A.1 Educational Philosophy

> *In the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past.* [1]
>
> (National Science Foundation)

A. Philosophical Approach to Improving Pupil Achievement

Mission

Through integrated learning environments immersed in Science, Technology, Engineering, and Math (STEM), SySTEM Phoenix will prepare students to become the innovative leaders of tomorrow.

Vision

All students graduate SySTEM Phoenix prepared to excel in STEM fields in college and affect innovative change in the world.

STEM

The term STEM was coined by former National Science Foundation director Judith Ramaley as a meta-discipline which integrates science, technology, engineering, and mathematics into a mutually reinforcing whole. STEM competencies do not exist in isolation from each other, and, as such, are most effectively learned through interdisciplinary connections. STEM therefore represents both a core body of knowledge and a student-centered approach to education driven by active inquiry and problem-solving.

The core of SySTEM Phoenix's educational philosophy rests on a firm commitment to STEM pedagogy and methodology. We exist to teach students STEM, so they learn how to think and change the world.

Current Reality/Need

The founders of SySTEM believe innovation is driven through progress in science, technology, engineering, and mathematics (STEM). It is this innovative capacity which has long been the source of our country's competitive edge. Leading growth industries are increasingly reliant on experts in STEM fields, and it is these experts who will comprise the middleclass workforce of

[1] STEM Career: For Those Seeking and Promoting STEM Careers. (2010) *Why STEM?* Retrieved from: http://stemcareer.com/why-stem/

the next generation. However, as a nation, we are not keeping up with our own demand for STEM expertise and are quickly on our way to outsourcing ourselves.

Consider these facts:

- Between 2010 and 2020 it is estimated that the United States will lack the qualified talent to fill anywhere from 12 to 24 million essential jobs throughout our economy.[2]
- 33 percent of all U.S. STEM doctoral students in U.S. universities are foreign students on temporary visas, and 57 percent of U.S. postdoctoral fellows in STEM fields hold temporary visas.[3]
- STEM occupations are projected to grow by 17 percent from 2008 to 2018, compared to 9.8 percent growth for non-STEM occupations.[4]
- It is estimated that by 2018 some 90% of occupations will be middle- or high-skill, with most of these jobs requiring a STEM education and more than a high school diploma.[5]
- Arizona alone will need to fill 166,000 STEM jobs by 2018.

While education reform in STEM has garnered national attention for some time, the serious repercussions resulting from a shortage of highly skilled STEM professionals on our economy and community have only begun to be discussed with nuance. Even in the midst of an economic recession, employers are finding that the education system is not producing enough people qualified to fulfill their needs. As a nation, our schools are not producing students who are prepared for STEM degrees and careers. "Of the 1.9 million students who enrolled in college, only 1.3 million were ready for college-level STEM work without remediation, and less than 280,000 intended to major in STEM-related fields." [6]

In Arizona, STEM education is in a state of crisis. Nearly one in four Arizona high school students did not graduate last year.[7] Students are not graduating from high school at an acceptable rate and are ill prepared for rigorous STEM programs. The "STEM Initiative Concept Paper", cited as a background document to the Science Foundation Arizona, candidly exposes the current failure of Arizona's education system to provide its students a viable STEM pathway. It details how only the top 5-10% of Arizona students graduate with the STEM and 21st Century skills necessary for college and workforce success. Additionally, the paper exposes a low-risk culture focused on remediation rather than enrichment.

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[2] Gordon, E.E. (2009). The Future of Jobs and Careers. *Techniques*. ACTE Online. Retrieved from: http://www.acetonline.org/techniques.aspx.

[3] National Science Board. (2010). *Science and Engineering Indicators 2010*. Arlington, VA: National Science Foundation, 2-25. Retrieved from: http://www.nsf.gov/statistics/seind10/pdf/seind10.pdf

[4] Langon, D., McKittrick, G., Beede, D., Khan, B., and Doms, M. (2011). STEM: Good Jobs Now and for the Future. *U.S. Department of Commerce: Economics and Statistics Administration.* Retrieved from: http://www.esa.doc.gov/sites/default/files/reports/documents/stemfinalyjuly14_1.pdf

[5] National Commission on Mathematics and Science Teaching for the 21st Century & United States. Dept. of Education. (2000) *Before it's too late: A report to the nation form the National Commission Mathematics and Science Teaching for the 21st Century.* Jessup, MD: Education Publications Center, U.S. Dept. of Education.

[6] Bill & Melinda Gates Foundation. (2012) *STEM Education.* Retrieved from: http://docs.gatesfoundation.org/college-ready-education/pages/stem-education.aspx

[7] Department of Education. (2011) Arizona Snapshot. *ED Data Express: Data about Elementary & Secondary Schools in the U.S.* Retrieved from: http://www.eddataexpress.ed.gov/state-report.cfm/state/AZ/

As demonstrated in Table A.1.1, the most recent performance of Arizona students on the National Assessment of Educational Progress (NAEP) shows the pervasiveness of this failure at all levels.

Table A.1.1: Students Failing in Arizona and the Nation[8]

4th Grade Students *Below Proficient* In:	Arizona	Nation
Math	72%	62%
Reading	76%	68%
Science	82%	73%

8th Grade Students *Below Proficient* In:	Arizona	Nation
Math	71%	67%
Reading	76%	71%
Science	80%	73%

Foundational Beliefs

SySTEM Phoenix' philosophical approach to increasing student achievement in Central Phoenix is rooted in four foundational beliefs:

1. STEM competencies and scientific values are necessary for success in the 21st century workforce.
2. Socioeconomic status does not determine access to or achievement in STEM fields.
3. Citizens who understand Arizona's STEM challenges will invest in solving them.
4. Integrated, meaningful educational experiences result in deeper learning.

1. STEM competencies and scientific values are necessary for success in the 21st century workforce.

The founders of SySTEM recognize not every student will want to become a scientist, an engineer, a mathematician or a computer programmer. However, the scientific process of asking questions and creating new knowledge in the process of answering those questions is a highly social endeavor which transcends into all arenas of life. Scientific values push society to question its beliefs and continually improve its understanding of the world. In preparation for the 21st century workforce, STEM competencies comprise *what* workers need while scientific values describe *how* they achieve. Both components are intimately connected and must be taught in conjunction. The following scientific values identified by the writers of the Next Generation Science Standards will serve as SySTEM Phoenix's core values:

- ***Logical Thinking*** – Think in a clear and consistent manner.
- ***Precision*** – Strive for accuracy in word and action.
- ***Open-mindedness*** – Entertain new ideas.
- ***Objectivity*** – Pursue truth without prejudice.
- ***Skepticism*** – Question accepted beliefs.
- ***Honesty*** – Represent the truth free of deceit.

[8] National Center for Education Statistics. (2011) Arizona. *State Education Data Profiles.* Retrieved from: http://nces.ed.gov/programs/stateprofiles/sresult.asp?mode=full&displaycat=7&s1=04

The American Association for the Advancement of Science upholds "In learning science, students should encounter such values as part of their experience, not as empty claims."[9] SySTEM Phoenix is designed to provide students with ongoing opportunities to define and refine these values in order to live by them regardless of their career path. These values will be explored in nuance through a Problem-Based Learning model that prompts students to make judgments in real-world contexts and present their findings to authentic audiences.

2. Socioeconomic status does not determine access to or achievement in STEM fields.

Due to the increasing need for a STEM workforce, all students can and should be prepared to enter STEM careers after graduating high school. Yet, most students in low-income, minority neighborhoods do not have access to the high quality education they need to enter our country's increasingly STEM dependent workforce. The Gates Foundation asserts:

> "STEM disciplines pose some of the highest barriers to college readiness for students, especially students from disadvantaged and underserved backgrounds. And yet STEM study, when taught well, can be powerfully motivating for students, engaging and nurturing their natural curiosity about how their world works.[10]

STEM education is therefore simultaneously our collective problem and our collective solution.

Unfortunately, few quality educational options are available to students in Arizona living in poverty and schools providing high-quality STEM education in low-income communities are virtually non-existent. Two-thirds of Arizona adults do not have beyond a high school education, and the majority of its children are first-generation college students. SySTEM Phoenix is designed to provide all students the substantial support necessary to prepare them for the high quality, high skill STEM jobs of the future through quality instruction, individualized intervention programs, and college admission guidance.

3. Citizens who understand Arizona's STEM challenges will invest in solving them.

A civically engaged society is critical to providing the fertile ground for interaction and discourse, which is at the core of STEM innovation. In 2006, academic circles warned: "[It] is more essential than ever that the STEM education community wisely exploit and build upon our past investment in developing intellectual and human resources so that we can effectively deploy them to meet the local, regional, and global challenges we face."[11] However, civic participation has been on a steady decline since the seventies.

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[9] American Association for the Advancement of Science. (1991). Effective Learning and Teaching. *Science for All Americans*. Retrieved from: http://www.project2061.org/publications/sfaa/online/chap13.htm

[10] Bill & Melinda Gates Foundation. (2012) *STEM Education.* Retrieved from: http://docs.gatesfoundation.org/college-ready-education/pages/stem-education.aspx

[11] MacGregor, J., Middlecamp, C., Millar, S. & Seymour, E. (2007). White paper Marshaling the Postsecondary STEM Education Community for Significant Student Learning About Global Issues: Sketch for a Proposed National Endeavor.

In the book *Bowling Alone*, Robert Putnam emphasizes the school's role in fostering civic participation. "The four years of education between 14 and 18 total years have *ten times* more impact on trust and membership than the first four years of formal education."[12] Students must have opportunities in their educational settings to practice Service Learning in which they learn in order to be of service. Through their experiences, students connect their efforts to their impact and begin a life-long pattern of civic involvement. SySTEM students will use their learning to act as agents of change. Through service learning, students will identify pressing community issues and engage in the three A's of service learning, Awareness, Advocacy, and Action. We will foster students who are able to think critically about the world and, ultimately, contribute to improving it. No matter what their chosen field, SySTEM students will become productive and influential citizens, invested in the improvement of their communities.

4. Integrated, meaningful educational experiences result in deeper learning.

SySTEM Phoenix's educational approach is founded on the belief that an integrated, relevant instructional model results in deeper learning. Through the context of real-world problems, which are naturally integrated and interdisciplinary, students learn to apply all of their skills and knowledge to create innovative solutions. These learning experiences are more meaningful because they reflect how authentic learning occurs in the workplace and community. Researchers Geoffrey and Renate Caine explain how rich interdisciplinary learning experiences actually reinforce how the brain naturally learns. "Rather than separating knowledge into discrete partitions, the brain creates a complex web of information that recognizes patterns."[13] In short, integrated learning is about connections. The more connections students forge, the deeper the learning experience and the higher the level of mastery.

SySTEM Phoenix will design curriculum and develop instructional methodologies through an integrated model that optimizes opportunities for students to connect learning across content areas. The following are components of SySTEM Phoenix's model that represent the daily experiences specifically crafted to stimulate interdisciplinary connections.

- ***Integrated Core Courses:*** These instructional blocks will use best practices in Problem-Based Learning to emphasize interdisciplinary connections. In Humanities, English Language Arts Common Core Standards are embedded in the context of Social Studies Standards. Similarly, Math Common Core Standards and the Next Generation Science Standards are combined in an integrated curriculum.
- ***STEM in Action:*** These thematic courses driven by the Next Generation Science Standards will highlight the connection between STEM ideas and everyday activities. A service learning component will call upon the full repertoire of students' knowledge and skills to create solutions to real world problems posed by STEM industry and community partners. Students will become adept at recognizing how their learning serves an important function in the improvement of their local community.

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[12] Putnam, Robert D. (1996). The Strange Disappearance of Civic America. *The American Prospect,7,*24.
[13] Caine, Renate Nummela and Geoffrey Caine. (1992). *Making Connections: Teaching and the Human Brain*. Alexandria, VA: Association for Supervision and Curriculum Development.

B. Principles Fundamental to Program of Instruction

SySTEM Phoenix recognizes science, technology, engineering and mathematics as the key drivers of innovation. We exist to teach students STEM, so they learn how to think and change the world.
All our students will graduate with a firm foundation in critical thinking skills, problem solving abilities, and interest in using STEM to create innovative change in their communities. At SySTEM Phoenix, we will fulfill our purpose by basing every program and practice on five essential tenets:

1. Problem-Based Learning
2. All Students, All Standards
3. Collaboration and Communication
4. STEM Partnerships
5. Exceptional Teachers

1. Problem-Based Learning

SySTEM Phoenix will utilize the principles of Problem-Based Learning to embed continual opportunities for students to assimilate new information and negotiate their understanding with peers.[14] Because learning to think critically requires lots of practice, every unit begins with an open ended, "ill-structured" problem. Ill-structured problems reflect those encountered in the real world because not all of the information necessary to solve the problem is given and there may be multiple solutions. The problem informs all subsequent learning, reinforcing the relevancy of the knowledge students gain every step of the way.

Though our world continues to change and evolve, the need for individuals who think beyond their current constraints to push society forward will never change. The PBL model satisfies the dual need for students to go deep in the construction of their own knowledge and to develop enduring skills that translate to any situation.[15]

2. All Students, All Standards

As discussed by the writers of the Next Generations Science Standards, "All Students, All Standards" is a commitment to exposing every student to the breadth of scientific endeavors regardless of academic performance in other subject areas. To ensure students are on track to master all standards, SySTEM will develop a standards-based grading system comprised of

[14] PBL is an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem. Savery, John R. (2006) Overview of Problem-Based Learning: Definitions and Distinctions. *Interdisciplinary Journal of Problem-Based Learning*: 1(1), Article 3.
[15] Examples of enduring skills would include: flexible knowledge, effective problem solving skills, self-directed learning, effective collaboration skills and intrinsic motivation. Hmelo-Silver, C.E. (2004). Problem-Based learning: What and How Do Students Learn? *Educational Psychology Review*, 16(3).

Learning Goals and Success Criteria. Based on the work of leading assessment researcher Margaret Heritage, Learning Goals specify curriculum expectations in student friendly language and Success Criteria explicitly outline what students need to do to achieve each Learning Goal in a progressive set of 'I can' statements. Together, these components create a formative assessment system that gives students the important information they need to successfully track their progress and meet their learning goals.

At SySTEM, we believe what matters most is *if* students learn, not *when* they learn. Learning Goals and Success Criteria give all stakeholders-- teachers, students, parents, and school leaders-- the meaningful data necessary to set and track each student's progress. Students will be explicitly taught how to self-assess their progress towards Learning Goals by analyzing their performance on Success Criteria for each lesson. As a result, students learn to identify what they know and, more importantly, what they do not know. This information cultivates reflective learners that take ownership of their progress.

3. Collaboration and Communication

The founders of SySTEM Phoenix believe the environment most conducive to innovative change must promote effective collaboration and communication. Problem-Based Learning ensures these two capabilities work in concert. Students must communicate effectively in order to contribute to the team's understanding of novel, ill-defined problems. SySTEM Phoenix's Problem-Based Learning model includes Cognitive Coaching and Cooperative Learning strategies to support the development of these crucial 21st century skills.

The complex, open-ended problems that drive Problem-Based Learning require students to collaborate in teams towards a common goal, fostering goal interdependence. Cooperative learning strategies structure classroom activities in such a way that "group members perceive that they are linked with each other in a way that one cannot succeed unless everyone succeeds." [16] This approach prepares students for success in STEM careers as "students develop the skills necessary to work on projects too difficult and complex for any one person to do in a reasonable amount of time." [17] As a result, students learn significantly more in a cooperative setting which capitalizes on the collective knowledge and skills of the team. This environment also 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. At SySTEM, cooperative learning will be infused in every course.

Additionally, teachers will utilize Cognitive Coaching strategies to help students think through their thinking. 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. The Center

[16] Green, Kathy. 5 Basic Elements of Cooperative Learning. Retrieved from: http://cooperativelearning.nuvvo.com/lesson/216-5-basic-elements-of-cooperative-learning
[17] Teed, R., McDaris, J., & Roseth, C. Cooperative Learning. *Starting Point Teaching Entry Level Geoscience.* Retrieved from: http://serc.carleton.edu/introgeo/cooperative/index.html

for Collaborative Support has identified the following ways students benefit from this communication style and teaching approach:[18]

- Enhances understanding and higher level thinking
- Helps others become their own problem-solvers
- Creates collaborative rather than dependent relationships
- Develops genuine trust and support
- Supports others in feeling competent in challenging work environments

4. STEM Industry Partnerships

The job market is drastically changing and many predict that the jobs that will be available for SySTEM Phoenix's first graduating class do not currently exist. Consider the following quote from former Secretary of Education Richard Riley:

> "The top 10 in-demand jobs in 2010 did not exist in 2004. We are currently preparing students for jobs that don't yet exist, using technologies that haven't been invented, in order to solve problems we don't even know are problems yet."[19]

SySTEM Phoenix will proactively address this reality by fostering strong relationships with industry experts to provide relevant experiences that complement student studies and deepen their knowledge.

Partnerships and ongoing interactions with major STEM companies will transform SySTEM Phoenix's curriculum into a living, working document which evolves to meet the growing demands of college STEM programs and ensures our students graduate prepared to excel in rigorous college STEM programs. SySTEM Phoenix and the larger STEM community will work together to expose students to authentic learning opportunities. Partners may get involved in a variety of ways (i.e. lending lab space and equipment for student research, launching programs, offering internships, acting as mentors and providing real-world feedback). As a result, SySTEM students will have an extensive understanding of how what they are learning is part of what someone would do in real life and connects to actual jobs.

5. Hire, Train, and Sustain Exceptional Teachers

SySTEM Phoenix is relentless in its search for professionals who align with and have the skills to implement the school's mission, vision and philosophy. SySTEM Phoenix hires individuals willing to call upon the full range of their talents as leaders, collaborators, learners and everything in between in the pursuit of student achievement as part of the SySTEM team.

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[18] Center for Collaborative Support. An Introduction to Cognitive Coaching. Retrieved from: http://www.svsd410.org/CCS/Cognitive%20Coaching.asp

[19] Fisch, K., McLeod, S., & Bronman, J. "Did You Know?" video on the progression of information technology. Transcript retrieved from: http://www.metfamily.org/agatheringofgood/AGOG_pdf/Did_You_Know.pdf

Hiring the right people alone will not guarantee dramatic gains in student achievement. To ensure a highly effective yet sustainable model for education, the founders of SySTEM Phoenix have intentionally designed an environment that is uncompromising in its commitment to support teachers as professionals. To this end, great value is placed on creating a supportive community of reflective practice and continual improvement. The following components of SySTEM Phoenix ensure every employee continues to raise the bar for and promote excellent learning opportunities for students year after year.

In order to create a community in which reflective practice and continued improvement is the norm, we:

- Dedicate the resources needed to invest in the growth of our staff as professionals
- Provide job embedded, high-quality professional development throughout the school year
- Operate with a reflective practice that continually challenges teachers' current understandings of best instructional practices, drives growth in their craft, and increases student achievement.

Overall, these tenets create a solid foundation for students to excel in STEM subjects in college and use their talents to dramatically improve the world in which we live.

C. Rationale for Target Population

We have specifically selected downtown Phoenix as our target population with the goal to serve the high percentage of students in need of an excellent education who currently do not have access to A-rated schools. While we believe a rigorous STEM education can benefit all students, we will initiate action on this belief by opening SySTEM Phoenix in an area within the city that is in desperate need for high-quality school options. Students in downtown Phoenix deserve exceptional teachers who are implementing best practices in educational theory on a daily basis, yet they do not currently have access to a variety of schools that are successfully implementing these principles. By providing students in downtown Phoenix with an exceptional educational opportunity, where best practices are implemented with fidelity and rigor, we will actively contribute to closing the achievement gap.

Additionally, downtown Phoenix is quickly growing into a STEM hub. Organizations such as the Science Foundation of Arizona and T-Gen in conjunction with academic institutions like the Arizona State University downtown campus, University of Arizona Medical School, and Bioscience High School are turning downtown Phoenix into a central location for STEM higher education and research. Even though the downtown target area has been dubbed part of the city's new "Bioscience Corridor", not one A-rated STEM elementary or middle schools exists in this region to provide local children the foundational knowledge needed to engage in the burgeoning STEM fields. Further, the dismal statistics on national and state test scores document to what extent low income students in downtown Phoenix are not being prepared for engagement in a 21st century workforce. For these reasons, downtown Phoenix is the ideal location for a STEM-immersion school that leverages Arizona's STEM community. SySTEM Phoenix ensures

students have a rigorous and continuous STEM educational experience until college. Section A.2 Target Population provides an in-depth description of the current condition of downtown Phoenix schools. This data substantiates the need for a rigorous STEM school in downtown Phoenix and describes the tremendous impact SySTEM Phoenix will have on the target community.