A.3 Program of Instruction

The program of instruction at SySTEM Phoenix is designed to meet the needs of students in its target population and prepare them with the skills they will need to pursue careers in science, technology, engineering, and mathematics (STEM). The majority of these students live in families without a college going tradition. As a result, most face substantial barriers to academic achievement, including low expectations, limited support, and lack of exposure not experienced by their more affluent peers. The tangible effects of these barriers have been documented year after year by low performance on the Arizona Instrument to Measure Standards, particularly in math and science.

Program Overview

SySTEM Phoenix is the first 6th through 12th grade STEM-focused charter school designed to leverage Arizona's robust STEM community to transform students into active learners and practitioners in the field. Through authentic, hands-on educational experiences, all students will develop the academic and social skills necessary to compete in an increasingly STEM-based, global workforce.

STEM competencies do not exist in isolation from each other, and, as such, are most effectively learned through an interdisciplinary approach. The core of SySTEM Phoenix's educational approach is founded on the belief that an integrated, relevant instructional model results in deeper, more meaningful learning. Through a Problem-Based Learning pedagogical approach, students develop the skills to tackle the robust problems characteristic of the real-world. As active agents in the learning process, students pursue and use knowledge to negotiate their learning in peer groups and present solutions to authentic audiences.

Every component of SySTEM Phoenix's academic program reflects this commitment to integrated learning. Courses are designed to ensure coursework is connected within subjects and to the outside world. As well, the Common Core English Language Arts standards will be incorporated across all content areas.

Math/Science and English/History Common Core Integrated Blocks
The Common Core Integrated Blocks will use a combination of research-based best practices to present grade level English Language Arts Common Core Standards through the context of Social Studies Standards and grade level Mathematics Common Core Standards through the context of Next Generation Science Standards.

STEM in Action Block
STEM in Action is an opportunity for students to apply concepts from the Next Generation Science Standards to become an agent of change and solve a variety of community problems. In collaboration with members from the local community, these courses will build connections between STEM subjects, civic engagement, and everyday life. Students will participate in units such as gardening, yoga, and art through the lens of STEM. For example, a gardening course might include data collection and analysis of soil composition, rain cycles, and the effects of pollution on crops.

A. Curriculum Overview and Alignment

Curriculum Alignment to Arizona State Standards/Common Core Standards

Curriculum will be based on Arizona Common Core Standards in order to create a robust and rigorous college-prep curriculum. Common Core Standards will be broken down into scaffolded interdisciplinary units to create viable pathways for student academic achievement. Curriculum will be structured to reinforce the interconnectedness of traditional disciplines, and instructional units will be designed to

maximize the rich interdisciplinary connections which promote strong critical thinking and problem-solving skills.

Curriculum will be constructed using the principles of Backwards Design to ensure alignment between SySTEM Phoenix's curriculum and the Common Core State Standards. By designating the standard as the end goal, teachers will create essential learning goals, which will be broken down into concrete, evaluable success criteria. These success criteria are detailed in terms of assessment evidence, which then inform daily lessons. In this way, all student experiences support and align to the state standards.

Curriculum Alignment to Supplementary Standards

STEM Industry Expectations
Transferable skills key to student success in advanced STEM courses and professions will be emphasized throughout all courses.[1] Partnerships and ongoing interactions with major STEM companies will inform how these standards can best be clustered to develop written, verbal, problem-solving, and collaborative skills to STEM industry expectations. SySTEM Phoenix will also communicate with top colleges and STEM businesses to determine critical competencies needed by incoming college freshmen. This two-way dialogue will transform SySTEM Phoenix's curriculum into a living, working document which evolves to meet the growing demands of college STEM programs.

Next Generation Science Standards
Though scientific advances continue to change our understanding of the world and our interaction with it, the Next Generation Science Standards (NGSS) represent the first attempt in over a decade to update science education in the United States. Highly integrative by design, the standards are organized into Cross-Cutting Concepts that "bridge [inter]disciplinary boundaries" and articulate connections to the Common Core State Standards throughout. The Next Generation Science Standards will be used to ensure SySTEM Phoenix's curriculum represents the most current and applicable scientific learning expectations.

Partnership for 21st Century Skills
The Partnership for 21st Century Skills (P21) Framework for 21st Century Readiness "describes the skills, knowledge and expertise students must master to succeed in work and life." These higher order processes complement the content-based Common Core State Standards. SySTEM Phoenix's curriculum will include the Learning and Innovation Standards, particularly those focused on creativity, critical thinking, problem solving, collaboration, and self-direction.

Course Frameworks for Academic Core Content Areas

SySTEM Phoenix exceeds the Common Core's expectation for building knowledge within the disciplines by offering integrated courses which build knowledge both within and between disciplines.

English/History
All written expression occurs within a complex social matrix. Regardless of whether the text is narrative or expository, a poem or a technical manual, understanding the historical context in which a work is created only enriches the reader's ability to engage with the author. Purpose, audience, and argument unfold with nuance when the primary resources of an era are connected with its artistic expression. Through a close reading of seminal exemplars of written expression, students will identify the elements and structures an author uses to convey his/her message and begin to incorporate them into their own

[1] Problem-Based Learning Faculty Institute. (2013). *What is Problem-Based Learning?* Retrieved from: http://www.pbl.uci.edu/whatispbl.html

writing. Written expression will be driven by historical problems, requiring students to develop and support their perspective within the larger context.

In 6th through 8th grade, students will cite textual evidence to support their claims, analyze the development of a text, and make comparisons amongst texts. Students will develop as readers, writers, and communicators, utilizing appropriate conventions of English grammar and usage while honing their ability to read independently for learning. With this solid foundation, high school students will contribute to in-depth explorations of increasingly complex texts, constructing strong arguments, and conducting original research.

Mathematics/Science

When math and science are integrated, context and process unite and corresponding concepts become mutually reinforcing. Since science is the arena in which mathematical phenomena are experienced, relevant, real-world applications of either requires competency in both. Mathematics will be developed as the means to represent scientific concepts and a conduit to recognizing patterns and modeling the world.

In the middle school grades, mathematical concepts are deduced through data collection and interpretation with increasing levels of sophistication each year. In grade 6, students extend their understanding of whole number operations to include rational numbers. Student begin to use symbols to express relationships and explore attributes of two and three-dimensional figures. In grade 7, symbolic representations are manipulated and interpreted to reflect real-world situations. Quantities of change are expressed in appropriate units as ratios, rates, and proportions. A strong emphasis is placed on mathematical discourse and logical argumentation. Grade 8 builds operational fluency with the real number system. Students also create and interpret models to deepen their understanding of mathematical concepts form the prior two grades.

In high school, students will take the integrated course pathway which consists of Integrated Math I, II, and III. These courses utilize a holistic approach that highlights the interconnectedness between concepts from number sense, algebra, geometry, and probability and statistics. Fourth year courses will include Pre-calculus, Calculus, Discrete Mathematics, and Advanced Statistics.

Proposed Curricular Materials

Leaders in research on Professional Learning Communities argue that curriculum is the number one activity teachers should engage in to impact student learning. The development of the curriculum and curricular materials embodies ongoing, job-embedded professional development. This activity has two main benefits: (1) teachers become more discerning users of course materials and (2) course materials are treated as variable entities that are evaluated solely on their effectiveness in terms of student learning.

Careful development and effective dissemination of innovative STEM instructional resources and experiences require sustained effort and support. Curricular materials will be both selected and created by school staff in response to student needs, data analysis, and teacher reflection. While teachers will have access to a library of curricular resources and databases to draw from, no textbook or resource will dictate how curriculum is implemented in the classroom. As much as possible, curricular resources will be non-consumable and updateable. Below is a list of just a few of the numerous curricular materials available online to support curriculum:

Table A.3.1: Online Curricular Resources and Databases[2]

Broadcasts	Kahn Academy, PBS, Annenberg Media Learner
Common Core	Curriki, The Common Core Mapping Project, Ohio Resource Center for Mathematics, Science & Reading, Engage NY, University of Arizona Progressions
Lessons	Adobe Education Exchange, Digital IS, Buck Institute
Online Courses	National Repository of Online Courses, University of California Open Courses, The Great Courses, Coursera
STEM	The Dayton Regional STEM Center, Siemens STEM Academy, The STEM PBL Project, National Science Foundation: Graduate STEM Fellows in K-12 Education, eGFI: Engineering, Go For It!, NASA Education for Educators
Texts	Shmoop, Beyond Textbooks, Library of Congress

The unique components of SySTEM Phoenix's curriculum require innovative STEM instructional resources that are continually scrutinized and updated. This emphasis on developing resources is in recognition of a well-known rule in cutting edge practices, namely: "Materials that make innovative use of contemporary technologies need almost continuous revision to assure they remain au courant."[3]

Meeting the Needs of Special Education Students

SySTEM Phoenix will provide special education services to qualifying students in accordance with state and federal laws. SySTEM is committed to ensuring that all students eligible under the Individuals with Disabilities Education Act receive a high-quality education and learn in an environment consistent with their academic, social, and physical needs.

All SySTEM Phoenix students will be provided the appropriate level of support to fully integrate into mainstream, grade level classes. The student-centered nature of the Problem-Based Learning classroom requires students to regularly articulate both what they know and what they need to know in order to craft personalized learning experiences necessary to solve real-world problems. This approach to learning embeds differentiation and scaffolding into the daily classroom experience and seamlessly adapts with the principles of Universal Design for Learning (UDL). Comprised of a highly regarded set of guidelines and checkpoints proven to "reduce barriers to learning and provide innovative and supportive learning to meet the needs of all learners"[4], UDL is a commitment to offering flexible learning environments rather than flexible learning expectations. The key tenants of this model listed in the table below are universally offered to all students.

Table A.3.2: Key Principals of Universal Design for Learning

Representation	Learners differ in the ways they perceive and comprehend information presented to them.
Expression	Learners differ in the ways they navigate a learning environment and express what they know.
Engagement	Learners differ in the ways they can be engaged or motivated to learn.

[3] Center for Study of Mathematics Curriculum. (2010). The Future of STEM Curriculum and Instructional Design: A Research and Development Agenda for Learning Designers. *STEM Instructional Design Workshop Series – Report.* Retrieved from: http://www.mathcurriculumcenter.org/PDFS/reportSTEMworkshop.pdf

[4] Center for Applied Special Technology - CAST. (2011). Universal Design for Learning Guidelines version 2.0. *National Center on Universal Design for Learning.* Retrieved from: http://www.udlcenter.org/aboutudl/udlguidelines/principle1#principle1_g2

Furthermore, we will follow the intent of the principle of least restrictive environment suitable for individual student learning, as defined by IDEA 2004. SySTEM will contract with special education specialists and service providers as needed. Additionally, teachers will be trained to deliver appropriate accommodations and modifications in the classroom based on a student's Individual Education Plan (IEP).

Meeting the Needs of English Language Learners

SySTEM Phoenix will provide appropriate English Language Learner (ELL) support to qualifying students in accordance with state and federal laws. SySTEM is committed to ensuring all students eligible take the Arizona English Language Learner Assessment (AZELLA). If test scores designate a student as an ELL, the student will be eligible for English Language Services with parent consent. Services will either take the form of Structured English Immersion (SEI) or an Individual Language Learner Plan (ILLP). The principles of Universal Design for Learning will be fully implemented to meet the needs of SySTEM's ELL students.

B. Methods of Instruction

The instructional methods directly align to our mission to provide inquiry and Problem-Based learning opportunities that instill critical thinking and problem-solving skills in students in order to ensure their success in STEM careers. The methods described below have been intentionally chosen to support teachers and staff to create instructional experiences that cultivate key dispositions such as perseverance to solve ill-defined problems, empowerment to create change in the world, and self-reflection through meta-cognitive processes.

Hands-On Learning

Hands-on learning has been shown to level the playing field for disadvantaged students. A study by Bredderman states: "It has been demonstrated that students who are disadvantaged economically or academically gain the most form activity-based programs."[5] Hands-on learning is learning by doing. Through the use of manipulatives and interactive technologies, students conduct investigations in which they directly observe and test their ideas. The learning experience enhances students' ability to think critically and learn what, how, when, and why concepts interact.

Cooperative Learning

Though not a new strategy, meta-analyses of cooperative learning methods found "Hundreds of research studies demonstrate that cooperative efforts result in higher individual achievement than do competitive or individualistic efforts."[6] A cooperative setting capitalizes on the collective knowledge and skills of peer groups. This group interaction supports the development of strong critical thinking skills as team members brainstorm, develop action steps, posit questions for discussion, and evaluate each other's ideas.

Problem-Based Learning

A comprehensive review of the research on Problem-Based Learning cited in the book *Problems As Possibilities: Problem-Based Learning for K-12 Education* found that this approach to teaching and

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[5] Bredderman, Ted. "Effects of Activity-based Elementary Science on Student Outcomes: A Qualitative Synthesis." Review of Educational Research. 53.4 (1983): p499-518. Web. 24 Jan. 2012.

[6] Johnson, David W., R. Johnson & M. Stanne. (2000 May) Cooperative Learning Methods: A Meta-Analysis. Universiyt of Minnestora, Minneapolis. Found on: http://www.ccsstl.com/sites/default/files/Cooperative%20Learning%20Research%20.pdf

learning effectively promotes the higher order thinking skills our students need to compete for university STEM programs and 21st century jobs. "Research conducted to assess the effectiveness of Problem-Based Learning programs cites certain benefits, including increased motivation, sustained self-directed learning behaviors, long-term knowledge retention, comparable content coverage with traditional approaches, learning for understanding, and the development of professional reasoning strategies."[7]

Problem-Based Learning is the culmination of interconnected learning, incorporating standards in a holistic way to motivate mastery of various content standards through the lens of a novel, ill-defined problem. A problem is ill-defined when not all the information necessary to solve the problem is given, which requires students to consider the application of knowledge before its acquisition. This sequence infuses the learning experience with purpose and motivates students to conduct research and discover new knowledge to actively solve robust problems. The table below details how Problem-Based Learning is sequenced within a unit of study.

Table A.3.3: Problem-Based Learning Model Sequence

Step 1: Understand	Meet the problem Know/need to know Define the Problem Statement
Step 2: Explore	Gather information Acquire skills/knowledge Share information Generate possible solutions
Step 3: Resolve	Determine best fit solution Present the solution Debrief the problem

Cognitive Coaching

Cognitive Coaching strategies help students reflect on their thinking processes. Cognitive Coaching is a facilitative process in which the coach guides students towards the solution to a problem rather than providing direct instruction on concepts. This instructional method fosters the development of key PBL competencies. These include:

1. *Student-centered learning:* Students engage with the problem with whatever their current knowledge or experience affords.
2. *Small group learning:* Students share information and work productively with others.
3. *Teacher as facilitators and guides:* The teacher asks questions or provides comments that steer students to more fruitful discussions.
4. *Problems organize and stimulate learning:* Students identify the problem and set parameters on the development of a solution.
5. *Problems stimulate the development and use of problem solving skills:* Students take on the active role of problem solver.
6. *Knowledge acquisition through self-directed learning:* Students collect information that will inform the group's decision-making process in relation to the problem.

C. Formative and Summative Assessment Plan

[7] Torp, Linda & S. Sage. (2002) *Problems As Possibilities: Problem-Based Learning for K-12 Education.* ASCD, Alexandria, VA.

Our assessment system will also reveal how well the implemented curriculum serves our educational purpose as a STEM school. As assessment data is reviewed, both curriculum and assessments will be reviewed and revised to better align what teachers teach and what students learn.

Student learning will be assessed through a variety of measures on a yearly, 6-week, unit, daily, and minute-by-minute scale. This will include state standardized tests, 6-week benchmark assessments, unit tests, and daily exit tickets or check for understanding data points. The majority of assessments will be used in a formative manner in order to increase student learning and close the gap of student learning, as illustrated in Margaret Heritage's model of formative assessment below. This cycle of constant reflection and adjustment will ensure students are continually progressing in their learning and teachers are aware of each student's current performance level.

Formative Assessment

Learning Goals and Success Criteria
Based on the work of leading formative assessment researcher Margaret Heritage, Learning Goals are specific curriculum expectations phrased in student friendly language, and Success Criteria are a progressive set of 'I can' statements that explicitly outline what student need to do to achieve each Learning Goal[8] Together, these components create a formative assessment system that is "fundamental and indigenous to the practice of teaching and learning."[9] Formative assessment involves three key activities:

1. Teachers make adjustments to teaching and learning in response to assessment evidence.
2. Students receive feedback about their learning with advice on what they can do to improve.
3. Students participate in the process through self-assessment.

In a synthesis of the research on these practices, Paul Black and Dylan William found "student learning gains triggered by formative assessment were amongst the largest ever reported for educational interventions with the largest gains being realized by low achievers."[10]

Summative Assessment

Benchmark Assessment
After each unit, students will complete unit tests to measure mastery and retention of unit specific standards. Teachers will also create comprehensive benchmark assessments to be administered to students every six weeks, which cumulatively measure student mastery over the course of the school year. These benchmark assessments will be created from a Common Core aligned test item bank, such as Galileo, which provides teachers with research-based, Common Core aligned question banks to select test items for specific standards. Since Galileo is predominantly multiple choice questions, other Common Core aligned database systems, such as Mastery Connect or Northwest Evaluation Association, will be considered along with other up and coming platforms to comprehensively assess critical thinking and problem solving skills. Teachers will analyze the data from the assessments and conduct skills workshops for standards not yet mastered.

Accountability Assessment

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[8] Heritage, Margaret. (2007). Assessment and Accountability Center (AACC)/ National Center for Research on Evaluation, Standards and Student Testing (CRESST) at University of California Los Angeles.
[9] Heritage, Margaret. (2010 September). Formative Assessment and Next-Generation Assessment Systems: Are We Losing an Opportunity?
[10] Black, P.J. and William, D. (1998) Inside the Black Box: Raising Standards Through classroom Assessment. *Phi Delta Kappan, 80, 139-48.*

Annual accountability assessments include the Arizona Instrument to Measure Standards (AIMS) and/or the Partnership for Assessment of Readiness for College and Careers (PARCC) as well as ACT exams at the high school level. These exams will provide the necessary data to determine student mastery of the Arizona State Standards and track longitudinal growth. Though many details about the PARCC exams are still in the development stage at this time, this interactive, performance-based test will provide important information to assess the effectiveness of the academic program and its impact on student achievement. Course specific End-of-Course exams administered at the high school level will provide teachers with an unbiased measurement of student mastery of college-readiness standards.

D. Alignment of Program of Instruction and Performance Management Plan

SySTEM Phoenix's Performance Management Plan for math and reading details the action steps, timelines, and resources necessary to fully support successful implementation of the program of instruction, including accountability measures for staff and school leadership.