VISION
for CPS
STEM
EDUCATION
A CALL TO ACTION:
THE CASE FOR STEM EDUCATION

America’s global competitiveness will increasingly depend on our ability to better educate our young people in math and science and to attract more of our best and brightest students into technological careers. Progressively more jobs across various fields and levels will require some knowledge of STEM. A STEM-literate workforce will attract investment and jobs to Illinois, while good jobs and economic opportunity will attract world-class talent to the city of Chicago. STEM education unleashes students’ creativity and gives them the skills needed to conceive and develop the revolutionary products and processes that will continue to shape the nation and Chicago’s economic future.

The purpose of this document is to guide the strategic planning, resource allocation, desired outcomes and critical criteria for developing STEM-focused practices, programs and schools. As part of our vision, we include key qualities that are important for developing any effective school, but especially STEM-focused schools. These universal qualities include the necessary elements to build a strong foundation for a high-quality learning environment and successful STEM education. In addition to these core elements, key stakeholders will find STEM-specific components to drive the planning, systems, and structures to achieve goals in alignment with the CPS/Citywide STEM Strategy.

EXPECTED OUTCOMES:

- Create a pipeline and pool of highly-qualified STEM teachers
- Increase the percentage of minority students, specifically African-American, Latinos, and girls enrollment/participation in STEM courses
- Increase engagement and awareness of STEM and STEM-related fields
- Improve percentage of students meeting and exceeding performance expectations for standardized exams
- Increase percentage of students graduating with STEM credential
- Increase matriculation in post-secondary education for STEM-related fields
- Increase the number of students prepared for jobs in STEM fields
WHAT IS STEM EDUCATION?

A COMMON DEFINITION OF STEM EDUCATION is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise, enabling the development of STEM literacy and with the ability to compete in the new economy. (Tsopros, Kohler, Hallinen, 2009)

WHAT DOES THIS MEAN FOR CHICAGO PUBLIC SCHOOLS?

We Have Identified the Following Critical Components to Support High Quality STEM Education:

1. Mission Driven Leadership
2. School Structures and Culture
3. Institutional Capacity
4. STEM Program of Study
5. Instructional Approach
6. STEM Career Pathways
7. External Partnerships
Leaders of STEM schools must embrace a mindset that includes: leading by example, creating an environment of high expectations, pursuing opportunities that enhance learning, preparing students to meet the demands of tomorrow’s workforce, creating and communicating a “shared vision” of purpose and process. It is critical for leaders to demonstrate a commitment to STEM by concentrating on building capacity around STEM Education and minimizing competing initiatives in an effort to support a focused set of priorities. It is imperative for STEM leaders to align the mission, expectations, values, and resources with components of high-quality STEM education.
The school-wide norms, policies, and values should support high-quality STEM learning experiences: high expectations for all, applied and collaborative learning principles; approaches for developing critical thinkers and fostering innovation. Parents should also be welcomed in the school and engaged in supporting the academic success of their students. The learning climate must be student-centered, provide a safe, welcoming, and stimulating environment. A successful STEM school structure and culture should foster learning for ALL students.

**STRUCTURES:** Additional key academic structures are essential to fostering an integrated and holistic STEM experience.

**Teacher Collaboration, Interdisciplinary, and Vertical Planning:** This time is critical to building the types of units and projects to engage students in meaningful learning. Teachers need time to recognize and build off of the many connections between content areas that are typically taught in isolation.

**Range and Depth of Learning Experiences:** Students have adequate time and multiple opportunities to engage in meaningful STEM experiences exceeding state and district graduation requirements. This includes both in-school and out-of-school time.

**Professional Learning Community:** The on-going process of learning, collaborating, and teaming among teachers, administrators, and stakeholders is critical to the development of an environment conducive to developing adult learners and advancing student.

**Policies and Procedures:** Schoolwide policies and procedures must reflect alignment with developing a strong STEM culture; including common vocabulary and evidence for key concepts.

**CULTURE:** A school culture should be cultivated to support the Core Belief Statement of all stakeholders at CPS STEM schools.
CORE BELIEF STATEMENT: WE ARE DEVELOPING TOMORROW’S INNOVATORS

The following points outline components of school culture that must be in place to reinforce this core belief.

HIGH EXPECTATIONS FOR ALL: Every student is expected to achieve success. Students are supported in developing personalized goals for meeting these expectations.

STUDENT-CENTERED LEARNING: Learning is designed to engage students, build on their prior knowledge, and at the same time offer exposure to new topics to expand opportunities. Their interests, ideas, and questions should guide instruction placing the teacher as the facilitator of learning rather than the deliverer of content.

FOCUS ON INNOVATION, PROBLEM-SOLVING, & RISK-TAKING: Students are not afraid to make mistakes. Instead, they see the value in mistakes and are encouraged to learn from them. There is a focus on the iterative learning process so that teachers and students can work through problems in ways similar to STEM professionals.

APPLIED LEARNING: Students learn new content in order to apply it to real-world problems that need to be solved and/or explained. Students do not learn skills in isolation or without purpose.

EXPOSURE TO STEM CAREER PATHWAYS: Introducing and exploring a variety of STEM career pathways through specific curriculum content and in-school and out of school enrichment can lead to greater levels of interest and motivation for pursuing STEM-related careers.

STEM CONNECTIONS THROUGHOUT ALL COURSES: Teachers in all content areas, design units and lessons to include logical and relevant connections to STEM fields. Students begin to see how problem-solving practices in all content areas contribute to their preparation for STEM fields.

COLLABORATIVE LEARNING: Students regularly work in groups/teams to investigate and solve problems. Students learn the value of collaboration, have opportunities for reflection about their contributions, and increase their ability to work with others effectively.
A school’s ability to perform necessary functions, solve problems, set and achieve objectives is essential to supporting quality STEM Education. The points outlined below describe necessary components of any STEM school.

PROGRAM + SCHOOL MODELS ARE ADEQUATELY RESOURCED: The adequate allocation and strategic use of funds to support STEM education should be based on the overarching goals for high-quality learning experiences for all students. This has implications for staffing, professional development, materials, equipment, and facilities.

Research from National Science Foundation states "it takes approximately 80 hours to change practice, 120 hours to change culture."
HIGH-QUALITY TEACHING STAFF: An effective and talented staff at a STEM school is crucial to building capacity around STEM Education. Beyond required coursework and certification, teachers should be responsive to the idea of changing their practice, eager to collaborate with one another, and participate in high-quality, ongoing professional development. The following are key proficiencies and aptitudes of strong STEM teachers:

Mathematics and Science Content Knowledge and Pedagogical Content Knowledge: Specifically, teachers charged with teaching mathematics and science disciplines should use quality instructional practices strongly grounded in subject matter knowledge and pedagogical content knowledge.

Facilitators of Learning: Teachers should seek to foster curiosity and transfer more student ownership of the learning process.

Ability to Accept Failure as Part of the Learning Process: By providing opportunities for students to explore and make mistakes, teachers can assist students with the problem solving and allow for deeper learning.

LEADERSHIP: School leaders must be strategic in facilitating the growth and development of the entire staff. They must guide and provide opportunities for teachers to be reflective practitioners. School leaders should be focused on the instruction of all students and capable of providing support to advance learning throughout the school. Additionally, leaders should contain the qualities described below:

STEM Instruction: School leaders should build their capacity to understand what quality instruction in mathematics and science classrooms should look like to ensure strong support for a STEM foundation.

Capacity to Drive Change: School leaders should have experience with leading change within in a school while also recognizing the need for and benefits of change.

Creates a Safe Environment for Teachers to Take Risks: It is important for school leaders to create an environment that allows teachers and students to explore and develop new ways of teaching and learning in support of STEM

Models Innovative Behavior: New ideas and constructive feedback should be welcomed and considered.

Embraces and Promotes CPS STEM Core Belief: Leaders support and consider the school’s Core Belief in all decisions.
### STEM PROGRAM OF STUDY

Strong instruction in science, technology, engineering, and math is essential to preparing students for success in any STEM Field. This table outlines minimum expectations around the instruction of these content areas.

<table>
<thead>
<tr>
<th></th>
<th>PK-2</th>
<th>3–5</th>
<th>6–8</th>
<th>9–12</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIENCES</td>
<td>Minimum 200 minutes/week</td>
<td>Minimum 250 minutes/week</td>
<td>Minimum 300 minutes/week</td>
<td>4 years of Science recommended</td>
</tr>
<tr>
<td>TECHNOLOGY</td>
<td>Technology should be integrated across content areas -AND- addressed through additional electives</td>
<td>Computer Science embedded in math or science minutes</td>
<td>Exploring Computer Science required</td>
<td></td>
</tr>
<tr>
<td>ENGINEERING</td>
<td>Embedded in math and science minutes</td>
<td>Embedded in core math and science courses -AND- Addressed through additional electives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATHEMATICS</td>
<td>Minimum 450 minutes/week</td>
<td>4 years of Math recommended</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* greater than state minimum requirements – minimum minutes can be met through academic enrichment & intervention
*recommended offering of algebra by 8th Grade
STRONG MATHEMATICS & SCIENCE PROGRAM: A high quality mathematics and science curriculum is essential to the success of any STEM school. A solid program will provide students with opportunities to make connections between course content and real-world experiences.

Aligned to Standards: The Common Core State Standards for Mathematics and the Next Generation Science Standards provide the framework for the development of a focused and cognitively rich curriculum of which the content is logically sequenced to develop conceptual understanding.

Grade-level Appropriate Content: Prerequisite knowledge should be embedded in appropriate content to ensure that students have every opportunity to achieve grade-level expectations.

ENGINEERING: Engineering as a discipline will be addressed as specialized coursework and through the application of the Science and Engineering Practices as outlined by the Next Generation Science Standards;
- Emphasizes the engineering design process of identifying and solving problems
- Establishes connections between post-secondary studies and real-world practice
- Incorporates developmentally appropriate mathematics, science, and technology knowledge and skills
- Promote engineering “habits of mind”

COMPUTER SCIENCE: Computer Science coursework will be offered in all elementary and High School STEM schools, with both minimum requirements for all and for those interested, opportunities for advanced courses.

TECHNOLOGY-BASED ELECTIVES: Students will have an opportunity to explore technology-based courses via electives during the school day in addition to out-of-school time offerings. Offerings such as computer-aided design, digital media design, or robotics are examples of technology-based electives.
Common Core Standards for Mathematical Practices
and Next Generation Science Standards Science and
Engineering Practices: Developing Performance Expectations
and Integrating across the Curriculum Content Areas….

COMMON CORE STANDARDS FOR
MATHEMATICAL PRACTICES

Standard 1: Make sense of problems
and persevere in solving them

Standard 2: Reason abstractly and quantitatively

Standard 3: Construct viable arguments
and critique the reasoning of others

Standard 4: Model with mathematics

Standard 5: Use appropriate tools strategically

Standard 6: Attend to precision

Standard 7: Look for and make use of structure

Standard 8: Look for and express
regularity in repeated reasoning

Next Generation Science Standards:

K12 SCIENCE FRAMEWORK SCIENCE & ENGINEERING PRACTICES

The Framework identifies eight science and engineering practices
that mirror the practices of professional scientists and engineers.
Use of the practices in the performance expectations is not only
intended to strengthen students’ skills in these practices but
also to develop students’ understanding of the nature of science
and engineering. Listed below are the science and engineering
practices from the K12 Science Framework*:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

*Next Generation Science Standards Publication November 2013
INSTRUCTIONAL STRATEGIES: A core course sequence that makes use of inquiry-based learning activities must be mandatory for all students. Within these courses, students should regularly be cooperating with one another as they engage in problem solving projects.

Use of Authentic Assessments: While a variety of assessment types should be used to gauge understanding, students should be pushed to demonstrate their conceptual understanding and ability to apply their ideas around a particular topic. Performance tasks range from short activities taking only a few minutes to projects culminating in polished products for audiences in and outside of the classroom. In addition to quizzes and tests, examples of authentic and performance-based assessments include science journals, lab reports, rubrics, oral presentations, open response questions, rubrics, or models.

Problem-Based or Project-Based Learning: Students are engaged in learning opportunities that support the development of creativity, communication skills, and improved writing skills. Projects should pose non-routine tasks that encourage students to debate ideas and draw conclusions through investigation.

Capstone Project: Capstone projects provide a culminating experience through which students can display the knowledge, skills, and practices gained over the year. Capstones also offer an opportunity to demonstrate reflection and effective communication; in addition to student choice through areas of interest.

TECHNOLOGY INTEGRATION: Technology in all its forms should be an integral tool to enhance student learning and acquisition of 21st century learning skills. The availability and access to quality technology and supporting infrastructure connects students with information systems, models, databases and STEM research; additionally teachers, mentors, and social networking resources for STEM learning are available during and outside the school day.

21ST CENTURY SKILLS: Students engage in collaborative & cooperative learning experiences that promote critical thinking, problem solving, communication, and creativity.

CROSS-CURRICULAR UNITS: Teachers should work on interdisciplinary teams to develop meaningful units and projects that engage students in solving problems that require understanding from multiple disciplines. As teachers plan units, they should make a conscious effort to integrate skills that apply across content areas.
The specific STEM Pathways that are offered within a STEM School should be designed very intentionally to provide students with knowledge and skills of significant content in the field, an awareness of post-secondary STEM options, and out-of-school experiences that engage and motivate them in learning about STEM topics. Afterschool, co-curricular, and summer programs should be promoted to support classroom learning. Many of these programs reach out to underrepresented groups in STEM professions, and help to support the development of critical skills that will help students achieve success in the classroom. Students should participate in STEM related competitions allowing them to experience hands-on projects and real-world applications of STEM problems.

**HIGH SCHOOL CONNECTION TO POST-SECONDARY OPTIONS (college & career):**
Students from a STEM school must be given exposure to post-secondary experiences throughout their education. Teachers and staff should make conscious efforts to increase the visibility of STEM college and career options for students.

**Content:** Content expectations should be set with the assistance of post-secondary educators and industry professionals to ensure alignment to necessary skills for success in college and career.

**Specialized Coursework:** There will be multi-year progressive coursework available in one or more high-priority STEM labor market areas (e.g., IT, Healthcare, Manufacturing, etc.) that leads to professional certification opportunities and college credit opportunities.

**Dual Credit/ Dual Enrollment:** A flexible school schedule is designed to provide opportunities for students to take classes at institutions of higher education or online.

**OUT OF SCHOOL TIME – Blended Formal/Informal Learning beyond the Typical School Day, Week, or Year:** Learning opportunities are not bounded but ubiquitous. Learning spills into areas regarded as “informal STEM education.” Included are apprenticeships, mentoring, social networking and “doing STEM” in locations off of the school site, in the community, museums and STEM centers, and business and industry.
Partnerships with STEM professionals are necessary to enrich learning opportunities for students. These partnerships can vary in format but should provide students with a deeper understanding of how the content they cover in their coursework applies to the real-world. Ideally, these partnerships are consistent for students throughout their time in school providing opportunities to develop mentor-mentee relationships. All partners should support instruction and the school’s Core Belief.

**BUSINESS/INDUSTRY:** Students connect to business/industry/world of work via mentorships, internships, site visits, or projects that occur within or outside the normal school day/year.

**UNIVERSITIES AND COLLEGES:** College and university partnerships should also be developed and maintained to provide guidance on coursework and preparation for post-secondary education. Early College programs may be a part of this which would allow students to earn college level credit while attending the STEM school.

**INFORMAL LEARNING INSTITUTIONS:** Museums and other organizations provide support and opportunities to enrich in-school learning experiences.
REFERENCES

Chicago Public Schools. Performance Standards for School Leaders Rubric – Evaluating Practice of Principals
C-STEMEC. (2013). Putting it All Together – Supporting PK-12 STEM Education in Illinois. Chicago, IL.
Tsupsos, N., R. Kohler, and J. Hallinen, 2009. STEM education: A project to identify the missing components, Intermediate Unit 1 and Carnegie Mellon, Pennsylvania

REFERENCE SCHOOLS

Dayton Regional STEM School, Dayton, OH
eSTEM-Reynoldsburg, Reynoldsburg, OH
High Tech High, San Diego, CA
Illinois Math Science Academy, Aurora, IL
Manor New Tech High, Manor, TX
Miles Davis STEM Magnet Academy, Chicago, IL
STEM Magnet Elementary School, Chicago, IL

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