, deliberate about complex problems and pose creative solutions. Resulting actions are documented through a reflective process.

Nurtured by Visionary Leaders

The community is nurtured by visionary leaders who value the exchange of ideas and encourage out-of-the-box thinking. They collaborate with stakeholders in developing a shared vision for the acquisition and allocation of resources to support flourishing innovation. These resources include curriculum, creative work spaces, time, technology and human talent. Such leaders demonstrate their commitment to advancement through their words and actions. Throughout the organization, they inspire risk-taking, encouraging their colleagues to think and act in new ways.

Encourages Teacher Inventiveness

As school leaders encourage inventive thinking, teachers feel free to collaborate on innovative curriculum, instruction, and assessment design. They seek to become proficient in facilitating more inquiry and problem-based pedagogy, incorporating 21st century practices. They take risks in the integration of current technologies, often assisted by their students who are products of the digital age. Suzie Boss writes in *Bringing Innovation to School*, "The first step in teaching students to innovate is making sure that educators have opportunities to innovate themselves."

Fosters Student Inquiry

Teachers who implement practices promoting innovation engage students in active learning experiences. In the Wall Street Journal article, *Educating the Next Steve Jobs*, Tony Wagner writes, "…at the most innovative schools, classes are 'hands-on,' and students are creators, not mere consumers. They acquire skills and knowledge while solving a problem, creating a product or generating a new understanding." In this type of learning, it is vital students understand that successful innovators take risks, implement a design process and channel creativity as they struggle to stick with an idea from conception to reality. Students should also recognize the opportunities presented by learning from failure.

Engages Community Alliances

Developing and maintaining community alliances will infuse the school culture with new talent, ideas and resources to expand innovation efforts. Parents, universities, businesses and non-profit organizations can be tapped for mentors, internships, hands-on support with real world projects and sponsorships for innovation contests. In *Bringing Innovation to School*, Suzie Boss suggests establishing an innovation advisory council. This will engage all community stakeholders in sustaining the culture that inspires innovation.

A culture that inspires innovation brings together students' passions and interests with meaningful academic standards and the needs of society. Guided by this principle, the school becomes a laboratory where ideas that will positively impact the world are born.

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A culture that inspires innovation motivates school leaders, teachers, students and community alliances to think, dream and do in an atmosphere that has been thoughtfully created to embody a spirit of American ingenuity and inquiry.

Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Atmosphere

- As you think about the culture at your school, what are some of the things you are doing to ensure that the atmosphere is alive with an excitement of innovation and "possibility thinking"?
- What is present in the environment in your school that cultivates self-directedness and working interdependently to generate and test new ideas?

Nurtured by Visionary Leaders

- In what ways do school leaders nurture the exchange of ideas and encourage out of the box thinking?
- In what ways do school leaders collaborate with stakeholders to inspire innovation? To develop a shared vision for innovation? To make decisions about acquisition and allocation of resources to support innovation?
- How do school leaders demonstrate their commitment to innovation?

Encourages Teacher Inventiveness

- What autonomy do teachers have to collaborate on innovative curriculum, instruction and assessment design?
- In what ways do teachers seek to become more proficient in facilitating problem-based learning in their classrooms?
- In what ways are teachers willing to take risks in integrating current technologies?

Fosters Student Inquiry

- What are some ways in which students learning experiences engage them in being creators, not mere consumers?
- What structures are in place to ensure that students take risks, learn from failure, implement a design process, and channel creativity as they struggle with an idea from conception to reality?

Engages Community Alliances

- In what ways does your school engage all community stakeholders in creating a culture of innovation?
- In what ways does your school engage all community stakeholders in sustaining that culture of innovation?

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STEM MINDEDNESS: DATA-INFORMED DECISION-MAKING

Data-informed decision-making in a STEM school is a collaborative, recursive process that analyzes school-based data, along with workforce and global needs projections, to gain actionable information used to guide and monitor school decisions.

Collaborative Process

A school community is made up of multiple interdependent components. Changes in any of the workings have an impact on the others. For this reason, data-informed decisions should include multiple stakeholders. While not all stakeholders can or should be expected to collaborate on all decisions, consideration should be made to ensure the appropriate stakeholders are involved in decision-making.

Existing and Desired State

The desired state is defined by the goal in mind. In a STEM school, the desired state is driven by the nation's need for more individuals earning STEM-specific degrees and choosing STEM careers—in general, the citizenry becoming more STEM capable.

The existing state is evaluated through multiple data points. The "gap" between existing and desired state provides the starting place for improvement. Victoria L. Bernhardt, in her book *Data Analysis for Continuous School Improvement*, says, "Data not only tell us where we have been, where we are right now, and where we are going; data inform us of the ways to get there, sensibly."

Cycle of Inquiry

Protocols provide purposeful structure as stakeholders make meaning of the data to reach decisions. A report from the Institute of Education Sciences encourages school teams to engage in a "cycle of inquiry." This multi-step process involves analyzing data, developing hypotheses, formulating and implementing action plans, and then once again analyzing data to evaluate progress and inform next steps. This approach ensures that all school actions are examined for their impact on student achievement and on the school's goals for teaching and learning.

Preparing for the Future

STEM schools need to keep pace with the rapid rate of change in today's world. The decision-making process should use available technology to ensure decisions are timely and allow for adaptability.

For success in the 21st century, all school stakeholders, including students, must become proficient at data-informed decision-making. It is essential they understand how to sift through the multitude of data from multiple channels to gain information to navigate change. STEM schools provide opportunities for staff and students to engage in this process for maximum success.

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Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Collaborative Process

- What processes and procedures do you have in place to ensure that the appropriate stakeholders are involved in decision making at your school?

Existing and Desired State

- What information does your current data decision-making give your school about your current situation?
- What clues does your current data decision-making give as to what will lead to improvement?

Cycle of Inquiry

- What protocol(s) do your school teams use to make meaning of the data and plan action steps?
- What protocol(s) are in place to analyze effectiveness of action and determine next steps?

Preparing for the Future

- In what ways are you using available technology to ensure decisions are timely?
- In what ways are you ensuring that all stakeholders, including students, understand how to analyze data from multiple sources and use that information to navigate change?

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STEM MINDEDNESS: CULTURE OF COLLABORATION

A culture of collaboration in a STEM school is defined as an environment in which all stakeholders work interdependently and share accountability for student success. Characterized by trust and collective responsibility, schools with a culture of collaboration utilize communal strengths to prepare students for college, careers, and citizenship.

Norm in High Performing Schools

In *Adaptive Schools: A Sourcebook for Developing Collaborative Groups*, Robert Garmston and Bruce Wellman state that collaboration is not "contrived collegiality," nor should it be only project-based. They assert that true collaboration is the norm in high performing schools. It is developed through purposeful actions of leaders who recognize that superstars working in isolation do not produce the same level of growth and learning as teams working interdependently. Garmston and Wellman say leaders must recognize that the processes leading to systemic collaboration have to be "taught, practiced and learned." This includes processes for implementing behavioral and collaborative norms and for building trust.

Role of Trust

According to Stephen Covey, author of *The Speed of Trust*, "If developed and leveraged, trust has the potential to create unparalleled success and prosperity in every dimension of life." He states that trust is the glue and foundational principle that holds all relationships. This includes relationships within learning communities.

In their research on trust in schools, Anthony Bryk and Barbara Schneider identify four elements of relational trust: respect, competence, personal regard for others and integrity. In a collaborative culture, individuals demonstrate their trustworthiness by showing:

- Respect as they genuinely listen to and consider others' points of view.
- Competence in completing core role responsibilities.
- Personal regard and concern for others.
- Integrity through honoring commitments and being guided by a moral-ethical perspective.

Positive Results for Stakeholders

In a collaborative culture, a structure ensures that time is embedded within the school day for teachers to focus on curriculum and instructional practices and take targeted action based on assessment results. In this trusting environment, educators may openly share their practices, curriculum knowledge and student results, freely exchanging ideas and constructive feedback on instructional practices. With such support, teachers are more apt to integrate innovative teaching technologies and methods that promote STEM capabilities in their students.

While a collaborative structure enables adult learners within a school to work interdependently on designing and implementing the STEM curriculum, students have similar needs. Such a structure encourages students to collaborate with each other on real world tasks and to design innovative solutions to relevant problems. Collaboration, when integrated across the curriculum, gives students experiences similar to those they will find in the professional world of work.

As schools work to build the collaborative culture with the internal stakeholders, they must also initiate a plan for purposefully engaging parents and community stakeholders as vital contributors to the school team. This will provide access to a wide range of STEM knowledge and resources that can be utilized to ensure the school develops citizens who are successful and productive members of society.

In practice, the culture of collaboration principle ensures that through supportive, collegial interactions, learners throughout the school community can experience increased individual efficacy. As a result, collective efficacy is strengthened as all work together to ready students for college, careers and citizenship.

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Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Norm in High Performing Schools

- What processes are in place to ensure systemic collaboration?
- Describe the interdependent relationship among adults and among students and adults in your school work.
- What evidence do you have that stakeholders are working in teams as opposed to working in groups?

Role of Trust

- Within the context of learning communities at your school, what are some ways respect is demonstrated? Nurtured?
- Within the context of learning communities at your school, what are some ways competence in completing core role responsibilities is demonstrated? Nurtured?
- Within the context of learning communities at your school, what are some ways personal regard and concern for others demonstrated? Nurtured?
- Within the context of learning communities at your school, what are some ways integrity demonstrated? Nurtured?

Positive Results for Stakeholders

- What opportunities are available for teachers to meet with their colleagues to focus on curriculum and instruction practices within the school day?
- To what degree do teachers openly share their practices, knowledge and student results with each other? With stakeholders? Explain.
- To what degree are ideas and constructive feedback on instructional practices freely exchanged among faculty? With stakeholders? Explain.
- What structures are in place for students to collaborate with each other on real world tasks and to design innovative solutions to problems? Describe these structures.
- What plan is in place to engage parents and community stakeholders and tap into the wide range of STEM knowledge and resources they might potentially provide?

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STEM MINDEDNESS: CONTINUOUS LEARNING

Continuous learning is an active and ongoing process in which self-directed learners at all levels of the school pursue goals they identify through a reflective learning cycle.

Active and Ongoing

"Continuous learning is an ongoing, unbroken flow of learning that is carried out by the individual, every day, indefinitely," says Robert Talbert, mathematics professor at Grand Valley State University. As an example, he cites the work of engineers, increasing in complexity at an exponential pace. Talbert stresses that to keep pace with change, individuals must add continuously to their own skill sets.

In a STEM community, all stakeholders take responsibility for continuous learning relevant to improving student readiness for college, career and citizenship. Administrators and teachers stay abreast of research, best-practices and technological tools. Students set, monitor and implement learning goals with support from the school, parents and strategic alliances. These partners engage in ongoing opportunities to increase their understanding of student learning needs and the relationship between education and a safe and economically viable community.

Self-directedness

As self-directedness is an attribute of continuous learners, it also is part of the STEM culture. In *Cognitive Coaching, A Foundation for Renaissance Schools*, Art Costa and Bob Garmston posit that self-directed people know what they know, as well as what they don't know, and use this understanding to set challenging goals. They are able to accurately assess their progress towards meeting those goals and persevere in the face of barriers. STEM schools bear out this position. Individually and collectively, STEM communities are motivated to seek constant improvement with purpose and self-awareness.

Reflective Learning Cycle

In STEM schools, self-directed learners make meaning of experiences and use a reflective, cyclical process to determine next steps. The essential elements of a reflective cycle include:

- identifying goals
- planning
- implementing
- gathering evidence
- self-assessing
- adapting

The reflection process will not occur automatically. It has to be taught, modeled and practiced. In *The School as a Home for the Mind: Creating Mindful Curriculum, Instruction and Dialogue*, Bena Kallick and Art Costa write, "Every school's goal should be to habituate reflection throughout the organization—

individually and collectively, with teachers, students and the school community." Some tools for facilitating reflection are collaborative dialogue, portfolios, journals and self-assessment protocols. A STEM school's engagement in a recursive pattern for improvement is motivated by the need to prepare staff and students for teaching, leading and learning in a rapidly changing world.

The Principle

For maximum impact, STEM schools apply the principle of continuous learning community-wide. Through this process, school practices are refined, knowledge is deepened and skills are sharpened as educators continuously adapt their practices to meet the needs of the 21st century learner. Further, continuous learning becomes the norm for students as they embark upon college and careers and lead their lives as productive citizens. The ultimate benefit is reaped by the community at large having a better trained, more thoughtful workforce and citizenry.

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Continuous learning is an active and ongoing process in which self-directed learners at all levels of the school pursue goals they identify through a reflective learning cycle.

Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Active and Ongoing

- In what ways do teachers and administrators stay abreast of current research, best practices, and technological tools to improve student readiness for college, career, and citizenship?
- How are you supporting students to set, monitor and implement learning goals?
- What are some ongoing opportunities provided for stakeholders to understand student learning needs?
- What are some ongoing opportunities provided for stakeholders to understand the relationship between education and a safe and economically viable community?

Self-directedness

- In what ways are the characteristics of self-directedness developed and nurtured within the learning community?

Reflective Learning Cycle

- What tools are you using to promote the use of a reflective learning cycle among stakeholders?
- How are you preparing students and staff for the rapidly changing world?

The Principle

How is your school applying the principle of continuous learning community wide?

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TOTAL INSTRUCTIONAL FOCUS: ENGAGED SCHOOL AND STEM COMMUNITY

An Engaged School and STEM community is a partnership of all school stakeholders including staff, students, parents and strategic alliances. Together, these partners embrace the school's STEM vision and share responsibility for the success of each student.

A Shared Vision

The STEM school engages the full community in developing its vision for STEM education. Education consultant Rick Dufour says in clarifying its purpose and vision, a school should bring together representatives of the faculty, business community, parents, students and the administrative team. He recommends the initial work of the assembled team include developing an understanding of the research on effective schools.

In addition, STEM school leadership should solicit input from strategic alliances so that the team gains an appreciation for the skills and knowledge students will need to contribute to their own and their community's economic productivity. In an Engaged School and STEM community, stakeholders embrace the vision that has been collaboratively developed and share responsibility for the success of each student.

Partnering for Student Success

STEM schools work in partnership with stakeholders to provide support and services to develop all students' capacity and confidence to meet the challenges of STEM. Intentional outreach must be extended to students who are underrepresented in STEM fields. An Engaged School and STEM community collaboratively develops a plan to engage students as active partners in their own success. This is accomplished through opportunities for students to set goals and receive support in implementing and monitoring progress. STEM challenge opportunities are available to nurture and further students' natural gifts, interests and abilities. In addition, early identification and intervention strategies ensure students receive scaffolded support such as mentoring, tutoring and counseling as needed for success.

Collaboration with Parents

Recognizing that parents are a student's first teachers, STEM schools actively reach out to parents to be partners in their children's education. The National PTA sets forth the standard in its *National Standards for Family School Partnerships Implementation Guide:* "Families are active participants in the life of the school, and feel welcomed, valued, and connected to each other, to school staff, and to what students are learning and doing in class."

STEM schools employ multiple, ongoing and interactive modes of communication to keep parents informed of ways they can support their students' academic progress and encourage exploration, critical thinking and innovation. Opportunities for parental engagement include sharing specialized career expertise, helping facilitate a hands-on classroom exploration, chaperoning a field trip or tutoring a

small group of students. Since the majority of a student's time is spent outside of school, it is vital that parents share responsibility for high student performance.

Strategic Alliances

The STEM school works to build strategic alliances with business, community organizations and institutions of higher education to enhance the objectives of the school. Partnerships enable students to apply knowledge and skills to real-world settings through job shadowing, internships and service projects. Students benefit from onsite and virtual career talks and site visits. These alliances provide personnel resources for activities such as mentoring, tutoring, counseling and co-teaching, as well as financial support to fund scholarships, resource acquisition, grants and incentives for teacher and student innovations.

The Engaged School and STEM community makes available STEM learning opportunities that give learners insight into the nature, challenges and excitement of STEM career choices. These opportunities prepare students for success in studies at institutions of higher education, and place students in roles they will assume as productive 21st century citizens.

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Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

A Shared Vision

- In what ways does your school engage the faculty, business community, parents, students and the administrative team in developing the school's vision for STEM education at your site?
- What are some ways you have solicited input from your strategic alliances to gain a better knowledge and appreciation of the practices students will need to join the workforce?

Partnering for Student Success

- In what ways does your school work in partnership with stakeholders to provide support and services so that all students, including those underrepresented in STEM fields, meet the challenges of STEM?
- Describe your plan to engage students as active partners in their own success.
- Describe the STEM challenge opportunities available to nurture and further students' natural gifts, interests, and abilities.
- What intervention strategies are in place to support students?

Collaboration with Parents

- What are some ways you reach out to parents to be partners in their children's education and share responsibility for high student performance?

Strategic Alliance

- Describe your efforts to build strategic alliances with business, community organizations, and institutions of higher education?
- What are some of your STEM learning opportunities available to students that give them insights into the nature, challenges, and excitement of STEM career choices and prepare them for the world of work?

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TOTAL INSTRUCTIONAL FOCUS: RIGOROUS AND ENGAGING CURRICULUM

A rigorous and engaging STEM curriculum aligns with state standards and integrates disciplines. By incorporating 21st century skills and technology, the curriculum affords opportunities for real-world experiences and promotes civic responsibility.

Standards-based

A viable STEM curriculum is based on state-adopted content standards. It is guided by research on how students learn, and what they are able to learn at different levels of their cognitive development. Currently in the US, 45 states have adopted the Common Core State Standards (CCSS) for math and ELA. According to the CCSS developers, the standards "are designed to ensure that students graduating from high school are prepared to go to college or enter the workforce and that parents, teachers and students have a clear understanding of what is expected of them. The standards are benchmarked to international standards to guarantee that our students are competitive in the emerging global marketplace." A viable STEM curriculum reflects the goals of the CCSS and is based on these and other rigorous, state-adopted content standards.

Aligns K-12

Standards-based STEM curriculum is comprehensive, cohesive and connected across and within subjects and grade levels. Instruction and assessment practices support the content standards. Vertical alignment across grade levels identifies and eliminates gaps and overlaps in the curriculum. For example, within a district, all teachers of science K-12 may collaborate to see that all standards and concepts are taught and assessed at the appropriate level of rigor, ensuring prerequisite skills are addressed. This vertical process encourages learning that builds from grade to grade.

On the other hand, horizontal alignment occurs when teachers within the same subject have a clear understanding of what they must teach at their grade level and what students need to know and be able to do for that subject. Horizontal alignment ensures consistency of the knowledge and skills students possess as they move from one grade to the next. The implementation of a viable, aligned curriculum is essential to acquiring the knowledge and skills students need to experience success in STEM at each subsequent grade level.

Integrated, Real World

Teaching and learning with an integrated perspective mirrors the world of work where solutions require skills and knowledge from multiple disciplines. In their book, *Meeting Standards through Integrated Curriculum,* Susan Drake and Rebecca C. Burns have defined three categories of curriculum integration: multidisciplinary, interdisciplinary and trans-disciplinary. While there are multiple approaches within these categories, curriculum integration in a STEM school moves beyond integration of subjects in thematic units. It is the artful interweaving of rigorous academic standards to create meaningful learning experiences focused on innovation and solutions to current, real-world problems.

Categories of Curriculum Integration

Multidisciplinary	Interdisciplinary	Trans-disciplinary
• Disciplines are taught separately, but a common theme, skill or practice is infused into each. • Examples: Literacy across the curriculum; 21st century skills integrated across the curriculum; technology across the curriculum.	• Processes, methods and language from more than one discipline are integrated to examine a topic or solve a problem. • Example: Students apply mathematical practices, writing processes and the scientific method to report on their analysis of water quality in their town.	• All knowledge is interconnected and interdependent. • Example: Students design a school system for a poverty stricken country and engage knowledge from applicable disciplines as needed.

21st Century Skills and Technology

In STEM schools, 21st century practices are embedded in the curriculum to promote content mastery and facilitate real world investigations, applications and innovations. These practices include 21st Century skills and technology proficiencies that enable students to:

- Communicate ideas clearly, verbally and in writing for multiple purposes and audiences, locally and globally.
- Collaborate with classmates and other stakeholders to make decisions, solve problems and advance common goals.
- Create and innovate using a design process.
- Think critically, assimilating core knowledge and key ideas to address complex topics.
- Understand and use the most appropriate technology for a given task.

These practices are an integral part of teaching and learning in the STEM classroom, as teachers provide opportunities for students to apply important academic concepts in real world contexts.

Promotes Civic Responsibility

STEM-minded schools equip learners with skills and confidence to think and act in STEM-relevant aspects of civic life. Students learn the value of being informed, financially literate and productive citizens of their communities, state, nation and globe. A learning opportunity in a STEM classroom might require students to construct evidence-based arguments for or against a given candidate, based on the candidate's tax policy proposals for small businesses or farmers in their state. Another assignment might have students use data to analyze the impact of a proposed business on the local natural habitat vs. its effect on the local economy in their town, or in a village in a foreign land. A viable STEM curriculum provides students with experiences that focus on their civic rights and responsibilities as well as how their actions affect the rights of others.

A viable STEM curriculum is the result of a rigorous developmental cycle including expert review, field-testing and revision based on data about student learning. STEM schools systematically review their curriculum for effectiveness. All stakeholders have input into this process to ensure the curriculum remains challenging and current in its application, preparing students to flourish in an ever-evolving and demanding world.

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Solutions in Science, Technology, Engineering & Mathematics Education

TOTAL INSTRUCTIONAL FOCUS: RIGOROUS AND ENGAGING CURRICULUM

A standards-based STEM curriculum aligns with state standards and integrates disciplines. By incorporating 21st century practices, it affords opportunities for real-world experiences and promotes civic responsibility.

Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Standards-Based

- What processes are in place to ensure that your school's STEM curriculum is based on the Common Core State Standards and other state-adopted content standards?

Aligns K-12

- What are some things you are doing to identify and eliminate gaps and overlaps in the curriculum?
- What are some things you are doing to ensure that all teachers at the same grade level have clarity as to what they must teach?

Integrated, Real World

- What are some ways you are approaching teaching and learning from an integrated perspective?

21st Century Practices

- What are some examples of 21st century skills embedded in all curriculum at your school?
- What are some opportunities teachers provide students to apply important academic concepts in real world contexts?

Promotes Civic Responsibility

- How are you equipping students with the skills and confidence to think and act in STEM relevant aspects of civic life?

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TOTAL INSTRUCTIONAL FOCUS: PROFESSIONAL LEARNING

Professional learning in STEM education is adult learning that ensures a STEM curriculum is implemented with fidelity by educators who have deep content understanding and pedagogical content knowledge in the subjects they teach. This approach includes engagement in ongoing professional development and participation in STEM-related professional learning communities (PLCs).

Deep Content Understanding

With the world growing in complexity at a rapid place, it is essential teachers have deep content understanding in the subjects they teach, and that they engage in continuous learning. The National Research Council report, *Successful K-12 Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*, states, "Teaching in ways that inspire all students and deepen their understanding of STEM content and practices is a demanding enterprise." The report goes on to suggest that middle and high school teachers earn degrees and achieve certifications in the subjects that they teach. Horizon Research cites studies that indicate a positive influence of math and science teachers' content knowledge on three key areas: how teachers engage students with the subject matter, how teachers select instructional materials, and how well students achieve in those subjects.

Pedagogical Content Knowledge

In addition to deep content knowledge, teachers need to be highly competent in teaching their disciplines. Pedagogical content knowledge (PCK) is a phrase coined by Stanford University's Lee Shulman in the late 1980s. He defines the concept as the ways of representing and formulating a topic to make it comprehensible to others. "It is," he suggests, "a category of professional knowledge that distinguishes teachers from others who might know a subject well, but have no occasion to develop the knowledge entailed in teaching a subject." This type of knowledge enables STEM teachers to appropriately align teaching strategies and technology tools with curriculum concepts, placing them at the optimum point in the learning cycle.

STEM Professional Development

The focus of STEM professional development is to increase teachers' content knowledge and PCK as well as enabling them to implement a STEM curriculum with fidelity. Areas for teachers to increase their understanding include:

- aligning STEM assessments and instructional strategies with a standards-based STEM curriculum.
- integrating real world challenges.
- incorporating 21st Century practices and technology.
- promoting civic responsibility.
- addressing the unique learning needs of those underrepresented in STEM fields.

Graduate classes, workshops, webinars, and other formats are available for teachers to further their STEM learning; however, the most powerful and sustained learning occurs when professionals learn together in learning communities.

STEM Professional Learning Communities

The WestEd report, *STEM Teachers in Professional Learning Communities: From Good Teachers to Great Teaching,* states, "To meet the needs of today's learners, the tradition of artisan teaching in solo-practice classrooms will have to give way to a school culture in which teachers continuously develop their content knowledge and pedagogical skills through collaborative practice that is embedded in the daily fabric of their work." The expectation in STEM schools is that teachers share their expertise. Efforts to develop and maintain a professional learning community in STEM-minded schools are continuing and systemic. School leaders set expectations, providing the time and space for teachers to plan instruction and learn from student work and data. Participants in STEM PLCs share values, goals and collective responsibility for the learning that impacts student achievement.

The driving force behind a STEM school's professional learning plan is student preparation for success in the world of the 21st century and beyond. In STEM schools, professional learning is valued and expected of all staff. It is a coherent, continuous system aligned with the school's mission, vision, and goals. The learning is supported by appropriate time and funding, enabling staff to prepare students for success in college, careers and citizenship.

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Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Deep Content Understanding

- What measures are in place to ensure that teachers have deep content understanding in the subjects they teach?

Pedagogical Content Knowledge

- How do teachers go about representing and formulating a topic to make it comprehensible to their students?
- What evidence do you have to ensure that teaching strategies, technology tools, curriculum concepts, and assessments are aligned?

STEM Professional Development

- Describe how the focus of your school's STEM professional development increases teachers' content knowledge and pedagogical content knowledge.
- Describe how your school's professional development prepares teachers to implement the STEM curriculum with fidelity.

STEM Professional Learning Communities

- At your school, what are the expectations for teachers sharing their expertise?
- What are the expectations school leaders have set for teachers to plan instruction and learn from student work and data?
- Describe the ways in which professional learning is valued, expected of all staff.
- In what way is professional learning a coherent, continuous system aligned with the school's mission, vision, and goals?
- What support is in place for professional learning?

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TOTAL INSTRUCTIONAL FOCUS: ASSESSMENT GUIDES AND INFORMS INSTRUCTION

Assessment is an important tool that guides and informs STEM instruction. An effective design will mirror the STEM curriculum and instruction methods, employing a range of assessment strategies. Both formative and summative assessments are incorporated so the resulting data can guide instruction and learning.

Mirror the STEM Curriculum

An effective assessment of the engaging and rigorous STEM classroom mirrors the curriculum and its innovative instruction methods. Taking a standards-based, integrated approach with real world applications, the assessment measures students' ability to innovate, problem-solve and apply 21st century skills at each grade level. At the high school level, a diligent assessment also gauges students' readiness for college, careers and productive citizenship.

Range of Assessment Strategies

According to Hays B. Lantz of CurrTech Integrations, traditional modes of assessment alone are not sufficient to gather evidence of student understanding of the rich and robust STEM curriculum. Paper and pencil tests and quizzes are valid formats for gaining evidence of student learning; however, authentic assessment methods require students to find novel solutions to complex challenges within and beyond school contexts. An effective assessment of STEM instruction engages individual and collaborative teams in incorporating design processes, technology and standards-based content to show what students are learning, the knowledge they've retained and what they are able to do as a result.

Formative Assessment

Formative assessment, also called assessment *for* learning, takes place during instruction. It enables instructors to identify necessary adjustments while teaching and learning are in progress.

In a STEM classroom, teachers purposefully design tasks to reveal students' progress towards defined learning targets. These tasks simulate professional work environments, requiring students to apply their learning in meaningful ways. Because the work is not graded, these projects encourage innovation and risk-taking. Students have the advantage of descriptive feedback from their teachers and peers to incorporate with self-critique into final products. Teachers have the advantage of identifying and clarifying student misconceptions before final evaluation. Collaborative technology tools such as wikis, Google docs and other online sharing formats can aid in the formative assessment process. The teacher and fellow students use such tools to access and provide ideas for refinements of ongoing work, leading to enhanced summative assessment results.

Summative Assessment

Summative assessment, also known as assessment *of* learning, takes place at the end of an instructional unit, quarter, semester or year. It is the culminating evaluation of a teaching and learning progression in which a student has had multiple opportunities to hone and build on knowledge, skills and assignments. For example, a STEM-focused summative assessment may require students to produce a documentary highlighting a compelling community or world problem. Photos and video clips taken with a mobile phone or a Flip camera could be imported into the students' choice of digital media to vividly underscore key points. The final product might be in the form of a digital story or a podcast. Students might be expected to maintain a blog to keep the teacher

and fellow students abreast of their progress and new learning along the way. Although this type of assessment is summative and subject to a grade, data from it can still be used to guide next steps in instruction.

Data Guides Instruction and Learning

Decisions about what is next in instruction come from various data sources and can be collected through observations, dialogue and analysis of formal and informal student responses. Using data from formative and summative assessments, individual misunderstandings can be addressed as trends in student fallacies are identified. This information can used to make adjustments in instructional plans and learning strategies. To promote school wide congruence between what is taught and what is assessed, time should be embedded in the school day for teachers to collaborate on assessment design and take informed action based on student assessment results.

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Assessment is an important tool that guides and informs STEM instruction. An effective design will mirror the STEM curriculum and instruction methods, employing a range of assessment strategies. Both formative and summative assessments are incorporated so the resulting data can guide instruction and learning.

Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Mirrors the STEM Curriculum

- In what ways does your assessment design mirror your STEM curriculum?
- In what ways is your assessment design standards-based, integrated, real world?
- In what ways are students' ability to innovate, problem solve, and apply 21st century skills assessed?
- In what ways does your assessment design gauge students' readiness for college, careers, and productive citizenship by the end of high school?

Range of Assessment Strategies

- What assessment practices do you currently employ to guide and inform instruction in the STEM classrooms?
- How might you incorporate more authentic assessment methods that require students to find novel solutions to complex problems within and beyond the school contexts?

Formative Assessment

- In what ways do assessment practices highlight needed adjustments in ongoing teaching and learning?
- How well do assessment tasks simulate professional work environments requiring students to apply their learning in meaningful ways? Explain.
- What strategies do teachers employ to incorporate design processes, technology and standards based content in assessments?

Summative Assessment

- What do STEM focused summative assessments look like at your school?

Data Guides Instruction and Learning

- In what ways does assessment guide your next steps in instruction? Be specific.
- How do administrators promote school wide congruence between what is taught and what is assessed?

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TOTAL INSTRUCTIONAL FOCUS: NETWORK OF INSTRUCTIONAL SUPPORT

A network of instructional support in STEM education is a system facilitated by knowledgeable leaders, who lead the school community in acquiring and maintaining resources and maximizing learning time for all STEM instruction whether tested or not.

Instructional Leaders

Instructional leaders in STEM schools engage in their own professional learning to stay abreast of current research on STEM education. This gives them greater proficiency in creating the school conditions that support STEM learning. The National Research Council's report, Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics, suggests that school leadership is the driver for change. The report states, "Principals must be strategic, focused on instruction, and inclusive of others in the leadership work." Coordinating a network of instructional support that includes all stakeholders is among the multiple facets of leadership in a STEM school.

Assessing Needs - Providing Access

Guided by the school's vision and goals for STEM education the school sets priorities for fulfilling its STEM resource needs. The collective responsibilities of the network include recruitment of teachers qualified to teach a STEM curriculum, along with the acquisition and maintenance of resources vital to support STEM instruction. These include time, materials, facilities, technology, professional learning, and human resources.

A school needs assessment should be conducted to ascertain STEM teaching and learning needs. The analysis should address questions such as:

- How might we equip our classrooms, labs, media centers and common spaces for 21st century individual and collaborative learning?
- In what ways does our technology plan reflect the needs of learners in a digital age?
- What essential materials and supplies might we provide to support teaching and learning the STEM curriculum?
- How might we meet unique learning needs of individuals in the STEM school community, including students, staff and parents?
- What resources will enable our school to better serve the surrounding community, including businesses, institutions of higher learning and community organizations?
- In what ways can we leverage community resources to meet the school's needs?

The answers to these questions and others will guide school actions and should be clarified through a collaborative decision-making process that engages the full school community. The effective STEM school community is diligent in its efforts to gain and facilitate the purposeful use of essential resources that support the success of all students in achieving STEM goals.

Maximize Learning Time

A typical school day is 6 – 7 hours in length; therefore, the resource of time must be strategically managed. STEM schools value all content areas, those tested by the state and those not, and use creative strategies to maximize instructional time in all classes. The National Center on Time and Learning (NCTL) puts forth, "Every child in America deserves an education that prepares them for success in college and careers and a rich, fulfilling life. Unfortunately, our antiquated school calendar is too limiting to provide millions of children with the breadth and depth of educational experiences they will need to thrive." NCTL proposes strategies that expand the traditional school day to provide for greater depth of learning in core classes and enrichment in the arts and sports.

There are some promising strategies that maximize instructional time without adding to the school day. "Flipping" the classroom is an example. In this practice, students begin their learning at home where they view videos made by their teachers and take notes on knowledge level concepts. During class, with their teacher's guidance, students utilize those concepts, in collaboration with peers, to solve problems and design innovations. The STEM school community thinks and acts outside of the box to ensure the effective and efficient use of time as an instructional resource.

Thriving STEM schools are guided by a collaboratively developed strategic plan. Insightful leaders work with all stakeholders to form a network that fully supports every aspect of STEM instruction.

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Guiding Questions

Use the reflection questions below to guide discussions. We recommend documenting evidence to support each question. Doing so will assist you in setting action plans, goals, and progress monitoring.

Instructional Leaders

- What are some ways leaders at your school create conditions that support STEM learning?
- What are some ways the school principal is inclusive of others in her/his leadership work?
- How do administrators recruit teachers qualified to teach STEM curriculum?
- What processes and procedures are in place to acquire and maintain assets vital to STEM instruction?
- How do leaders at your school engage in their own professional learning to stay abreast of current research on STEM education?

Assessing Needs; Providing Access

- What collaborative decision-making process does your school use? How does this collaborative decision-making process engage the full school community?
- What are some ways you ensure community understanding of the school's vision and goals for STEM education?
- How are you ensuring that your school community has the essential materials and supplies to support teaching and learning the STEM curriculum?
- How are classrooms, labs, media centers, and common spaces equipped for collaborative learning? For individual learning?
- How does your technology plan reflect the needs of learners?
- What materials and supplies are essential to support teaching and learning STEM curriculum?
- How are unique learning needs of students, staff, parents and other individuals in the STEM school community met?
- What resources will enable our school to better serve businesses, institutions of higher learning, and community organizations?
- How might we better leverage community resources to meet the school's needs?

Maximize Learning Time

- What strategies are employed to maximize instructional time in *all* classes?
- In what ways do school leaders work collaboratively with the school community to put forth ideas that lead to equitable learning time?
- In what ways are teachers encouraged to practice innovative approaches that maximize instructional time?