Implementing STEM Programs that Capture and Nurture Imaginations and Talents

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NRC Successful K-12 STEM Education: Goals

- Expand number of students who pursue advanced degrees in STEM fields and broaden participation of women and minorities.
- Expand the STEM-capable workforce and broaden participation of women and minorities
- Increase STEM literacy for all

Presentation FOCUS

- **What worked: Scientific Village Strategy**
  PRIME the Pipeline Project: Putting Knowledge to Work for high school students and teachers
- **What is ongoing: STEM in the Middle**
  Grades 5 – 8 students and teachers.
- **What is being proposed: Step up to STEM**
  Grades K – 12 students and teachers

PRIME the Pipeline Project: Putting Knowledge to Work

NSF ITEST, 2008 – 2013 (including an NCE)

Evaluate the Scientific Village Approach for:

- Increasing the number of high school students who pursue college majors in STEM-B fields.
- Update secondary teachers in these fields.

Scientific Villages Approach

- Students and Teachers are equal partners
- Project-Driven Learning
  - Bring to bear previous knowledge
  - Learn at point of need
  - Extended time to think and wrestle with key ideas

Projects are designed and led by scientists from Universities, colleges, business or industry.

Scientific Villages Composition

- Half teachers (as learners) and half grades 10+ students, with approximately 24 villagers/village
- Undergraduate STEM major as mentor
- Scientist(s) leaders

Scientific Village Meetings

- After school, 2 ½ hours, 9 weeks/semester
- Summer, 2 weeks, 4 hours/day for villagers
- Summer 8 days, additional 2 hours/day for teachers for the Connections Courses

- Last day of each village: Showcase Open House

28 Scientific Villages

- Cellular Communications and Network Design
- Film and Media Production: Lights, Camera, Action!
- Energy: Harness the Wind
- Engineering Design: Rockets and Robots
- Visual Programming and Gaming
- Exploration of Scientific Puzzlers
- Virtual Modeling for Emergency Services
- Trauma Simulation
- Biotechnology: Forensics and DNA Fingerprinting
- Aviation: Flight Training
- Technology Remix: Village People Music Lab

Connections Courses for Teachers: Topics

- Implementation Strategies
- Collaboration Opportunities
- Alternative Instructional Techniques
- Alternative Assessment Practices
- Do you know what your students know?
- College Advising
- Grant Funding and Proposal Development

Results: Intervention Students (63)

- Completed significantly more STEM courses in high school and significantly more advanced courses (Honors, AP, Dual Enrollment)
- Had significantly higher GPAs
- Entered college STEM majors (69% vs 38%)
- Persevered in STEM majors after one semester (93%).
- Several are mentors in STEM in the Middle Project.

Patrick Hong, Pipeline Student

P^3 bolstered my college applications, but the experience I gained in the project has proven to be even more useful. In particular, my experience in the Scratch Village allowed me to see different aspects of game design that I wasn't able to explore before, and as a result, my current projects in college revolve around more than just code.

Then: Chandler High School

Now:UC – Berkeley, Electrical Engineering and Computer Science

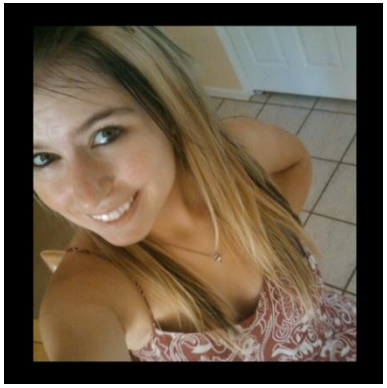
Bryce Munter, Pipeline Student

I learned how to effectively work in a team, how to pay attention to miniscule details and use them to my advantage, and how to really be organized in a scientific setting, and I definitely brought these skills to college with me.

Then: Hamilton High School, Chandler

Now: ASU Barrett Honors College, Business Management and Biomedicinal Chemistry

Henriette Pedersen, Pipeline Student



Pipeline helped me discover my college major. I never knew what to study because I did not really have any interests until I learned about film and also ended up participating in the high school film program that was offered at Highland.

Then: Highland High School, Gilbert
Now: ASU, Film and Media Production

Daniel Christian Jones, Pipeline Student

I know it is hard to believe, but before P^3, I was extremely shy and nervous about presenting to an audience. Little by little, showcase by showcase, it became easier and easier. This has made me feel more confident and has helped me in my presentations at my community college.

Then: Red Mountain High School, Mesa

Now: Mesa Community College, Geology

Results: Pipeline Teachers (46)

- 1/3 designed and implemented project-driven courses in their high schools as a fourth math course.
- 40% applied for and secured funding for project implementation ($250 – $40,000).
- One is editing the *Pipeline Story* book.
- One is developing a video of the STEM in the Middle Project.
- Two are leading villages in STEM in the Middle.

Teachers Learned About Students

- Working with students, teachers gained greater insight into
  - What students know and can do.
  - Strategies for leveraging that knowledge for new explorations.

Teachers now tell less and ask for more from their students.

Teacher Comments

Karen Jacques, Biology, Chandler Early College

Building a robot showed me how interrelated mathematics, engineering, and technology are. It is not enough to understand and be able to use the skills in isolation; we have to be able to see how they relate and solve problems.

Teacher Comments

Bill Gibson, Physical Science, Chemistry and Earth Science, Phoenix
STEM in the Middle Scientist Leader

I am convinced that a high-quality learning environment is diverse in that it includes a wide range of participant ages, degrees of expertise, experience, and skills in both the “student” and the “teacher” roles.

Teacher Comments

Nancy Foote, Chemistry, Higley

I learned a lot about being a teacher by being a student. My lessons include real world applications and my expectations for my students – and for myself – are higher.

Leaders Engaged Villagers in Explorations Like Those Conducted by Scientists

Pushpa Ramakrishna Scientist Leader

Professor of Biology, Chandler Gilbert Community College

The teachers and students were given the opportunity to think and work like real life scientists. It was exciting for them! There was both minds-on science and hands-on science going on at the same time!

John Black, Scientist Leader

Research Associate, School of Computing, Informatics, and Decision Systems Engineering, ASU

I wanted villagers to see scientists, not as experts who have learned specialized knowledge, but as people whose work is driven by their own curiosity about unanswered questions. I presented startling and puzzling phenomena that would provoke questions in their minds – questions that have not yet been adequately answered by scientific research.

STEM in the Middle

Funded by the Helios Education Foundation
2010 – 2013

- **Develop middle-school students' (grades 5 – 8) interests and talents in STEM fields.**

- **Upgrade middle school math and science teachers' (grades 5 – 8) knowledge of the big ideas in their own and sister fields, and of technology, instructional and assessment practices.**

Club STEM (102 students)

- 2 villages each semester
- 30 students per village
- One or two scientists per village
- 7 mentors per village
  - 4 high school-age mentors
  - 3 college-age (STEM majors) mentors

Club STEM Villages

- Aviation: Falling and Flying (Led by former Pipeline teacher)
- Engineering Design: Rube Goldberg Machines
- Photography & Video: Creative Imaging
- You Got Game! Video Game Design and Digital Animation (repeated)
- Engineering Design: SumoBot Grand Challenge
- A3D: Animate, Draft, Design and Develop

STEM in the Middle: Teacher Component (47 teachers)

Focus on proportions and proportional reasoning through projects, data collection and analyses, and assessment.

Focus on technology to advance explorations and learning, and grant writing.

Led by STEM in the Middle Staff and Scientists.

Teacher Updating

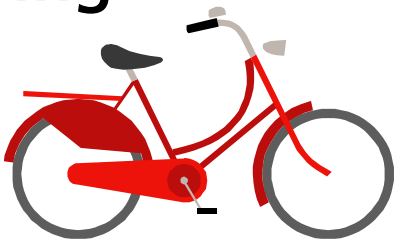
- Teachers engage in integrated project-driven learning.
- Projects are long term, require experimentation, conjecturing, data collection, and evaluation of approaches and solution paths.
- Projects focus on proportions and proportional reasoning, providing multiple scenarios for the application of the same concepts, skills and reasoning methods.

Teacher Updating

- Teachers modify projects they completed to be used with their students. They use them and document the effort.
- Teachers, with guidance, develop proposals to fund various materials, technology, and other resources necessary to conduct the projects.
- 3-4 hours per session, and at least once every four weeks during the academic year.

STEM in the Middle: Sample Teacher Projects

- Mazes
- Pendulums
- Reaction Time
- Portrait Painting
- Walk Light Analysis
- Shadows and Eclipses
- Supermarket Mileage
- Supermarket Check-out Speed
- Macy's Math
- Skateboards, Cycles, Cars: The Revolving Dilemma



Through engagement in projects

Teachers gained

- New knowledge.
- A feel for project work.
- Insight and experience with the need for more time to
  - Think.
  - Consider variables and consequences of choices.
  - Search for needed information.
  - Talk math.

MATHgazine and MATHgazine Junior (http://prime.asu.edu/)

STEP up to STEM
Developing STEM Schools

Refocusing from separate-subject to an integrated project-driven STEM learning program.

NRC Effective STEM Instruction Key Elements

- Coherent set of standards and curricula
  - Focus on big ideas
- Teachers with high capacity to teach in their discipline
- Supportive system of assessment and accountability
- Adequate instructional time
- Equal access to high-quality STEM learning opportunities

Goals for Students

- Increased achievement and interest in mathematics and the sciences
- Reason scientifically
- Employ technologies and engineering design principles
- Persevere
- Document project work with videos
- Greater insight into own talents

Goals for Teachers

- Greater knowledge of key STEM concepts, skills and reasoning methods that undergird school curricula
- Explore strategies for assessing and capitalizing on student interest in the design of projects to engage and develop their talents
- Design projects that facilitate concept and skill development in STEM
- Develop proposals to secure funding for needed resources

Goals for School Administrators

Increased knowledge of:

- What constitutes project-driven curricula and ways to assess performance and support the program
- Characteristics of good STEM teaching and learning to better assess and assist teachers
- Methods for communicating goals and activites to families, school board, businesses and the press, and engaging their support

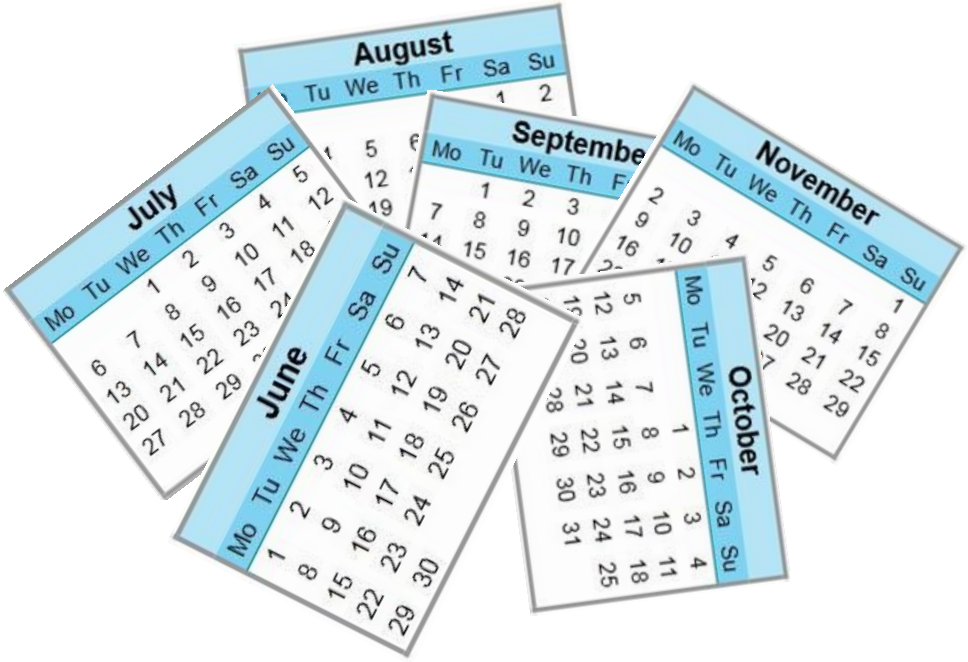
Goals for Families

Greater knowledge of:

- Children's achievements in math and science
- STEM careers and the preparation for them
- Ways to support learning (e.g., Home Work-Outs)

STEM Program Characteristics

- Clear and obvious goals
- Project-driven learning
- Ongoing-sustained (multi-year program)



Program Characteristics

Long-term explorations involve multi-age, multi-experienced groups:

- College and high school students trained as mentors for
  - Grades K-2
  - Grades 3-4
  - Grades 6-8
- Upper class undergraduate STEM majors and grad students mentor high school students

STEM Program Characteristics Time to Think (T^3)

- Reconfigure the school day
  - 2-Hour Exploration Blocks
    - Staggered classes
    - Extended school day, combine last hour of school with one hour after school
    - Saturday School
- Implement Chew & Chat

STEM Program Characteristics

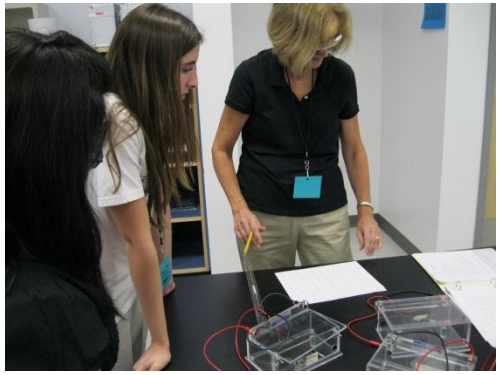
Publicity-Performances-Recognition

- **Opportunities for student and teacher presentations at:**
  - **STEM Fest at end of each semester and summer**
  - **Movie Night with documentaries of STEM student work**
  - **School-Board meetings**
  - **Parent-teacher conferences**

STEM Program Characteristics

Planned opportunities for Community Involvement. School district leaders offer:

- Coffee-house STEM chats
- School/District STEM Newsletters
- Senior Scholars Programs:
  - Train senior citizens to work in schools to mentor students
  - Seniors organize and lead STEM Fests

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