The Pipeline Story

Prime the Pipeline Project (P³):
Putting Knowledge to Work
Acknowledgements

The authors wish to acknowledge the support of the National Science Foundation (#0833760, 2008 – 2011 + 2-year no-cost extension) for P³, and the contributions of a great many outstanding STEM practitioners. As well as the scientists who designed and led villages and who are described in this book, we thank Ida Malian, Professor of Special Education, Arizona State University and Eugene Judson, Assistant Professor of Science Education, Arizona State University, for leading Connections Course discussions; Carol Findell, Clinical Associate Professor of Mathematics Education, Boston University, for collaborating on the design of one of the evaluation instruments; Deborah Toolson, Technology Specialist, and Stephanie Weight, PRIME Center staff member, for their work as project directors of P³ during years 1 and 2, respectively; and Michael Piburn, Professor Emeritus, Research Design, Arizona State University, for his assistance with the evaluation during Year 1 of P³. We are deeply indebted to Bert Valenzuela, Senior Technical Support Analyst at Arizona State University Polytechnic campus for assisting us with our technology needs during all three years of village meetings and Showcase Open Houses, to Jeff Bricker for assisting with space allocations for our staff meetings and Showcase performances in the Union Ballrooms, and to Intel and Motorola for supporting P³ by sending scientists to work with our villagers. Throughout P³, we received valuable guidance from our NSF program directors, Sylvia James and Darryl Williams, for which we are most appreciative. Finally, many thanks to all of the school district administrators, teachers, and families who contributed to make P³ an award-winning program.
Dear Reader,

This is the story of the NSF-funded project, Prime the Pipeline Project (P³): Putting Knowledge to Work that was conducted at the Polytechnic campus of Arizona State University from 2008 through 2011. Actually this story began many years ago when I became aware of the large number of freshmen enrolled in remedial mathematics courses at the college level, and the even greater number of undergraduate students who, after one semester in college, transferred out of STEM fields. This is a major concern for our nation. More scientists are needed to support our country’s STEM workforce and to make us competitive internationally.

Researchers who have studied remediation and STEM drop-out problems found that the lecture approach, learn-and-then-apply, which is typical for most high school and college courses, reduced student interest in the subjects, even among the high achievers. The separation or siloization of subjects in most high school and college programs, and the limited amount of time provided for exploration, application and discussion of the big ideas in the subjects, also contributed to diminishing interest in mathematics and the sciences.

In terms of college-going decisions of high school graduates, through interviews with juniors, we discovered that many are fearful of the college experience. In particular, they are concerned about finding new friends, communicating with and understanding their professors, knowing where to seek assistance with academics, and navigating around a large campus without getting lost. For these reasons, we decided to conduct the program on the university campus and involve students from a variety of high schools and communities.

We also wanted to update secondary STEM teachers in their own and sister fields, and provide them with opportunities to collaborate with high school students on projects so that they would get a different view of what students are capable of doing in project-driven settings. Being together with other teachers to share instructional ideas and getting to know university and industry scientists for future collaborations were also among our goals.

Taking into consideration all of the research and our goals, we designed the Pipeline Project. The uniqueness of the project is the engagement of students and teachers (as learners) as collaborators in the solution of STEM problems like those faced by STEM professionals. Also unique is the reversal of the learn-and-then-apply approach. Rather, students and teachers bring to bear what they already know to complete a project or solve a challenging problem, and then when they are stumped, they learn at that point of need.

The vehicle for conducting the program was the Scientific Village composed of students and teachers, mentored by undergraduate STEM majors, and led by scientists from the university, local colleges, business, or industry, who also designed the projects.

What follows is the story of this project and the impact it had, and continues to have, on all participants.

Enjoy!
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Introduction

The Project

Prime the Pipeline Project (P3): Putting Knowledge to Work, funded by the National Science Foundation (#0833760, 2008-2011 + 2-year NCE), designed, implemented, and evaluated the Scientific Village strategy for increasing secondary school students’ interest and achievement in Science, Technology, Engineering, and Mathematics (STEM). Concurrently, P3 updated secondary teachers in STEM subjects and workplace technologies.

Scientific Villages are communities of high school students and secondary school certified STEM teachers as learners, scientists from the university or industry as leaders, and undergraduate STEM majors as mentors. Villagers work collaboratively on long-term projects/problems (one per semester or summer) that are of high interest, are similar to those faced by STEM professionals, and require application of STEM concepts and skills for their solutions. The approach during project engagement reverses the lecture-then-apply method of instruction. Rather, villagers bring to bear what they already know and gain information and direction at point of need.

Four scientific villages were conducted each semester and summer, from spring 2009 through spring 2011, for a total of 28 villages. Three of those villages (starred below) were repeated because of participant interest. Below, villages are identified by their primary focus of Engineering, Technology, or Science. Mathematical concepts, skills, reasoning methods, and modeling techniques were integrated into all village explorations.

**Engineering:**
Aviation: Flight Training
Aviation: Flight Training – The Sequel
Cellular Communications Network Design: Can You Hear Me Now?
Cleanroom Science and Model Development: Clean Your Room
Engineering Design: Rockets and Robots
Engineering Design: Wind Turbines and Wind Tunnels
*Wind Energy: Harness the Wind

**Technology:**
3D Virtual Modeling for Emergency Services
Advanced Game Simulation: Visual Programming and Gaming with Scratch II
Documentary Film Design and Post-Production
Film and Media Production: Lights, Camera, Action!
Film and Media Post-Production: Video Editing
*Musical Technology: Bach to Rock & Technology Remix: Village People Music Lab
*Photography: Creativity + Technology
Scratch, C, and iPods
See C: Advanced Computer Programming
Technology Remix: Village People Music Lab
Visual Programming and Computer Game Design with Scratch
Web Weaver
You Shoot YouTube
All village work took place in the laboratories and other facilities at the Polytechnic campus of Arizona State University in Mesa, Arizona. Scientific Villages met once a week for 9 weeks each semester (2 ¼ hours per session) during the academic year, and for two weeks (4 hours per day for all and an additional 2 hours per day, Monday-Thursday, for teachers) during each summer.

P³ is Unique

Never before have high school teachers and students worked as equal partners on collaborative long-term projects. Never before has such a multi-experienced, multi-credentialed, and multi-talented group come together to solve and discuss complex problems. Despite initial skepticism about the likelihood of success of such an approach, P³ demonstrated that the Scientific Village model is effective at increasing student achievement in STEM subjects, interest in STEM careers, and in making a difference in how teachers engage their students in STEM explorations.

What’s in this book?

In this book, Prime the Pipeline Project (P³): Putting Knowledge to Work is described and brought to life with interviews and stories from the participants who made the program a success. The book is separated into three parts: Background, The P³ Program in Action, and Reflections. Each part offers more in-depth descriptions of the program’s components. The book concludes with an evaluation of P³.

The impetus for such a unique undertaking is described in Part One in the sections, Goals, Rationale, and the Scientific Village. The Project Management team, including the P³ staff, Advisory Board members, Scientific Village leaders and mentors, and business/industry experts who served as volunteers are introduced.

In Part Two, the P³ Program in Action, recruitment activities and information about the participant pool, as well as the site for P³ activities, are described. This is followed by a description of the program components including a list, by year, of Scientific Villages and a detailed description of each village. Also included in this part is information about the leader and mentor orientation meetings, a typical day at P³, Showcases where villagers described their accomplishments to the community, the Connections Courses for teachers, the P³ website, the Facebook page, and the MATHgazine.

In Reflections, you will hear from the participants and scientists. Included are interviews, stories, and comments from P³ students, teachers, mentors, and village leaders. Many stories are quite inspirational and illustrate the extent of impact that this type of learning community had on all who were involved.

The Appendix contains supporting documentation, including a project brochure, copies of the MATHgazine, a link to the video capturing the project in action, and additional photographs.
Part One: Background

Goals, Rationale, and the Scientific Village

The Problem

The need for more experts and innovators in Science, Technology, Engineering, and Mathematics (STEM) fields is critical to the success of our nation (Bray, 2010; Couto, Mani, Lewin, & Peeters, 2007; National Science Board, 2010). While this need has been increasing since 2000, the number of students pursuing and completing degrees in these fields is decreasing (Kendall, Pollack, Schwols, & Snyder, 2007; National Academies of Science, 2007; National Science Board, 2010).

Poor performance in mathematics and science classes in middle and high school, and the lack of interest and persistence in STEM and business courses in high school and college, may occur as a result of the siloized approach to education where subjects are taught separately, with little integration. In this approach, students are given little opportunity to apply what they have learned to solve compelling problems. More elaborate problems are often avoided with claims that students can’t solve them because they lack understanding of the context domains (e.g. economics or physics). Furthermore, because classes are usually taught in 45 – 50 minute time blocks, there is insufficient time for students to wrestle with challenging problems, to think, and to put their knowledge to work (Greier, et al., 2008; Jerald, 2009; Kazis, 2005; Smith, Sheppard, Johnson & Johnson, 2005; Stone, Alfeld, and Pearson, 2008).

Although Project Based Learning (PBL) and Project-Challenged Learning (PCL) are gaining momentum in education, they rarely involve problems typical of those solved by workers in STEM and business fields (Bronson, 2007; Clark & Ernst, 2007; Meeder, 2008). This has been the case since the U.S. Department of Labor published its seminal paper in 1991 that addressed the needs of the workplace, and stressed the importance of better preparing students for work on problems that require application of problem solving, collaboration, and communication skills.

Our Solution

Prime the Pipeline Project (P³): Putting Knowledge to Work proposed a solution to this problem by designing, implementing, and evaluating the Scientific Village strategy to:

1. Increase student interest in and success with the study of mathematics and science through engagement with others of varying backgrounds and talents in the solution of challenging problems that mirror those faced by STEM and business professionals, and that use workplace technologies.
2. Integrate workplace technologies, communication, collaboration, and critical thinking skills into the learning environment.
3. Increase student awareness of STEM and business careers, university preparatory programs for these careers, and their own talents in these fields.
4. Update teachers in STEM content and the requirements for various STEM careers.
5. Increase parents’ knowledge of STEM and business careers, the preparation needed for them, and their children’s talents as related to those careers.

Unique components of this design include: learning at point of need, increased time on task, and collaboration. In traditional classrooms, teachers introduce a new concept, show examples, and then
have students repeatedly practice similar examples, mimicking the illustrated procedure. In P3, a complex problem or project is presented with no clear path toward its solution. Students and teachers have to discover the path and learn new skills along the way, as they need them. This type of learning is far more organic and allows for learners to make clearer, more complex, and longer-lasting connections. This approach also allows students and teachers to have increased time on task. Working for 2 ¼ hours on their projects each week, or 4 hours each day in the summer, and returning to the project an additional 8 to 10 times, teams are able to dedicate the concentrated effort needed to make significant progress in discovering, understanding, overcoming obstacles, and ultimately, solving the multi-faceted problems.

**Support for this Solution**

Support for P3 comes from:

1. Research on workplace needs in STEM fields (Bray, 2010; Couto, Mani, Lewin, & Peeters, 2007; National Science Board, 2010) and the continually decreasing supply of well-prepared STEM professionals (Kendall, Pollack, Schwols, & Snyder, 2007; National Academies of Science, 2007; National Science Board, 2010).

2. The power of integrated projects to enhance student acquisition and application of mathematics and science concepts and skills, and various technology tools (Corcoran & Silander, 2009; Darling-Hammond, et al., 2008; Duschl, 2008; Markham, Larmer, & Ravitz, 2003), and to motivate students to learn (Allen, Bonous-Hammart, Yang, Gonzalez, & duCROSSs, 2004; Allen, Bonous-Hammart, & Suh, 2005; Sedlacek, 2004; Sedlacek & Sheu, 2004; Trent, 2004).

3. Evidence that teachers are underprepared to engage students in the application of mathematics and science concepts and new technologies to the solution of problems that both mirror those faced by the workforce and demonstrate a usefulness for that knowledge (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009; Hill, Rowan, & Ball, 2005; National Mathematics Panel, 2007; Stigler & Hiebert, 2009).
Project Management

Project Staff

*Prime the Pipeline Project (P³): Putting Knowledge to Work* was managed by a diverse and dynamic group of experienced educators and industry leaders who stimulated creative thinking and inspired students and teachers to learn.

**Carole Greenes: Principal Investigator**
Associate Vice Provost for STEM Education
Director, Practice, Research, and Innovation in Mathematics Education (PRIME) Center
Professor of Mathematics Education, College of Technology and Innovation
Arizona State University, Tempe campus

Principal Investigator (PI) for *Prime the Pipeline Project (P³)*, Dr. Greenes currently serves as PI for the Helios Education Foundation-funded *STEM in the Middle* project, 2010-2013, and Co-PI for *Model-it!*, an NSF I-3 project (#930109, 2010 – 2015). Past projects include: Co-PI for *Focus on Mathematics* (NSF #0314692, 2003 – 2008); Co-PI for *Big Math for Little Kids*, (NSF #9730683, 1998 – 2002); and PI for *Making the Connections: Higher Algebra to School Mathematics* (NSF #9950722, 1999 – 2001). She is author of more than 310 mathematics books, programs, and articles for students and teachers, including the *NCTM Yearbook on Algebra and Algebraic Thinking in School Mathematics*. She was inducted into the Massachusetts Mathematics Educators Hall of Fame in 2003 and in 2011 she received the NCSM Leadership Award in Mathematics Education. Her research focuses on the development of algebraic reasoning abilities of Pre-Kindergarten through grade 12 students. As PI, she provided oversight for all project activities, including recruitment of scientists, teachers, and students. She co-led the Teachers’ Connections Courses and the Showcases and co-authored all *MATHgazines*.

**Timothy Lindquist: Co-PI**
Professor, Department of Engineering, College of Technology and Innovation
Affiliate Professor, School of Computing and Informatics, Ira A. Fulton Schools of Engineering
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Co-PI for *Prime the Pipeline Project (P³)*, Dr. Lindquist has been a faculty member at Arizona State University since 1985. He served as the Associate Chair for Academic Affairs, Department Chair, Associate Dean and Director of the Division of Computing and Interim Dean of the College of Science and Technology on the Polytechnic campus. Lindquist held various research, industrial, and government appointments including summer faculty researcher with the Navy and visiting scientist with the Institute for Defense Analyses. He is author of numerous papers on programming language verification, software testing, software development environments, and software engineering of distributed, mobile computing and web-based applications. Dr. Lindquist also led several Scientific Villages.
Colleen Megowan-Romanowicz: Co-PI
Research Scientist, School for Arts, Media and Engineering,
Herberger Institute of Design and the Arts
Arizona State University, Tempe campus

Co-PI for *Prime the Pipeline Project (P³)*, Dr. Megowan-Romanowicz is also Co-PI for the NSF Innovation through Institutional Integration (I-3) project for which she was Director of The Modeling Institute for two years. Megowan-Romanowicz continues to do research with the SMALLab group at Arizona State University. In that capacity she is a Co-PI of an NSF DR K-12 project studying student thinking in small-group work centered around collaboratively constructed representations. She also is Executive Director of the American Modeling Teachers Association (AMTA), a professional organization of teachers who practice modeling instruction in the STEM disciplines. Dr. Megowen-Romanowicz also led one of the Scientific Villages.

Lakshmi Munukutla: Co-PI
Professor, College of Technology and Innovation
Arizona State University, Polytechnic campus

Co-PI for *Prime the Pipeline Project (P³)*, Dr. Munukutla is an active researcher with funding from NSF, the Jet Propulsion Laboratory, Motorola Inc., ON Semiconductor Inc., and Research Initiative Awards from Arizona State University. She is currently working with other faculty members and graduate students in the Department of Electronic Systems exploring specific fabrication of multi-wall and single-wall carbon nanotubes for hydrogen storage and gas diffusion layers for methanol based fuel cell applications. She has more than 60 refereed journal and conference publications, and serves as an associate editor for the *Journal of Nanoscience and Nanotechnology*. Dr. Munukutla also led one of the Scientific Villages.

Sethuraman Panchanathan: Co-PI
Senior Vice President, Office of Knowledge Enterprise Development
Professor, School of Computing, Informatics, and Decision Systems Engineering
Arizona State University, Tempe campus

Co-PI for *Prime the Pipeline Project (P³)*, Dr. Panchanathan is a foundation chair in Computing and Informatics and Director of the Center for Cognitive Ubiquitous Computing (CUBiC). He was founding director of the School of Computing and Informatics and was instrumental in founding the Biomedical Informatics Department at Arizona State University. His research interests are in the areas of Human-Centered Multimedia Computing; Face/Gait Analysis and Recognition; Haptic User Interfaces; Medical Image Processing; and Media Processor Designs and Ubiquitous Computing Environments for enhancing quality of life for individuals with disabilities.
Mary Cavanagh: Project Director
Executive Director, Practice, Research and Innovation in Mathematics Education (PRIME) Center
Arizona State University, Tempe campus

Project Director for Prime the Pipeline Project (P³) and Co-leader of the Connections Course for Teachers with Greenes, Cavanagh is currently Project Director for the Helios Education Foundation-funded STEM in the Middle project. She is author of numerous textbooks in mathematics and science. As Project Director of P³, Cavanagh was responsible for project planning, program implementation, and recruiting teachers and students. She co-authored all MATHgazines.

Julie Zehring: Project Coordinator
Assistant to the Associate Vice Provost for STEM Education
Arizona State University, Tempe campus

Project Coordinator for Prime the Pipeline Project (P³), Zehring assisted the PI, Co-PIs, and the evaluator with the collection of data from participants, including surveys and interviews of students and teachers; secured the data; assisted with the recruitment of students, teachers, and mentors; handled the project budget and classroom reservations; and maintained the website for the duration of the project.

Sue Wolf: External Evaluator
Executive Director, Empowerment Research, LLC

Evaluator for Prime the Pipeline Project (P³), Dr. Wolf also served as evaluator for The APEX Project: Arizona Providers Engaging in Excellence; Mentoring Model to Increase Access to Higher Education and Attainment of Education Goals; AzDAc Program, First Things First, 2009-2012; and Students Learning In and Through the Arts, 21st Century Community Learning Centers Program, US Department of Education, 2004 – 2008. Currently, she is external evaluator for the Helios Education Foundation-funded STEM in the Middle project.
Valentina Postelnicu: Co-Researcher  
Instructor, Applied Sciences & Mathematics, College of Technology and Innovation  
Arizona State University, Polytechnic campus

Pre-award advisor and proposal writer for *Prime the Pipeline Project* \( (P^3) \), and designer of the Algebraic Reasoning Assessment used with \( P^3 \) teachers and their students, Dr. Postelnicu received her Ph.D. in Curriculum and Instruction, Mathematics Education, from Arizona State University. She has taught mathematics courses at the high school and college levels, and has extensive experience with curriculum design. While working as a research assistant during her graduate studies, she participated in grant writing and research efforts to reform teacher education and to find innovative ways to teach mathematics and mathematics education courses. Recently, she served as a member of the STEM Education K-12 Initiative Task Force, College of Technology and Innovation at Arizona State University. Currently, she is leading a team with Professor Carole Greenes to develop a battery of assessments on algebraic reasoning targeted at students and their teachers in grades 5 – 12.

Shelley Tingey: Editor  
Coordinator, Practice, Research, and Innovation in Mathematics Education (PRIME) Center,  
Arizona State University, Tempe campus

Shelley Tingey is the PRIME Center Coordinator, co-editor of the \( P^3 \) book and the Project Coordinator for the Helios Education Foundation-funded *STEM in the Middle* project. Prior to joining ASU, Shelley taught mathematics at community colleges in Arizona and New Mexico and has participated in research studies focused on improving comprehension and student success in mathematics through the use of labs and the incorporation of writing in mathematics instruction. Shelley also taught mathematics to middle school students in both general and special needs classrooms. Shelley holds a Bachelor of Science Degree in Computational Mathematics and an MBA. Her responsibilities in the PRIME Center include developing proposals and coordinating grant-funded research projects designed to promote student and teacher success in STEM fields.

Laura Petersen, Editor  
Teacher Participant in \( P^3 \)  
High school mathematics teacher, Chandler Unified School District  
Adjunct faculty, Rio Salado College

Currently, Laura teaches Psychology and Education courses online for Rio Salado College and owns a local tutoring company, Student-Tutor. During \( P^3 \), Laura was a full-time Mathematics and Psychology teacher at Hamilton High School in the Chandler Unified School District in Chandler, Arizona. She has a B.A. in Psychology with a minor in German from UCLA and a master’s degree in Secondary Education from the University of Phoenix. She is certified to teach secondary mathematics and psychology in both Arizona and California.
Advisory Board

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Keith Hjelmstad, Vice President and Dean, College of Technology and Innovation, Arizona State University, Polytechnic campus

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Diane Moore, Parent Representative, Higley Unified School District

Jason Phillips, Science Instructional Specialist, Chandler Public Schools (Representing Superintendent Camille Casteel)

**Year 3**

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Betty Garcia-Pendley, President, Arizona Parent Teacher Association

Robert Greenes, Ira A. Fulton Chair and Professor of Biomedical Informatics, School of Computing and Informatics, Arizona State University, Phoenix campus

Diane Moore, Parent Representative, Higley Unified School District

Jason Phillips, Science Instructional Specialist, Chandler Public Schools (Representing Superintendent Camille Casteel)

David Schwalm, Former Dean, School of Applied Arts and Sciences, Professor of English, School of Applied Arts and Sciences, Arizona State University, Polytechnic campus
Scientific Village Leaders

Jim Anderson  
Lecturer, Department of Technology Management  
Coordinator, CRJ200 Flight Training Device, Aeronautical Management Technology Department  
Arizona State University, Polytechnic campus

**Education**  
M.A. Business Management, Central Michigan University  
B.A. Military Arts and Sciences, U.S. Air Force Academy  
Flight Ratings: Air Transport Pilot ATP, Advanced Ground Instructor, Instrument Instructor

**Villages Led (with Mittelstaedt)**  
Aviation: Flight Training (Spring 2010)  
Aviation: Flight Training – The Sequel (Summer 2010)

Anderson is a highly experienced aviation professional with more than 19,000 hours of flight time. In the Professional Flight Program, he teaches aviation and manages the CRJ200 Level 5 Flight Simulation Training Device. Anderson retired as a captain from Southwest Airlines in 2005 after 16 ½ years of service where he piloted Boeing 737-200/300/500/700 aircraft. During his 20-year career in the U.S. Air Force, Anderson flew a variety of aircraft including the T-41, T-37, T-38, O-2, T-33, F-4E and the F-5B/E/F. He is a graduate of the USAF Instrument Pilot Instructor School, and retired from the Air Force as a Lieutenant Colonel.

Srividya Bansal  
Assistant Professor, Department of Engineering, College of Technology and Innovation  
Arizona State University, Polytechnic campus

**Education**  
Ph.D. in Computer Science, The University of Texas at Dallas  
M.S. in Computer Science, Texas Tech University  
B.Tech. in Computer Science & Engineering, National Institute of Technology, Warangal, India (Formerly known as REC, Warangal)

**Village Led**  
Web Weaver (Spring 2011)

Bansal worked in industry for 5 years as a Software Engineer at SAP Labs India and Tyler Technologies in Plano, Texas before joining academia. Her research focuses on description, discovery, and composition of Semantic Web services. She designed and developed the Web service description language Universal Service-Semantics Description Language (USDL). Prior to joining Arizona State University in Fall 2010, she was Visiting Assistant Professor at Georgetown University.
Bray Beltrán
Global Change Ecologist, Environmental Life Sciences
Student, Ph.D. program in Environmental Life Sciences
Arizona State University, Tempe campus

Education
M.S., Environmental Studies, College of Charleston
B.S., Biology, minor in Chemistry, University of Miami
A.A., Biology, Miami Dade College

Village Led
Off Balance: Water, Plants, and You (Spring 2011)

Beltran is a Global Change Ecologist interested in the combined effects of Climate Change and Land Cover/Land Use Change (LCLUC) in the environment. His particular foci are the effects of climate change on future distribution of plants and future community composition (derived from plant migration) effects on ecosystem services and products.

John Black
Faculty Associate, School of Computing, Informatics and Decision Systems Engineering
Computer Science and Engineering Faculty
Arizona State University, Tempe campus

Education
Ph.D. Computer Science, Arizona State University
M.S. Electrical Engineering, Arizona State University
B.S. Electrical Engineering, Arizona State University

Village Led
Exploration of Scientific Puzzlers and What We Can Learn from Them: Optical Illusions, the Properties of Light, and Human Vision (Fall 2009)

Dr. Black worked in the electronics industry as an engineer for Sperry Flight Systems and Motorola where he was responsible for the development of the VMEbus specification, which has been internationally standardized as ANSI/IEEE std 1014 and IEC 821. After Motorola, Black launched Open Systems Publishing, http://www.opensystems-publishing.com. In 1988 he authored The System Engineer's Handbook, which was published by Academic Press. Black has been an Arizona State University faculty member since 2003. His research focuses on the structure and function of the human visual system.
Penny Ann Dolin
Chair and Lecturer, Graphic Information Technology (GIT) Program,
Department of Engineering, College of Technology and Innovation
Arizona State University, Polytechnic campus

Education
M.S. Technology, Arizona State University
B.A. American History, Bard College

Villages Led
Photography: Creativity + Technology (Fall 2010/Spring 2011)

Dolin has been involved in the graphics field for over 30 years. Her early career was as a photojournalist for *The New York Times* and *Newsday*, then with American Color as a member of the Corporate Research and Development team and as Western Region Technical Manager. Dolin’s core expertise is in commercial photography and technical imaging. She is a regular guest lecturer on lighting for high speed photography at MIT. An ASU faculty member since 1998, she is the founder of the GIT Commercial Photography Studio at ASU’s Polytechnic campus and has developed a Technical Imaging Lab that explores high speed imaging, stroboscopic and thermal photography, and is currently serving as an Adobe Educator Leader and the Barrett Faculty Honors Advisor.

Carol Findell, Visiting Scholar
Clinical Associate, Professor of Education, School of Education
Boston University

Education
Ed.D. Mathematics Education, Boston University
M.S.T. Mathematics Education, University of New Hampshire
B.A. Mathematics, University of New Hampshire

Village Led
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009)

Findell authored and edited several National Council of Teachers of Mathematics (NCTM) publications, including *Student Math Notes, World’s Largest Math Events, Figure This!*, and the *Navigations* series, and was head writer for the Mathcounts Competition. She was teacher and developer for two Annenberg mathematics series. She is co-author of many books and games for elementary and middle school students including the *Groundwork* series (McGraw Hill), *Algebraic Reasoning Modules* (CK-12 Foundation), *Problem Solving Think Tanks* (ORIGO), and *Zupelz: A Game of Logic* (ORIGO). She was inducted into the Massachusetts Mathematics Educators Hall of Fame and is the recipient of two awards for mathematics education. She spent a year as a visiting professor at Arizona State University.
Anna Wheeler Gentry
Associate Faculty, Honors Disciplinary, College of Letters and Sciences
Lecturer, School of Music, Herberger Institute for Design and the Arts
Arizona State University, Polytechnic campus

Education
M.A., University of Missouri-Kansas City
Vocal Performance Certificate, Aspen Music School
B.A., Loretto Heights College

Villages Led
Technology Remix: Village People Music Lab (Fall 2010)
Music Technology: Bach to Rock (Spring 2011)

Anna Wheeler Gentry performed solo concerts at New York’s Lincoln Center and Moscow’s Tchaikovsky Conservatory of Music, and operatic roles (Mozart, Britten, Gilbert & Sullivan, Persichetti) throughout the United States. She also performed in musical theater (Sondheim, Gershwin, Lerner & Loewe, Rodgers & Hammerstein), as well as in concert works (Stravinsky, Saint-Saëns, Brahms, Haydn) in Philadelphia, New York, Pittsburgh, Kansas City, Denver, and Phoenix. Focusing on the restoration and preservation of historic masterpieces within the American musical theater genre, Gentry’s projects have garnered support from the American Multi-Cinema Foundation, Yip Harburg Foundation, and the Society for American Music. Gentry's writings have been published by Kendall Hunt, McFarland, Johns Hopkins University Press, Continuum UK, and Gale.

Mark Henderson
Professor, Department of Engineering, College of Technology and Innovation
Teaching Faculty, School of Sustainability
Senior Sustainability Scientist, Global Institute of Sustainability
Arizona State University, Polytechnic campus

Education
Ph.D., Mechanical Engineering (CAD), Purdue University
M.S., BioMechanical Engineering, Purdue University
Secondary Teaching Certificate, University of Michigan
B.S., Mechanical Engineering, Purdue University

Villages Led (with Rogers)
Wind Energy: Harness the Wind (Summer 2009/Fall 2009)
Engineering Design: Rockets and Robots (Spring 2010)
Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010)

Winner of the Presidential Young Investigator Award, Henderson has published 60 papers on his major research in computer-aided design and global engineering. He serves on the editorial board of The Journal of Computer-Aided Design (CAD). As part of a multi-university collaboration on student mobility, he began the Nomadic Academy in 2004, a summer study abroad program in design and manufacturing with Pennsylvania State University, University of Washington, University of Leeds (UK), IUT Bethune (France), Ecole Centrale Lyon (France) and University of Navarra (Spain). He founded the Global Engineering Design Team, co-founded GlobalResolve, and co-directs the InnovationSpace at Arizona State University.
Jon Howell  
**Instructor, Anatomy and Physiology**  
**East Valley Institute of Technology**

**Education**  
B.S. Agriculture, University of Arizona

**Village Led (with Perez)**  
Trauma Simulation: A Virtual Journey through the Human Body (Spring 2010)

Howell instructs students in nutrition and job development skills at the East Valley Institute of Technology (EVIT). He also serves as the National Technical Honor Society advisor and Chairman of the Board of Directors for the Arizona Health Occupations Students of America (AzHOSA). While a student at the University of Arizona, he was named outstanding senior in the College of Agriculture in 2006. Howell is currently a member of the Arizona Career and Technical Educators Association.

Christopher LaMont  
**Faculty Associate, Film Production, Herberger Institute for Design and the Arts**  
**Arizona State University, Tempe campus**  
**Co-founder, Phoenix Film Festival**

**Education**  
B.A. Interdisciplinary Arts and Sciences, Arizona State University  
A.A. Phoenix College

**Villages Led**  
Film and Media Production: Lights, Camera, Action! (Spring 2009)  
Film and Media Post-Production: Video Editing (Summer 2009)  
Documentary Film Design and Post-Production (Fall 2009)  
You Shoot YouTube (Fall 2010)

LaMont is a multi-award winning independent filmmaker. He directed and co-wrote *Film Club*, which was put on the *George Lucas in Love* DVD. As President of the Phoenix Film Foundation, he started the Phoenix Film Society, the Phoenix Film Project, the International Horror and Sci-Fi Film Festival, and the Arizona Student Film Festival. Since 2003, he has taught film production at Arizona State University, and since 2006, has been a member of the faculty in the Digital Video Program at the University of Advancing Technology. He also oversaw production of the P³ Project Film.
Timothy Lindquist, Co-PI
Professor, Department of Engineering, College of Technology and Innovation
Affiliate Professor, School of Computing and Informatics, Ira A. Fulton Schools of Engineering
Arizona State University, Polytechnic campus

Education
Ph. D. Computer Science, Iowa State University
M.S. Computer Science, Iowa State University
B.S. Mathematics/Computer Science, Purdue University

Villages Led
Visual Programming and Gaming with Scratch (Summer 2009)
Advanced Game Simulation: Visual Programming and Gaming with Scratch II (Fall 2009)
See C: Advanced Computer Programming (Spring 2010)
Scratch, C, and iPods (Summer 2010)

Note: See Project Management section for biographical information.

Ida Malian
Professor, Special Education, Mary Lou Fulton Teachers College
Arizona State University, West campus

Education
Ph.D. Special Education, University of Michigan
M.A. Child Development, University of Michigan
B.A. Psychology, Oakland University

Village Led
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009)

Malian was Associate Director of the School of Teacher Education at San Diego State University, Assistant Professor at the University of Nebraska at Omaha with a joint appointment at the University of Nebraska Medical Center at Meyer Children’s Rehabilitation Institute, and Director of Educational Training at Children’s Psychiatric Hospital at the University of Michigan Medical Center. She served as Principal Investigator on numerous federal projects. She was Coordinator of The Arizona Follow Along Project, which followed students with disabilities through post-secondary transitions, and was involved with the Phi Delta Kappa National Student at Risk Project. She serves as editor for top-tiered special education journals and has written numerous books and articles on topics ranging from the correlation of self-concept and sensory integration to law and disabilities. Currently, she is involved with a national study of para-educators in inclusive classrooms, and the efficacy of co-teaching for student achievement.
Colleen Megowan-Romanowicz, Co-PI
Research Scientist, School for the Arts, Media and Engineering,
Herberger Institute of Design and the Arts
Arizona State University, Tempe campus

Education:
Ph.D. Physics Education Research, Arizona State University
M.N.S. Physics, Arizona State University
B.S. Pre-Medicine, Loyola Marymount University

Village Led
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009)

Note: See Project Management section for biographical information.

Al Mittelstaedt
Director of Aviation Programs
East Valley Institute of Technology

Education
M.B.A., Pepperdine University
B.S. Aeronautical Engineering, Embry-Riddle Aeronautical University
Flight Ratings: ATP, CFI, CFII, IGI and ME

Villages Led (with Anderson)
Aviation: Flight Training (Spring 2010)
Aviation: Flight Training – The Sequel (Summer 2010)

Mittelstaedt worked as an aerospace test engineer with Wernher von Braun and his team of German “Rocketeers” on Apollo, Sky Lab and the Space Transportation System programs before entering the U.S. Air Force, where he flew fighters for 20 years and was an Alaskan Bush Pilot during six of those years. Following his service in the Air Force, he was captain for Southwest Airlines for 17 years accumulating more than 20,000 flight hours. Mittelstaedt taught aviation at Arizona State University and took pride in keeping ASU’s programs at the “cutting edge” of the technology. He is currently the Director of Aviation Programs at the East Valley Institute of Technology (EVIT) at its new East Branch campus located at the PHX-Mesa Gateway Airport.
Lakshmi Munukutla, Co-PI
Professor, Department of Engineering Technology, College of Technology and Innovation
Arizona State University, Polytechnic campus

Education
Ph.D. Solid State Physics, Ohio University
M.SC. Nuclear Physics, Andhra University, India
B.SC. Mathematics, Physics and Chemistry, Andhra University, India

Village Led
Cleanroom Science and Model Development: Clean Your Room
(Spring 2009)

Note: See Project Management section for biographical information.

Robert Pahle
Senior Sustainability Scientist, Global Institute of Sustainability
Assistant Research Professor, Decision Theater, Global Institute of Sustainability
Arizona State University, Tempe campus

Education
Ph.D., Environmental Design and Planning, Arizona State University
Dipl. Ing. Arch., Architectural Engineering, University of Siegen, Germany

Village Led
3D Virtual Modeling for Emergency Services (Summer 2009)

Pahle’s Ph.D. in environmental design and planning focused on dynamic, real-time informative warning systems and intelligent buildings. He works with a variety of 3D modeling technologies and databases to support researchers. His expertise is in database systems, modeling and simulation, urban planning, solar energy systems, informatics, data-fusion technology, data mining, data cleaning and information extraction, and data analysis. He has taught classes in building structure and design at Arizona State University.
Eric Perez  
**Instructor, Digital Image and Web Design**  
**Chair, Department of Technology**  
**East Valley Institute of Technology**

**Education**
B.A. Visual Communications and Digital Media, Collins College  
School of Design and Technology  
A.A. Graphic Design, Collins College School of Design and Technology 

**Village Led (with Howell)**
Trauma Simulation: A Virtual Journey through the Human Body  
(Spring 2010)

At the East Valley Institute of Technology, Perez teaches 2D and 3D production courses to high school students. Perez has worked with commercial art and visual communications software for more than 20 years, was awarded the Civic Star in 2005 for having the best program in the state, and was named Graduate of the Year by The Accrediting Commission of Career Schools and Colleges of Technology (ACCSCT). He also earned the Platinum Apple award in 2007, was named ACTE Arizona Teacher of the Year in 2008, and received the Citizen's Meritorious Service Award from the Mesa Police Department in 2009.

Pushpa Ramakrishna  
**Professor, Biology**  
**Chandler Gilbert Community College**

**Education**
Ed.D. Higher Education, Arizona State University  
M.N.S. Molecular Biology, Arizona State University  
M.S. Biochemistry, Bangalore University, India  
B.S. Biochemistry, Bangalore University, India 

**Villages Led**
Biotechnology: Forensics and DNA Fingerprinting (Summer 2010)  
Biotechnology: The Case of the Mystery Genes (Fall 2010)

As Professor of Biology at Chandler Gilbert Community College, Dr. Ramakrishna started the biomedical research technology program. She served as co-PI for the NSF project SyRIS, which was awarded the prestigious Gustav Ohaus Award for Innovation in Science teaching from the American Association for the Advancement of Science.
Brad Rogers  
Associate Professor, Department of Engineering Technology  
Arizona State University, Polytechnic campus

Education  
Ph.D. Mechanical Engineering, Arizona State University  
M.S. Mechanical Engineering, Montana State University  
B.S. Mechanical Engineering, Montana State University

Villages Led (with Henderson)  
Wind Energy: Harness the Wind (Summer 2009/Fall 2009)  
Engineering Design: Rockets and Robots (Spring 2010)  
Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010)

Dr. Rogers’ experience is in fluid mechanics, heat transfer, magnetohydrodynamics, and applied mathematics, and has been involved in the design and evaluation of traditional and alternative energy conversion systems for 27 years. An Arizona State University faculty member since 1984, Rogers has taught more than 40 different courses. He is currently the chief technical officer (acting) of Arizona State University’s GlobalResolve social entrepreneurship initiative with responsibility for technical research and development, academic coordination, and proposal generation and evaluation. He also was involved in the design of sustainable enterprises in the developing world, particularly in West Africa.

Scientific Village Mentors

Major contributors to the success of the Scientific Villages were the undergraduate mentors who facilitated collaborative problem solving and project coordination among participants. Mentors also served as role models for students who were considering college majors in STEM or business disciplines, and helped villagers become Arizona State University Polytechnic ‘insiders’ over the course of the project.

At the start of P³, mentors were recruited from college freshmen and sophomores enrolled in STEM courses on the Polytechnic campus of Arizona State University, or in Biological Science at Chandler Gilbert Community College. Each mentor applicant was interviewed by two members of the project staff. All those accepted into the program indicated a willingness to remain involved in the project throughout its duration.

Mentors conferenced with Village Scientist Leaders preceding each village meeting and prepared for that day's session. Following each session, mentors were surveyed for feedback about the session and topics/issues to consider in the next village meeting. Each village had one or two mentors.

Mentors received a stipend of $500/summer and $250/semester.
Tim Gunty, Lead Mentor
Major: Engineering
Arizona State University

Michael Astrauskas
Major: Computer Systems Engineering
Arizona State University

Danielle Billeaux
Major: Film and Media Production
Arizona State University

Dan Bridenstine
Major: Aviation
Arizona State University

Ryan Fogelsanger
Major: Aviation
Arizona State University

Sabrina Gant
Major: Biological Science
Chandler Gilbert Community College

Jon Garcia, Mentor and Assistant to the PI
B.A. Exercise and Wellness
Arizona State University

Robert Hanback
Major: Aviation
Arizona State University

Jason Harris
Major: Exercise and Wellness, Nutrition and Health Promotion
Arizona State University

Jamil Kassum
Major: Aviation
Arizona State University

Jason Kurneta
Major: Computer Studies
Arizona State University

Bryan Labadie
Major: Computer Systems Engineering
Arizona State University

Nadia Madias
Major: Nutrition and Health Promotion
Arizona State University

Jake Manbeck
Major: Aviation
Arizona State University

Ian McClarren
Major: Film and Media Production
Arizona State University

Lisa Miller
Major: Biological Science
Chandler Gilbert Community College

Chris Minneci
Major: Aviation
Arizona State University
**Emmy Nicoll**  
Major: Nutrition, Health Sciences  
Arizona State University

**Johnny Tran**  
Major: Mechanical Engineering Technology, Automation Engineering Technology  
Arizona State University

**Alain Ochoa**  
Major: Psychology  
Arizona State University

**Thu Truong**  
Major: Biological Science  
Chandler Gilbert Community College

**Rebecca Ramirez**  
Major: Biological Science  
Chandler Gilbert Community College

**Chad Westover**  
Major: Graphic Image Technology  
Arizona State University

**Ryan Stewart**  
Major: Computer Systems Engineering  
Arizona State University

**Volunteers**

**Allen Clark**, Assistant Chief of Police, Arizona State University. An administrator for 20 years with a B.A. in Police Management, Clark is responsible for the Incident Command System at Arizona State University and Emergency Manager for the Arizona State University Police Department. He worked with Robert Pahle on the design of the 3D Virtual Modeling for Emergency Services Village in Summer 2009.

**Carmen Coleman**, Engineer, Intel Corporation. Coleman attended project meetings and provided information on STEM related careers. She worked with the Cellular Communications Network Design: Can You Hear Me Now? villages in Spring 2009.

**Sean Dengler**, Engineering Lab Manager, College of Technology and Innovation, Arizona State University, Polytechnic campus. Dengler has a BA in Robotic Engineering and expertise in CAD design and robotic programming. He collaborated with Professors Henderson and Rogers for the Spring 2010 Engineering Design: Rockets and Robots Village and led the SUMO Robot Challenge at the Showcase.


**Brant Hinrichs**, Professor of Physics, Drury University. Hinrichs delivered two lectures as a guest speaker on electricity and magnetism to the Cellular Communications Network Design: Can You Hear Me Now? villages.
Sean Hogberg, Engineer, Motorola Home and Networks Mobility, and designer of cellular mobility communications networks. Hogberg is responsible for engineering design, delivery, customer interface, manufacture of large-scale telecommunications infrastructure, and development of cellular products. Hogberg attended P3 program planning meetings with cell phone village leaders to develop the cellular network communications project, and assisted with identifying industry collaborators for the project. He delivered lectures, provided instructional materials, assisted with project management and with participant design ideas for cellular network models for the Cellular Communications Network Design: Can You Hear Me Now? villages in Spring 2009.


Mark Shaughnessy, Engineering Fellow, Motorola Home and Networks Mobility. Shaughnessy is the Dan Noble Fellow (highest honor awarded at Motorola) Motorola cellular networks architecture team member, and Motorola Master Inventor. He was awarded 'Patent of the Year' from Motorola corporate. He attended P3 program planning meetings with cell phone village leaders to develop the cellular network communication project, and assisted with identifying industry collaborators for the project. He delivered project lectures, provided instructional materials, project management, and assisted with participant design ideas for cellular network models in the Cellular Communications Network Design: Can You Hear Me Now? Villages in Spring 2009.
Part Two: The P³ Program in Action

Program Participants and Location

Recruitment

Recruitment for the P³ program was conducted by project staff who visited with district superintendents and local high school principals, teachers, and students to enlist participants.

Student Villagers

Students were recruited from the following six Unified School Districts in Arizona: Chandler, Gilbert, Higley, Mesa, Payson, and Superior.

Teacher Villagers

In addition to the six districts cited for students, teacher participants also came from Apache Junction, Casa Grande, Coolidge, Dioceses of Phoenix, JO Coombs, Kyrene, Phoenix Union, Roosevelt, and Santa Cruz school districts and from Insight Schools.

Where and When P³ Took Place

The work of the Scientific Villages took place in the labs and other facilities at the Polytechnic campus of Arizona State University. All 2 ¼ hour sessions were conducted after school, once a week, for 9 weeks each semester during the academic year. Each summer institute was held for two weeks, 4 hours per day, Monday through Friday. During the summer programs, teachers also participated in Connections Courses for an additional 2 hours, Monday through Thursday. During the Showcase Open Houses, held during the final village meetings in the Cooley Ballroom, villagers presented their projects to other villagers, family, friends, and members of the community.
Program Components

All Scientific Village projects aimed to:

- Promote deeper understanding of key mathematics and science concepts.
- Incorporate workplace technology tools, including databases, simulations, and graphing.
- Consider scientific problems specific to Arizona, and design solutions to those problems.
- Develop participants' critical thinking skills.
- Enhance communication among team members as they collaborated to solve problems.

Scientific Villages by Year

Note: Some villages were repeated due to participant demand. In Spring 2009, three villages focused on Cellular Communications. That was the only time that sessions repeated in the same time period and the only time that five villages took place.

**Spring 2009**
Cellular Communications Network Design: Can You Hear Me Now? (3 Villages)
Cleanroom Science and Model Development: Clean Your Room
Film and Media Production: Lights, Camera, Action!

**Summer 2009**
3D Virtual Modeling for Emergency Services
Film and Media Post-Production: Video Editing
Visual Programming and Gaming with Scratch
Wind Energy: Harness the Wind

**Fall 2009**
Advanced Game Simulation: Visual Programming and Gaming with Scratch II
Documentary Film Design and Post-Production
Exploration of Scientific Puzzlers and What We Can Learn from Them: Optical Illusions, the Properties of Light, and Human Vision
Wind Energy: Harness the Wind

**Spring 2010**
Aviation: Flight Training
Engineering Design: Rockets and Robots
See C: Advanced Computer Programming
Trauma Simulation: A Virtual Journey through the Human Body

**Summer 2010**
Aviation: Flight Training – The Sequel
Biotechnology: Forensics and DNA Fingerprinting
Engineering Design: Wind Turbines and Wind Tunnels
Scratch, C, and iPods
Scientific Villages: Detailed Descriptions

Spring 2009

Cellular Communications Network Design: Can You Hear Me Now?

Project Overview:
We cannot function without our cell phones in today's busy world. But have you ever stopped to think about how your trusty phone transmits phone calls, text messages, and data? In this project, villagers learned how this critical technology works and created their own cellular communications network models before analyzing and presenting the model and data.

Summary of Key Participant Activities and Accomplishments:
- Developed a basic conceptual model of the cell phone and became familiar with the underlying physical models needed to understand how cell phones send and receive voice and data.
- Developed a basic conceptual model of the cell tower and became familiar with the underlying physical models needed to understand how microwave telecommunications take place.
- Investigated design parameters for regional cell phone communication systems.
- Gained insight into the basics of electromagnetic and optical information transfer.
- Designed a cell tower network for a geographic area in Arizona with a population of approximately 50,000, and estimated the cost of construction, taking into consideration sustainability, aesthetics and evolving patterns of usage.

Leaders: Village 1 Leader and Director: Colleen Megowan-Romanowicz
Village 2: Carol Findell
Village 3: Ida Malian
Cleanroom Science and Model Development: Clean Your Room

Project Overview:
The cleanroom environment is essential to the manufacture of various nanostructures, microelectronic devices, pharmaceuticals, and hospital surgical rooms. This village focused on the engineering and technology skills necessary to create, operate, maintain, and monitor a cleanroom environment. Villagers were given cleanroom specifications and the tasks of constructing a cleanroom model, measuring its cleanliness level, and classifying the cleanroom using national cleanroom standards. They also toured a real cleanroom at Arizona State University.

Summary of Key Participant Activities and Accomplishments:
- Exposed to new concepts of cleanroom sciences.
- Created, operated, and monitored a cleanroom environment.
- Gained understanding of how particles of contaminants and their sources, temperature, and humidity affect the cleanroom environment.
- Designed a conceptual cleanroom model using a computer aided design (AutoCAD) program.
- Learned measurement techniques to estimate contaminants in a clean environment and then analyzed the data and compared it to national standards to determine the classification level of the cleanroom.

Leader: Lakshmi Munukutla

Film and Media Production: Lights, Camera, Action!

Project Overview:
With today's digital technology available at our fingertips, it's possible for anyone to make a movie. This village took participants behind the camera to discover how to make a short film that could play at film festivals across the world. Villagers were introduced to the ins-and-outs that make movies stand out from the crowd. Villagers were able to bring their creative ideas to life on the screen and be part of the filming action.

Summary of Key Participant Activities and Accomplishments:
- Created themes and ideas for films.
- Authored screenplays.
- Conducted pre-production activities and directed films.
- Filmed and edited short movies using Final Cut Express.

Leader: Chris LaMont
Summer 2009

3D Virtual Modeling for Emergency Services

Project Overview:
Urban planners, emergency responders, and decision makers face real-world problems that require them to look at a multitude of types of information. Much of the information is spatial, stored in massive databases, and distributed to users in visual form to show the context of problem sets and ease the comprehension of complex relationships needed for decision-making.

In this project, villagers explored a variety of technologies like GIS, databases, 3D modeling, design, web-based content management to support planners, emergency responders, and decision makers, with science-based visual analysis in an urban context.

Summary of Key Participant Activities and Accomplishments:
- Learned a variety of project software (e.g. Google Sketch-up, CAD).
- Engaged in small-group collaboration to generate integrated visualization examples using the software.
- Developed skills in the areas of data management, design, programming, and research.
- Produced a working example of an interactive, distributed 3D Geographic Information System that was shared with planners, emergency responders, and decision makers.

Leader: Robert Pahle

Film and Media Post-Production: Video Editing

Project Overview:
Villagers learned non-linear digital editing to create short movies, collaborated on film projects, and used existing footage to create their own edits of the films. The goal was for each participant to leave the Village with a comprehensive knowledge of taking a production idea from conception through creation to completion. Villagers learned how to digitize film footage; manipulate picture and sound with color correction and saturation techniques; add credits and graphics, music and sound effects; and present their movies to participants in the other Villages and the community at the Showcase.
Summary of Key Participant Activities and Accomplishments:

- Digitized film footage.
- Manipluated picture and sound with color correction and saturation techniques.
- Added credits and graphics, music and sound effects.
- Authored a DVD.
- Presented a movie to the other villagers and the community.

Leader: Chris LaMont

Visual Programming and Computer Game Design with Scratch

**Project Overview:**

Villagers worked individually and in teams to create computer-based interactive stories, animations, and games using Scratch.

Scratch provides a drag-n-drop user interface where building blocks are dropped into a construction area to assemble a script. This is described as snapping together blocks. Scripts can be developed and run incrementally, so new activities can be incorporated into an existing project. Scripts run on a storyboard during development, and can be posted to share with everyone when the author wishes. Villagers used Scratch to animate, create a game, and create and play music. They learned fundamental aspects of programming and media manipulation. For more information, see scratch.mit.edu.

Summary of Key Participant Activities and Accomplishments:

- Developed “teaming” skills through working with a group to problem-solve.
- Applied principles of computation, including decision, iteration, commands, variables, data types, events and object manipulation.
- Developed computer programing skills, including saving, interpretation, and user interactions providing input to program control.
- Applied concepts of mathematics, including working with a 2D coordinate system, points, lines, movement on the plane, and random-number generation.
- Learned and applied principles of animation design.
- Developed skill with problem-solving methods, including problem identification and definition, identification of constraints and goals, the brainstorming of solutions, and the implementation of solutions.

Leader: Timothy Lindquist
Wind Energy: Harness the Wind

Project Overview:
Focusing on wind energy and its uses, villagers began by deciding if wind energy makes sense from a homeowner's perspective. They explored how wind energy is produced, and finally looked at how wind itself is produced (it is actually solar energy). Villagers learned about renewable energy, and the pros and cons of its use. They performed an energy audit of their homes and compared their home audit results with other environments, including energy use on the Hopi Indian Reservation where Dr. Henderson and colleagues have worked to utilize wind to power the village.

Villagers collaborated to answer the following questions:
- Is there sufficient wind to operate a wind turbine and produce electricity?
- How do we optimize the efficiency of a wind turbine?
- What is the best design for a wind anemometer?
- How should the wind turbine be connected to the power grid?
- Where in the world should a wind turbine company sell its product?

Summary of Key Participant Activities and Accomplishments:
- Built a wind assessment tower to record wind data.
- Processed wind data to calculate the Weibull distribution enabling matching to a wind turbine.
- Built an anemometer.
- Performed an energy audit of homes.
- Explored the world to identify high wind areas.
- Matched wind turbine models to local wind patterns.
- Improved wind turbine blade efficiency.
- Calculated the wind force on buildings and wind turbines.
- With accumulated data, developed an economic model for using wind power as electricity.

Leaders: Mark Henderson and Brad Rogers
Advanced Game Simulation: Visual Programming and Gaming with Scratch II

Project Overview:
This Village was for those who completed the introductory Scientific Village, Visual Programming and Computer Game Design with Scratch in Summer 2009. Advanced Game Simulation expanded on the introductory Scientific Village and provided participants with a deeper understanding of game creation and animation.


Leader: Timothy Lindquist

Documentary Film Design and Post-Production

Project Overview:
Documentary filmmaking is a great way to tell a story and connect with audience members on subjects that touch the heart and mind. Issues of the day, fascinating people, and interesting stories are opened to the world through documentaries. Villagers explored the world of documentary creation, production, and completion.

All phases of pre-production, production, and post-production were explained and villagers were guided through production of their own short documentary films that were completed by the end of the village. Villagers had access to cameras, lighting, and sound equipment to bring their short documentaries to life, and developed the skills to tell stories through the art of the motion picture.

Summary of Key Participant Activities and Accomplishments:
- Manipulated picture and sound with color correction and saturation techniques.
- Added credits and graphics, music, and sound effects.
- Authored a DVD that uses all technological skills explored.
- For the final project, each villager edited a self-produced documentary film utilizing Final-Cut Express, synchronized sound and video, and pressed a DVD master for presentation at the Showcase.

Leader: Chris LaMont
Exploration of Scientific Puzzlers and What We Can Learn from Them: Optical Illusions, the Properties of Light, and Human Vision

Project Overview:
Villagers explored the physics of light and color, photography, image processing, and the working of human vision through hands-on activities integrated with technology. Using software programs, including MatLab and Adobe Photoshop, villagers learned how to create and manipulate digital images including a variety of optical illusions.

Summary of Key Participant Activities and Accomplishments:
• Discovered how light can be a wave or particle, how it is affected by mirrors and lenses, and what role light plays in the exploration of our universe.
• Demonstrated skills related to taking digital photos and transforming them using Photoshop.
• Experienced how human vision and depth perception work, and how to make 3D images.
• Studied intriguing scientific puzzles, and by using collaborative research methods, learned how to apply mathematics and science concepts to solve fascinating real-world problems.
• Produced PowerPoints, pictures, and 2D and 3D posters, and identified the visual elements that created optical illusions, (e.g. figure-ground displays) using Adobe Photoshop technology.

Leader: John Black

Wind Energy: Harness the Wind
(See Summer 2009, Scientific Village repeated because of popular demand).

Spring 2010

Aviation: Flight Training

Project Overview:
Villagers were introduced to all aspects of instrument flying. They learned the basics of the instrument cross check with hands-on simulator flight experience, and explored how flight simulators are used to train pilots. Villagers worked to master advanced mathematics used in instrument flight, such as calculating the rate of descent required for the ILS Approach, calculating a visual descent point, and calculating acceleration. Tours of Arizona State University flight training facilities included the Arizona State University Flight Line hanger and aircraft, new Adacel ATC Tower and Radar Simulators, CRJ200 Flight Training Device, Powerplant Laboratory, Structures Laboratory, and the Air Traffic Control Tower and Radar Simulators.
Summary of Key Participant Activities and Accomplishments:
- Became familiar with the history of instrument flight.
- Understood how flight instruments work and their primary use in instrument flight.
- Learned basic instrument scan techniques of control and performance.
- Operated a flight simulator in simulated instrument flight conditions and maintained control of the simulated aircraft.
- Explored instrument approach procedures and practiced flying instrument approaches with the flight simulator.
- Learned the forces involved in flight, namely lift, drag, weight, and thrust, and understood the basic principles of flight.
- Mastered mathematics used in instrument flight through calculating rate of descent required for ILS Approach, visual descent point, and acceleration.

Leaders: Jim Anderson and Al Mittelstaedt

Engineering Design: Rockets and Robots

Project Overview:
Villagers explored the process of engineering design while developing their problem-solving abilities and increasing collaboration skills while constructing and testing model rockets and Sumo Robots. The Village culminated with a Sumo Robot competition. Villagers’ robots were programmed in Basic X to use sonar to detect and chase other teams’ robots in a Sumo-Style match on a custom-built field.

Summary of Key Participant Activities and Accomplishments:
- Worked in engineering project teams.
- Developed designs for model rockets and Sumo Robots.
- Constructed models of both rockets and Sumo Robots.
- Tested rocket and robot designs.
- Participated in Sumo Robot team competitions.

Leaders: Mark Henderson and Brad Rogers
See C: Advanced Computer Programming

Project Overview:
Objective-C programming language is the major platform for developing software applications for Apple devices, such as the iPhone, iPod, and Mac computers. Villagers explored the development of games and other applications for the iPhone using Objective-C and the iPhone software development environment. The environment runs on Mac computers and includes an iPhone simulator, which provides a software-only iPhone device on which to execute programs.

Villagers studied iPhone game development through a series of team projects, each of which focused on a different aspect of object-oriented programming. They also learned the organization of a software program, as well as how programs are built and tested. Various strategies for developing 2D games on the iPhone were explored. Along the way, villagers learned enough about Objective-C to read and enhance existing applications.

Note: To participate in this Scientific Village, participants had to have participated in the Scratch Village or had some other prior programming experience.

Summary of Key Participant Activities and Accomplishments:
- Learned the iPhone software development environment.
- Explored the development of games and other applications for the iPhone using Objective-C.
- Developed software applications for personal use.

Leader: Timothy Lindquist

Trauma Simulation: A Virtual Journey through the Human Body

Project Overview:
Villagers coupled their knowledge of biology and anatomy with software graphics to create two-dimensional virtual tours of the major organ systems of the human body.

Summary of Key Participant Activities and Accomplishments:
- Described normal structures and functions of the brain and spinal cord, heart and blood vessels, lungs, kidney and bladder, digestive system (stomach and intestines), muscle and skeletal framework, and eyes and ears.
- Explored disorders associated with these structures.
- Learned and utilized computer modeling software to create virtual tours.
- Using Adobe Illustrator, developed technical and informational brochures, posters, and animations about anatomical disorders and trauma.

Leaders: Eric Perez and Jon Howell
Aviation: Flight Training – The Sequel
(See Spring 2010, Scientific Village repeated because of popular demand.)

Biotechnology: Forensics and DNA Fingerprinting

Project Overview:
Biotechnology is a burgeoning new field that has far reaching applications in the future of medicine and health, with strong underlying interdisciplinary connections with agriculture, forensics, bio-engineering, and ethics. One of the goals of the Biotechnology Scientific Village was to communicate the excitement from the forefront of research in order to motivate villagers to pursue interests in biotechnology. Villagers explored the various applications of biotechnology and their impact in the real world.

Summary of Key Participant Activities and Accomplishments:
- Learned basic microscopy techniques in a forensic microscopy laboratory and performed DNA fingerprinting to solve crimes.
- Learned new methods of genetic engineering and state of the art research by analyzing genetically modified foods.
- Isolated and analyzed DNA of cheek cells.
- Researched existing biotechnology projects.

Leader: Pushpa Ramakrishna

Engineering Design: Wind Turbines and Wind Tunnels

Project Overview:
Villagers learned about wind flow on Earth, why there are few locations that are prime for producing wind energy (thus the need for low speed turbines), and aspects of wind turbine design. Villagers experienced the engineering design process as they created and tested their own wind turbines. Testing was carried out with a custom built wind tunnel (designed specifically for this village) with the goal of creating the most efficient wind turbine. Efficiency is measured as the highest level of energy attained at the lowest speed. Using the engineering design process, villagers were able to discover variables, including blade shape, blade tilt, number of blades and their orientation, that have the greatest impact on energy production.
Summary of Key Participant Activities and Accomplishments:
- Constructed, tested and modified a wind turbine to achieve the optimal design.
- Tested wind turbines in a custom-built wind tunnel.
- Isolated variables that affect energy production.
- Graphed the efficiency of turbines as related to each variable.

Leaders: Mark Henderson and Brad Rogers

Scratch, C, and iPods

Project Overview:
  Villagers worked individually and in teams to create stories, animations, games and applications using Scratch and the iPhone. Scratch, a multimedia scripting environment, was used to familiarize villagers with 2D game and programming concepts. Villagers transitioned to the iPhone/iPod Touch development environment to create Objective-C applications and 2D games similar to those developed in Scratch. Villagers used the multimedia scripting concepts developed in Scratch to facilitate learning program construction in Objective-C.

Summary of Key Participant Activities and Accomplishments:
- Read, understood, and executed a functional, well-formed program.
- Made minor program modifications to change functionality.
- Imagined and implemented substantial changes in functionality.
- Imagined and implemented related, but separate, programs.
- Developed enhanced knowledge of group dynamics, quantitative computational thinking, and software structures.

Leader: Timothy Lindquist
Biotechnology: The Case of the Mystery Genes
(See Biotechnology: Forensics and DNA Fingerprinting in Summer 2010, Scientific Village repeated because of popular demand.)

Photography: Creativity + Technology

Project Overview:
Villagers learned commercial and technical photography in a professional photographic studio using two shooting bays outfitted with high-end digital cameras and lighting equipment. They developed original concepts, learned set building, conducted photography (both traditional and high speed), and output to a variety of media: print, Flash, Web, and Rich Media PDF. Areas explored included chip technology, strobe effects, color management, and optics, with an emphasis on creativity and problem solving.

Summary of Key Participant Activities and Accomplishments:
- Learned set building.
- Explored light effects (photoelectric, stroboscopic).
- Learned color management.
- Explored optics (how lenses work).

Leader: Penny Dolin
Technology Remix: Village People Music Lab

Project Overview:
Villagers applied rhythmic and melodic creativity within an electronic music laboratory setting. Through structured guidance and varied projects, villagers explored basic music composition, songwriting (including collaborative songwriting), basic arranging, and optional electronic orchestration using versatile music notation software. Sessions were intended to accommodate a broad range of backgrounds; no prior music experience was required.

Summary of Key Participant Activities and Accomplishments:
- Explored various styles of music.
- Learned to use Audacity and Sibelius software programs.
- Learned to take popular recordings and original works and modify by remixing and squashing, or by varying tempos and keys.
- Presented final projects, alternating between original electronic compositions using Sibelius (software) and remixes of commercially recorded music using Audacity (software) at the Showcase Open House.

Leader: Anna Gentry

You Shoot YouTube

Project Overview:
Villagers wrote, shot and edited videos for YouTube while learning principles of video production and post-production, and exploring how social media can help make videos "go viral.”

Summary of Key Participant Activities and Accomplishments:
- Filmed using professional equipment (lights, cameras, and microphones).
- Digitized film footage utilizing state-of-the-art editing technology (Final Cut Express).
- Manipulated picture and sound with color correction and saturation techniques.
- Added credits, graphics, music and sound effects.
- Authored a YouTube video that utilized all technological skills explored in the village.

Leader: Chris LaMont
Music Technology: Bach to Rock
(See Technology Remix: Village People Music Lab in Fall 2010, Scientific Village repeated because of popular demand.)

Off Balance: Water, Plants, and You

Project Overview:
Current species and climate data were used to model and predict temperatures, precipitation, and what species habitats may look like 20, 30, 40, or more years from now. Villagers learned to download environmental data from the Internet and to process it using the geographical information system ArcMap. ArcMap was used to transform the data, isolate the area of interest, convert the map units into commonly used units of temperature and precipitation, and create maps to display the differences between present and future environmental conditions and distributions (environmental or species), and then relate those findings to quality of life.

Summary of Key Participant Activities and Accomplishments:
- Learned to use a Geographic Information System (GIS) to obtain, process, and analyze climate data.
- Used GIS to compare spatial differences between current and future climate data.
- Gained greater insight into the relationship between climate change and quality of life.
- For the Showcase, villagers presented 15-minute PowerPoints that summarized the results of their climate data analyses for Arizona.

Leader: Bray Beltran
Web Weaver

Project Overview:
Villagers designed, created, and edited interactive websites, and explored basic web design tenets, effective use of color and style, use of multimedia (sound, animation, and video), and graphics. Adobe Dreamweaver and Flash software tools were used for web authoring, creating animations, and building rich internet applications.

Summary of Key Participant Activities and Accomplishments:
- Learned XHTML (eXtensible Hyper-Text Markup Language) to create effective and structured web pages.
- Learned CSS (Cascading Style Sheets) to style web pages and provide uniform presentation across the website.
- Used multimedia (sound, animation, and other media) and Adobe Flash and Dreamweaver on the websites for the delivery of interactive content.
- Developed basic knowledge of client-side scripting using Javascript.
- Developed talents setting up a database (MySQL) and managing it.
- Learned and used emerging technologies including Content Management Systems (e.g., Drupal), blogging, and wikis.

Leader: Srividya Bansal
Orientation Meetings for Village Leaders and Village Mentors

At the start of each semester and summer, at least three weeks prior to the first village meetings, project staff provided an orientation for village leaders and mentors. During those orientations, the goals of P³ were reviewed. Leaders received assistance with the development of syllabi, village-specific pre-and post-assessments, and timelines for the conduct of various village activities. Mentors received instruction and training from Village Leaders and project staff.

A Typical Day in P³

Village students, teachers, leaders, and mentors gathered in the Cooley Ballroom at Arizona State University’s Polytechnic campus for the first 15 minutes of each scheduled P³ session. During that time, project staff made important announcements, and with the exception of Day 1, villagers “debriefed,” reporting on their work to participants in other villages. Villagers then went to their workspaces and collaborated to complete their projects.

Debriefings

During debriefings, a representative from each Scientific Village was handed the microphone and charged with describing the Village’s progress toward meeting its goals, the challenges encountered, and any revised goals established. At the end-of-semester and end-of-summer evaluations, many students identified the debriefings as most useful in developing their public speaking talents.

Showcase Open Houses for Parents and the Community

At the end of each semester and summer, villagers invited family, friends, and other members of the community to attend an open house where projects were displayed and described. During presentations, all members of the Scientific Villages spoke to the audience, describing the results of their collaborative efforts.
Connections Courses for Teachers

Held daily in tandem with summer villages (an additional 2 hours per day, Monday through Thursday), and led by project staff, village leaders, and visiting scientists, teachers gained greater insight into big ideas in their content areas of expertise and sister fields, and experience with various types of technology, assessment strategies, (e.g., clinical interviews to probe students’ depths of understanding, collaboration assessment protocols), and methods for counseling students through the STEM Pipeline. Teachers developed proposals to fund materials and supplies needed for implementing project learning in their classrooms. They connected/networked with other teachers to examine common difficulties and to learn about instructional programs and activities offered by their peers.

2009 Connections Course Topics:

1. Knowing what your students know
Carole Greenes, PI and Professor of Mathematics Education, and Valentina Postelnicu, Instructor of Mathematics, College of Technology and Innovation, ASU Polytechnic campus, led discussion of linearity and linear functions, fundamental concepts in Algebra I. All teachers completed a 7-item assessment on aspects of linearity, developed by Greenes and Postelnicu, which had been given to more than 3000 students worldwide, 1500 of those in Arizona. After completing the assessment, teachers rank ordered the problems from most to least difficult from the perspective of their students, and for the most difficult item, provided a rationale. Results of teacher rankings were compared with the performance and rankings of students. The lack of agreement between teachers’ rankings and student performance and rankings prompted heated conversations about how teachers make decisions about intervention activities, and the need for more in-depth assessments of students’ talents.

2. Career counseling
Tim Lindquist, Co-PI and Professor of Computer Science, described careers in various fields of technology and requirements for them. Brad Rogers, Professor of Engineering, did the same for engineering. Teachers were amazed by the diversity of engineering vocations, and most interested in the high school and college courses needed in preparation for those careers.

3. Co-teaching
Ida Malian, Professor of Special Education, led discussion of the advantages of co-teaching special education with mathematics, science and technology. She described methods for reaching students with various learning challenges.

4. Online teaching
Two P^3 teacher participants were on-line mathematics and science high school teachers for Insight Schools, owned by the Apollo Group that also operates the University of Phoenix. They described how their virtual high school operates. Each teacher carries a load of 100 students and works closely with the students to ensure that they remain active and engaged in their schoolwork.

5. Project-Based Learning
Mark Henderson, Professor of Engineering, described advantages of project-based learning (PBL) used in the Pipeline Project. He reaffirmed that the interdisciplinary nature of the projects helps students become more engaged in the learning process. While working on projects, students (and teachers) develop their problem solving, communication, collaboration, and planning skills. Henderson led discussion of ways to develop and implement other PBL opportunities into high school courses. P^3 teachers, who had started to or were already
implementing PBL in their classrooms, commented about how PBL helps reveal student talents.

6. **Seeking external funding to support implementation of project explorations**
Mary Cavanagh and Carole Greenes, Project Director and PI respectively, led discussion about types of funding opportunities available for individual teachers and for schools. Attention was given to the steps entailed in preparing proposals for funding. The group brainstormed ideas for projects, where to apply, and opportunities for collaboration.

7. **Using documentary filmmaking to enhance student learning**
Chris LaMont, Filmmaker, described ways that student-made and teacher-made films can be used to reinforce and enhance learning. He also showed some videos that were developed by Pipeline Villagers. He pointed out the value of humor and the performing arts (music, drama, and dance) to heighten the interest of viewers. Several teachers showed videos they made in LaMont’s Villages, one to teach a specific concept and another to demonstrate chemistry lab safety.

8. **Productive classroom discussions**
Colleen Megowan-Romanowicz, Co-PI and Science Educator Researcher, shared effective methods for fostering thoughtful, reflective discussions. This included participants simulating the use of white boards in small groups, and then sharing with the whole group.

**2010 Connections Course Topics:**

The Connections Course for Summer 2010 responded to teacher requests for more time to brainstorm and plan together.

1. **Assessing student thinking**
Carole Greenes, PI, introduced and simulated one-on-one student interviews. Most teachers were not familiar with clinical/flexible interviews and indicated their need to better understand students’ thinking and depths of understanding, and how that information could be used to inform their instruction.

2. & 3. **Seeking external funding**
Teachers who succeeded in winning funding in the previous year shared their grant proposal preparation experiences. Mary Cavanagh and Carole Greenes worked with small groups or individual teachers to identify funding opportunities and to outline proposals for materials/resources to use to implement PBL in their classrooms or schools. Teachers wrote proposals, made copies for all of the teachers, and discussed their work.

4. **Assessment of science integrating mathematics**
Eugene Judson, Assistant Professor of Science Education, Arizona State University, developed an instrument to assess the degree of integration of mathematics and science in teacher-led classes. Class lessons are videotaped and analyzed. Since Judson was in the process of establishing the validity of the instruments, teachers heard, first hand, about the steps involved when conducting action research in education.

5. **Classroom discourse and interactive learning environments**
Colleen Megowan-Romanowicz, Co-PI, Science Educator Researcher, addressed classroom discourse that is central to the modeling instruction approach in science education. She also led teachers’ explorations of the Situated Multimedia Arts Learning Laboratory (Interactive Learning Environment).
6. Preparing students for success in STEM

STEM career opportunities and college training for STEM careers were addressed by a panel of professors including Jim Anderson, Aviation; Mark Henderson, Engineering; and Tim Lindquist, Computer Science. They offered teachers advice on ways to better prepare students for STEM programs in college. They also provided hard copies of information about, and url addresses for valuable websites.

7. Integrating labs with classwork

Pushpa Ramakrishna, Professor of Biology at Chandler-Gilbert Community College, described her techniques for integrating science labs with regular class lessons in a community college program. The teachers engaged in discussion with Ramakrishna about approaches they might use to modify their high school schedules to accomplish a similar program.

8. Counseling/Advising high school seniors for success in STEM

Arizona State University counselors and admissions staff provided information about ways teachers could help their seniors gain admission to post-secondary STEM programs, the courses they need, and strategies for avoiding potential obstacles.

The P³ Website

The P³ website served as a communication portal for project activities, and provided valuable information for all those involved in the project as well as for others eager to learn about the program.

As a benefit of enrollment, all villagers had access to the Arizona State University computer network and university computing resources.

Through the site, P³ villagers could:

- Obtain project information and applications.
- Access technology support.
- Locate calendars of P³ village meetings, Connections Courses, and local STEM events.
- Link to other STEM programs in the state.
- Obtain contact information for project staff, leaders, and mentors.

Facilitation of communication among villagers and leaders was further accomplished by a Blackboard site for each village. While some villages used Blackboard to a greater extent than others, assignments, discussions, and critical information were posted on each village’s site.

The family and community pages contained links to 1) village projects to show parents what their children were exploring; 2) information about STEM careers, career counseling, and student scholarship opportunities; 3) public STEM-related events; 4) directions to the campus; and 5) copies of the MATHgazine.
Facebook Page
As a new outreach component, P³ added a Facebook page during its third year. The purpose was to enhance communication with participants and serve as a marketing tool for the project. The P³ Facebook page included photos of village explorations, project announcements, information about upcoming events, and links to project resources.

The MATHgazine
In order to further develop villagers’ mathematical reasoning powers, P³ staff produced the PRIME MATHgazine, a monthly 4-pager of challenging problems that require application of concepts of algebra, geometry, measurement, probability and statistics for their solutions. Villagers were invited to send solutions to the editor. Scores were tabulated for the respondents, and a STEMatician Award was given to the solver with the highest score at the end of the publication season. The MATHgazine began in January 2010. The staff then sent the MATHgazine out to secondary schools in Arizona. The PRIME Center is continuing publication of this on-line mathematics newspaper. To access the MATHgazine, see the Appendix or visit prime.asu.edu/MATHgazine.
Part Three: Reflections

Reflections from Students

Student Quotes

Students in the Prime the Pipeline Project ($P^3$) were accepted on a first-apply, first-accepted basis. All had to be members of the graduating class of 2011 and had completed and passed Algebra I. Thus, at the start of $P^3$, students were all high school sophomores. In year 2 of $P^3$ all students were juniors and in year 3, all students were seniors. Once enrolled in $P^3$, students had first choice of villages in subsequent sessions. Empty spaces were filled by students on the waiting list. Approximately 155 students participated in $P^3$ throughout the life of the project.

The following are student comments about $P^3$ from surveys and interviews conducted.

Question 1: What did you like most about participating in Prime the Pipeline?

“I enjoyed working with professionals who explained how the concepts of the projects were related to our everyday life.”

“Being able to work with people my age and accomplish things that adults do.”

“Hands-on projects that were not computer related.”

“I met a lot of new people and friends. It was great to get to know other people. Also, the amount of information we covered was amazing. The teacher I had was brilliant and he taught me a lot of new information. One last thing I absolutely loved was the public speaking during debriefing and Showcases. Some people are deathly afraid of it, but I loved it.”

“It was a great experience working with the other students and with the faculty at Arizona State University.”

“The thing I enjoyed the most about this program was the knowledge I accumulated through each project and the friends I made from other schools.”

“It provided a different atmosphere with more hands-on and student-led projects. I liked the experience gained and the staff involved.”

“I loved how in the Film Village we had such a hands-on experience. I could go out and tell people I edited this movie not just that I was in a group that did it. I feel like this experience has made me more of a confident person in knowing that I am able to do things like that.”

“I most enjoyed the experience of being at a college and working with college professors.”
Question 2: Has $P^3$ helped you to better understand mathematics and science concepts? If so, how?

“By being involved in $P^3$, I learned that much of programming and animation is significantly based on mathematics that has to do with the coordinate plane.”

“I see how experimental processes work and how teamwork is important in science.”

“I would say it helped me immensely with technology concepts, which, as you probably know, is the T in S.T.E.M.”

“Yes, they have helped me understand how much mathematics it takes to do things.”

“Yes, $P^3$ has most definitely helped me in my understanding. I have learned from the professors and experts how to create a process and follow it to make learning more organized and simple.”

“Yes, it linked mathematics and science to more applicable areas of life, such as programming and the way technology works. $P^3$ taught how the science actually worked, and in an interesting way.”

Question 3: Where are you now? If you are in college, what is your major? (Data were collected through email and phone conversations from 38 students.)

- Ten students are at Arizona State University with majors in embedded systems engineering, mechanical engineering, chemical engineering, computer science, biological sciences, health/life sciences, criminology and criminal justice, business management, nutrition, and film studies.
- Five students are at Arizona State University’s Barrett Honors College with majors in biological sciences, biochemistry (pre-med), computer information systems, business communication, and psychology.
- One student is at Bard College majoring in political studies and international relations.
- One student is at Boston College and has not yet selected a major.
- Two students are at Brigham Young University in the Honors College with majors in science/mathematics and neuroscience, respectively.
- Two students are at Central Arizona College and have not yet selected majors.
- One student is at Chandler-Gilbert Community College and interested in majoring in either graphic design, biomedical engineering, or ultrasound technology.
- Two students are at Grand Canyon University with majors in nursing and music, respectively.
- One student is at Hanze Hoge School in Groningen, Netherlands, majoring in law.
- One student is at Hawaii Pacific University majoring in marine biology.
- One student joined the Marines.
- Three students are at Mesa Community College completing their pre-requisites before transferring to a four-year university. One plans to major in geology and the other two are undecided.
- One student is at Northern Arizona University majoring in electronic media and film.
- One student is at Stanford University majoring in pre-med and plans to become an anesthesiologist.
The Pipeline Story

One student is at Scottsdale Community College majoring in audio production technologies, and music theory and composition.

Three students are at the University of Arizona with majors in plant sciences, biochemistry, and mathematics, respectively.

One student is at the University of California - Berkeley majoring in electrical engineering and computer science.

One student is at the University of Pittsburgh majoring in biomedical engineering.

Student Interviews

Phone interviews were conducted with several P³ students after they entered post-secondary education programs. Some of those interviews are reproduced here.

Darleen Alvarez

High School Attended: Hamilton High School in Chandler, Arizona
College Attending: Chandler-Gilbert Community College
College Major/Minor: Graphic Design/Biomedical Engineer/ Ultrasound Technician

Villages Participated In:
Web Weaver Village (Spring 2011)

How did the P³ Project help with college? The P³ Project was an intriguing experience. Not only did I learn a lot more than I had learned in my graphic design class at Hamilton High School, but I could also better understand Java Script and After Effects in much more detail. Attending the Scientific Village while I was still in high school pushed me away from my comfort zone. Now with peers of different ages, attending a community college was not as intense as it was during my first couple days in the P³ program. I enjoyed P³ and would recommend this to anyone who is considering any majors/minors in the media industry.

Were you fearful of professors, attending college, or presenting to an audience before the project? If yes, did that fear abate after participation? Heading off to my first village at the university was a bit overwhelming because on my first day going to the campus, I happened to have taken the wrong bus, heading in the opposite direction, and in the end, I arrived at campus in a taxi. I arrived late. But once in the village classroom and hearing the introduction to the Web Weaver Village, I eased up a bit. The professor was enthusiastic and took her time introducing the material. She was patient and followed along with the needs of the villagers, helping here and there. My fears of college decreased and my motivation to attend college increased through the P³ Project experience.

Did you meet other students, teachers or professors who have helped you in any way? Through the P³ Project I got to meet many new students and work with the professor in creating my very own web design.

Are you glad you participated? My participation in the program increased my knowledge of web design.
Taylor Kay Hamilton

High School Attended: Campo Verde High School in Gilbert, Arizona and Primavera Online High School
College Attending: Scottsdale Community College
College Major/Minor: Audio Production Technologies and Music Theory and Composition

Villages Participated In:
Music Technology: Bach to Rock (Spring 2011). I only heard about the program in its last semester. I wish I had heard of it sooner and had been able to participate in more villages.

Favorite Village:
My default favorite would be music because that is the only one I participated in.

How did the P³ Project help with college life? I feel like P³ helped a lot in realizing what I want to do with my life. It really helped me ascertain the fact that I want to be a part of the music industry.

Were you fearful of professors, attending college, or presenting to an audience before the project? If yes, did that fear abate after participation? I was a bit afraid of college before the program and now I'm not at all. I am very excited about college. I feel like the professor I had and the student mentor were both very nice and I really enjoyed talking to them both about college and music. I think they were helpful.

Are you glad you participated? I am very glad I participated. Again, I wish I would have known about it from the beginning so I could have participated in all 3 years.

Patrick Hong

High School Attended: Chandler High School in Chandler, Arizona
College Attending: University of California - Berkeley
College Major/Minor: Electrical Engineering and Computer Science

Villages Participated In:
Scratch, C, and iPods (Summer 2010), Technology Remix: Village People Music Lab (Fall 2010), Web Weaver (Spring 2011)

Favorite Village:
Scratch Programming was my favorite. I personally have a passion for programming, software, and video game development. The Scratch Village allowed me to explore these passions in a way I’d never done before, which of course made for a good adventure.

How did the P³ Project help with college? P³ definitely 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 into 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. (Actually, the code itself is probably the least of my worries right now).

**Were you fearful of professors, attending college, or presenting to an audience before the project?** If yes, **did that fear abate after participation?** Not really. I can say that the project definitely solidified my confidence in being able to talk with my elders and superiors while still being myself.

**Did you meet other students, teachers or professors who have helped you in any way?** Every interaction I had with others in the project helped me become more comfortable in “professional” social interactions.

**Are you glad you participated?** Most definitely.

**Is there anything else you can share?** For me, P³ wasn’t about bolstering my college application; it was a place where I could pursue my passions in a fun and engaging learning environment. I’m sure many others felt the same way.

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Alexander J. Iadicicco

**High School Attended:** Williams Field High School in Higley, Arizona  
**College Attending:** Arizona State University  
**College Major/Minor:** Computer Science

**Villages Participated In:**  
Cleanroom Science and Model Development: Clean Your Room (Spring 2009), Visual Programming and Gaming with Scratch (Summer 2009), Documentary Film Design and Post-Production (Fall 2009), See C: Advanced Computer Programming (Spring 2010), Aviation: Flight Training (Summer 2010), Technology Remix: Village People Music Lab (Fall 2010), Photography: Creativity + Technology (Spring 2011)

**Favorite Village:**  
Aviation: Flight Training was my favorite Scientific Village because flying is a hobby of mine.

**How did the P³ Project help with college?** I got a jump-start on what it is like to be in college. It helped me in real life by giving me some experience with a college environment before I actually entered college. It also provided me with an experience to describe on college applications.

**Were you fearful of professors, attending college, or presenting to an audience before the project?** If yes, **did that fear abate after participation?** I was not really fearful, no, but being able to speak at presentations really helped with my fear of public speaking.

**Are you glad you participated?** Definitely!
Daniel Christian Jones

**High School Attended:** Red Mountain High School in Mesa, Arizona
**College Attending:** Mesa Community College
**College Major/Minor:** Geology

**Villages Participated In:**
- Wind Energy: Harness the Wind (Summer 2009), Documentary Film Design and Post-Production (Fall 2009), Aviation: Flight Training (Spring 2010), Biotechnology: Forensics and DNA Fingerprinting (Summer 2010), Technology Remix: Village People Music Lab (Fall 2010), and Web Weaver (Spring 2011)

**Favorite Village:**
I liked all villages because, as a whole, they would describe my interests in life. I liked learning about energy, and we were able to build a wind anemometer tower. The Documentary Village helped me learn about the importance of lighting, and I was able to use my video editing skills. I really enjoyed learning about planes and flight, especially getting to fly in the expensive simulator. This was probably my favorite village. Not only did the villages help me find out what I did like, but they also helped me find out what I didn't like as much. The Music Village was a blast. We had the chance to create our own songs using software I had never used before, and I even brought in a theremin, a strange musical instrument that we learned about in the Music Village. And last but not least, Web Weaver. My dad is a programmer, so this was a great village to help me understand more of what my dad does in his job. I also learned about Photoshop, and even learned to write lines of code to create my website.

**How did the P³ Project help with college?** Overall, I'm glad I was able to take each village, and it has definitely helped shape me into who I am today. I know it is hard to believe, but before P³, 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.

**Did you meet other students, teachers or professors who have helped you in any way?** During my time at P³ I have met and had the privilege to work with a ton of awesome students and teachers, many of whom I am now friends with on Facebook. I don't have time to name all of them, but I don't think I would have had as great of an experience without them all. Carole was a lot of fun to work with, and I really miss her. I am so, so, so glad I was involved, and I wish I could keep doing it throughout college. My goal is to become a Petroleum Engineer, which would fall under one of the many interesting careers in the STEM fields.
Bryce Munter

High School Attended: Hamilton High School in Chandler, Arizona
College Attending: Barrett Honors College at Arizona State University
College Major/Minor: Business Management/Biomedical Chemistry

Villages Participated In:
Biotechnology: The Case of the Mystery Genes (Fall 2010)

Favorite Village:
I loved Biotech because it was a way to enhance my scientific skills, and I loved using tools and machines that I normally wouldn’t be able to use in high school.

How did the P³ Project help with college? I came back as a mentor in a different STEM program, and I even used the project that my group worked on (tracking a certain allele to see if it traveled down ethnic lines) as my science fair project. 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.

Were you fearful of professors, attending college, or presenting to an audience before the project? If yes, did that fear abate afterwards? I have always been very good at public speaking if I have a speech set up, but I was terrified of speaking about my actual project to professors or scientists because it was improvisation. I just had to know everything about my topic, and I was terrified that I would mess up. I didn’t have the opportunity to actually discuss my findings with professors, but I definitely feel like I would have been confident in this situation because I knew so much about the topic and so much about what I learned that there was no way I would lose my words.

Did you meet other students, teachers or professors who have helped you in any way? My high school Human Biology teacher was in my biotech village, and I grew closer with her over the course of the year. The teachers in my small group helped with the project tremendously, but I haven’t kept in touch as much. Dr. Greenes also wrote me a fantastic letter of recommendation, and I know that I will always have her as a mentor and teacher if I ever call on her.

Are you glad you participated? ABSOLUTELY!

Anything else you can share? You get out of it what you put into it, but it was definitely worth the work for me; time flew by and I really enjoyed myself the entire time. Our project didn’t work, but it doesn’t matter!
Dixit Patel

**High School Attended:** Mountain View High School in Mesa, Arizona  
**College Attending:** Arizona State University – Barrett, the Honors College  
**College Major/Minor:** Biochemistry with an emphasis in Medicinal Chemistry; Mathematics

**Villages Participated In:**  
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009), 3D Virtual Modeling for Emergency Services (Summer 2009), Exploration of Scientific Puzzlers and What We Can Learn From Them: Optical Illusions, the Properties of Light, and Human Vision (Fall 2009), Aviation: Flight Training (Spring 2010), Biotechnology: Forensics and DNA Fingerprinting (Summer 2010), Photography: Creativity + Technology (Fall 2010), Off Balance: Water, Plants, and You (Spring 2011)

**Favorite Village:**  
Biotechnology: Forensics and DNA Fingerprinting

**How did the P³ Project help with college?** It introduced me to many advanced concepts used in college as well as techniques in a lab, critical thinking and analysis, and technology.

**Were you fearful of professors, attending college, or presenting to an audience before the project? If yes, did that fear abate after participation?** I was never really fearful, but participating in P³ definitely helped ease any nervousness.

**Did you meet other students, teachers or professors who have helped you in any way?** Yes. I met Kevin in P³ and he was a familiar face at Barrett. It gave me someone early on to be friends with. John Black taught me to always learn even when I think I know everything already. Nearly everyone I met in P³ helped me or inspired me but the two above are the most memorable.

**Are you glad you participated?** I am extremely happy to have participated and cherish the friends, connections, and experience I had while in P³.

Henriette Pedersen

**High School Attended:** Highland High School in Gilbert, Arizona  
**College Attending:** Arizona State University  
**College Major/Minor:** Nutrition (dietetics), but switching to Film and Media Production with a minor in Food and Nutrition Management

**Villages Participated In:**  
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009), Film and Media Post-Production: Video Editing (Summer 2009), Documentary Film Design and Post-Production (Fall 2009), Trauma Simulation: A Virtual Journey through the Human Body (Spring 2010), You Shoot YouTube (Fall 2010)
Favorite Village:
My favorite village was Documentary Film Design and Post-Production because it inspired my current passion for editing film. Chris LaMont was fantastic.

How did the P³ Project help with college life? It 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.

Were you fearful of professors, attending college, or presenting to an audience before the project? I was a little nervous to see how the professors were going to be. However, I had Chris LaMont most of the time and he was absolutely awesome. If yes, did that fear abate afterwards? Very much so!

Did you meet other students, teachers or professors who have helped you in any way? I did meet a fellow named Seth who went to my school and he ended up becoming a very good friend of mine and he stuck with me even after the program.

Are you glad you participated? Yes.

Anything else you can share? It's a program that is so amazing you have to experience it to know how it is.

Reflections from Teachers

All P³ teachers held state certification to teach middle or high school STEM subjects in Arizona, and were interested in updating their knowledge of concepts and skills in their own and related fields, in learning instructional strategies that promote student interest in and success with STEM concepts and skills, and in understanding methods for counseling students into college programs leading to STEM careers. Teachers worked side-by-side with students as co-learners in the Scientific Villages. In total, 143 teachers participated in P³, many of whom participated in multiple sessions or completed the entire program. Teachers received stipends of $500 each semester and $1000 in the summer.

In surveys, interviews and stories, teachers described changes in their attitudes and expectations for student engagement and performance. Several teachers were observed in their classrooms. Results of these are included in the evaluation section.

Teacher Survey Responses

Changing teacher attitudes and student expectations:
Almost 30% of participating teachers noted that they were changing or already had changed their expectations about what their students could accomplish. P³ students’ comfort levels with technology provided new insights into areas teachers had not explored. In most instances, teachers addressed issues of raising expectations, adding rigor to their instruction, and respecting what students can achieve.

“I now look for more ways for students to display their creativity in problem solving.”
Increased awareness of what interests and motivates students:
P³ teachers (28%) noted that they had an increased awareness of what is motivating and interesting to students. They also indicated an increased value of the importance of holding students’ attention so that more in-depth learning can occur.

“I was inspired to provide only a few specifications for a project and allow students to explore and develop projects along their interests.”

“P³ has encouraged me to be more of a facilitator to my students by helping them answer their own questions.”

“I have tried to develop lessons/projects that show my students the relevance of mathematics in the real world.”

Improved teacher confidence:
The P³ Project provided strong foundational information so that teachers gained confidence with presenting core content. One teacher noted that P³ helped “to add fun facts and real world applications to the subject I teach.” Several teachers stated that with the knowledge gained, they could go deeper into content and skill sets, moving away from procedures and toward conceptual development.

“P³ has allowed me to be more creative and to try new things.”

“I now have a base of information that I didn't have before. I feel like I can talk about cell phones or aviation and use it as examples to illustrate a point.”

Teacher Interview Comments

Question 1: What did you like most about participating in P³?

“I teach Computers and Multi-Media, and film the morning announcements at my junior high school. This program was a perfect way to be placed in the situation I put my students in every day. I learned many things I took back and taught them the very next day!”

“The thing I liked most is learning about technology and what goes on behind the scenes. Also, I found the relationships that developed with other teachers and a few students to be very rewarding.”

“I liked working with the students in a non-instructing role. I could talk to them on a common level about the material we were learning and they were able to view me from a less authoritative role. I also enjoyed working with teachers and professors that I would normally not work with in the course of my career. I really liked getting to know some of the engineering professors that I now feel comfortable referring students to in the future. Overall, I would say that the connection with people has been the best part.”

“I most benefited from the interaction with other teachers about how to implement STEM projects into the curriculum.”
Question 2: What have you taken from the Villages to implement in your classroom?

“The exact things I was learning in the Film Village I took back and taught my students. I am planning to do the same thing with the Scratch program! My district will support simple classes in technology such as teaching Word or Excel, but it is not supportive when it comes to innovative technology, like movie making or multi-media. This program has saved my program by teaching me the things I want to teach my students! Thank you!”

“Last spring I filmed my students' presentations and made a video. This year I plan to make a movie with special effects and sound.”

“I had my AP Chemistry students from last year work on the final video project for my village with me. I then edited the video during the summer session and showed it to my new AP Chemistry class the first day of school this year. The students enjoyed seeing the work. I also uploaded the video to YouTube (for the first time) so my former students could see the video they helped put together.”

“From the Cleanroom Village, I have talked with my students about the electronic chips, how they have to stay clean, and about the amount of particles they emit. From the Film Village: everything!”

“We have done the cell tower activity, tearing apart cell phones and created the speakers.”

“I started using Scratch with my Technology classes.”

Question 3: How has your knowledge and understanding of technology increased as a result of your participation?

“I believe my knowledge and understanding of technology has increased directly and indirectly. I was involved in the Documentary Production Village so I learned first-hand video filming, editing, and production techniques. At the Village debriefings I learned indirectly about the game simulations, wind towers, and the cleanroom technologies. All of this I found fascinating! I felt pride in showing off our work at the presentations and Showcase.”

“I used the editing software on a Mac this summer. I do not have access to that program but I have looked into the software we do have and, if time permits this year, would like to play with it. I might repeat the ‘advice video’ for AP Chemistry with this year’s class and make it a reoccurring assignment from year to year.”

“Before P³, I did not know anything about the cleanroom or film production. Through the project, I learned a lot that I can share with students.”

“By exposure to other programs that are FREE that can be used in the classroom.”

“I didn’t know Scratch existed until P³. I was able to work with it and start to build my own games, which is exciting. I was able to learn from the high school students too. They filled in a lot of gaps, which was really fun. They got to be the teachers.”
Teacher Stories

Alicia Abel

Alicia is an ecology and biology teacher at Canyon Valley High School in the Gilbert Unified School District in Gilbert, Arizona. She received her B.S. in Biology and her M.Ed. in Curriculum and Instruction from Arizona State University. Her career included positions as a veterinary technician, zookeeper, and a biological field researcher. These positions offered her insight into the world of science which she loves to share with her students.

P³ Villages Participated In:
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009); Visual Programming and Gaming with Scratch (Summer 2009); Wind Energy: Harness the Wind (Fall 2009); Biotechnology: Forensics and DNA Fingerprinting (Summer 2010); Technology Remix: Village People Music Lab (Fall 2010); and Off Balance: Water, Plants, and You (Spring 2011)

Story: My Reflections

In reflecting upon my time in the P³ program, I remember thinking that the program would teach me mostly about science. What I ultimately gained from the experience, however, was a much greater understanding of the capabilities of our youth.

I began the program in the Cellular Communications Network Design Scientific Village. We were tasked with designing and modeling a system of cell phone towers. At the time, I remember being disappointed that I ended up in that Village. I was a biology teacher, and was doubtful that I would get any information useful to my field. On the contrary, not only did I learn a great deal about the importance of project-based learning and modeling in this Village, but I was also introduced to a large library of online science simulations which I now use in my classroom.

I continued the program with the Visual Programming and Gaming with Scratch Scientific Village. I thought, “Aha! Here is an excuse to play video games all day.” If only I had known earlier in my career how much I would learn about adolescents in this Village! While I struggled to pound out a very simple program to model the process of natural selection, the high school students in my Village were moving at light-speed, creating detailed and masterful games. I was flabbergasted! I was a TEACHER! How was I supposed to teach teenagers when they were clearly so much better than I was at programming and design? This Village is where I truly realized that teaching is not about throwing facts and figures at students. Rather, it is about encouraging students to explore and learn through their own experiences and experimentations.

The Wind Turbine Scientific Village was next. This Village taught me a great deal about the importance of teamwork and problem solving. For example, one of our tasks was to figure out how to raise a tower, similar in design to one that would hold up a wind turbine. We were provided with materials and could request certain tools, but there were no step-by-step directions. We had to plan and work together. At first, there was some trial and error, but we accepted that as part of the problem-solving process. When we succeeded, it was amazing to step back and look at what we had done. A task that I had assumed would take dozens of people and heavy lifting equipment was accomplished with a handful of people and some very basic tools such as ropes and screwdrivers.

I had to miss the next session for personal reasons and thought I would not be able to return. However, I missed the program so much, that I resolved to make it work for the following semester.
When I returned, I was part of the Biotechnology Scientific Village. This was the Village in which I gained a great show-and-tell opportunity for my own students. We did genetic recombination in which we inserted DNA from a jellyfish into bacteria. The result of this was that we made bacteria that glowed bright green under a black light. I took the bacteria to school with me and shared the spectacle with my students. It was a great way to illustrate how all organisms have the same structured DNA. It also got my students discussing other possibilities of biotechnology. We had some great discussions and debates on ethical issues involving biology, as well. Through this Village, I also got great examples of how to engage students in interesting and goal-driven projects. Rather than directing the (high school) students, we (teachers) were working on a team with them. I gained a much greater respect for how students think. Although I had more background knowledge on the subject of genetics, the students typically had a different (and often better) way of tackling the problem.

The Technology Remix: Village People Music Lab Scientific Village gave me an even greater appreciation for the creative capabilities of teenagers. We used various computer programs to either arrange or compose music. As a result of this Village, I try to offer more opportunities for my own students to be creative. I find myself leading my students on many more creative projects. Not only do my students get more involved in the class, but it makes the topics that much more interesting for all of us!

The final Scientific Village I participated in was Off Balance: Water, Plants, and You. In this Village, we had the greatest discussions! I was excited about all of the probing questions that the high school students brought to this village. As teachers, I think we focus so much on content that we sometimes do not think to question where we get our information. This helped me to appreciate how rewarding and important discussions in the classroom are, especially about controversial topics.

In addition to working with the students in the villages, the teachers had Connections Courses during the summers. I found these sessions to be very helpful. For example, one topic I learned about was how easy it is to apply for grants. I have brainstormed several ideas with other teachers, and I plan on making use of this soon, as I have been tasked with creating an anatomy/physiology program for our school and we do not have any lab facilities. Another topic that I distinctly remember involved the importance of modeling. Due to the challenge of not having a lab, I have made extensive use of modeling in the classroom. I believe it is important that students are given opportunities to learn and show what they have learned by using hands-on methods.

In general, the Prime the Pipeline Project helped me to be a better teacher. What I had initially expected to be a sort of “science school” actually taught me much more about students than science. I can honestly say I gained a better understanding of adolescents from the P³ program than I did in my formal education at the university. Furthermore, so much of what I experienced and learned has helped me tremendously in teaching at an alternative school. It is very important that science be a class in which students are challenged, allowed to investigate, encouraged to discuss, expected to work as a team, and taught that their opinions and input are important.
Renee Ashlock

Renee is a middle school science teacher at St. John Vianney Catholic School, in Goodyear, Arizona, part of the Diocese of Phoenix. She teaches 5th grade integrated science, 6th grade Earth Science, 7th Grade Life Science, 8th grade Physical Science, A Forensic Science Elective and a Science in Photography Elective. She received her B.A. in Biology from Rhode Island College and M.A. in Educational Leadership from the University of Connecticut. She obtained her teaching certificate in Arizona while substituting and working as a youth minister. Her career included positions as Student Affairs Administrator, and middle and high school youth minister. In her spare time, she is a professional photographer.

P3 Villages Participated In:
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009); Wind Energy: Harness the Wind (Summer 2009), Exploration of Scientific Puzzlers and What We Can Learn from Them (Fall 2009), Trauma Simulation Village (Spring 2010), Biotechnology: Forensics and DNA Fingerprinting (Summer 2010), and Photography (Spring 2011)

Story: Biotechnology and Photography
Prime the Pipeline, P3 was one of the best teaching experiences of my short science teaching career. I joined Pipeline in its very first semester with the cell phone villages. I was apprehensive as I drove to the first meeting by myself, but what awaited me and the other participants was a chance of a lifetime to work with current scientists and mathematicians who teach and are active in research in their respective fields. We worked on a series of project-based activities over five semesters and two summers. I am one of those people who loves to learn. I thought it would be a way to refresh my science and math knowledge. I became a teacher five years ago after spending several years in University Student Affairs and Catholic Youth Ministry. My science knowledge was rusty, dating back to my bachelor degree in biology in 1989. What I discovered, through Pipeline is that my love for science never left me. I also discovered that the path to rejuvenating and updating that knowledge would be accomplished with the help of teenagers.

I enjoyed all of the villages but had three favorite villages: The forensic science village, the wind village, and the photography village. I took aspects of each of these villages and was able to use them in my classroom. I created two semester-long electives to be taught at St. John Vianney in the Middle School. I am working on a way to have my 6th graders learn about alternative energy along with a school in St. Marc, Haiti.

The village that was most useful to me was the Biotechnology: Forensics and DNA Fingerprinting Village. I participated in this village during one of the summer sessions so it was a two week session. The professor was Pushpa Ramakrishna, Professor at Chandler-Gilbert Community College. She was an incredible teacher. There were 10 students and 10 teachers in that village. The Biotechnology sessions began with an introduction to different techniques for capturing and identifying DNA through a short lecture followed by two days spent solving the case of the missing computers. We analyzed fibers, blood, fingerprints, hair, DNA and a ransom note. After the mystery was solved, we were divided into small groups to use DNA processing techniques. My group was composed of two teachers and two high school students. Each group was assigned a topic to research. My group researched the migration of a particular gene across the globe, and performed various DNA tests. We decided to test to determine if different nationalities had different DNA when taken from their hair follicles. It was great to see the lab from students’ perspectives and to
see how they think. We made a list of the different nationalities that we had available and a list of people we wanted to include in our sample. We tried to get as many different backgrounds as we could, and we tested a mother and son. We donned our blue non-latex gloves and grabbed evidence bags and set out with a camera and some tweezers.

We acted like the mad scientists portrayed in movies and hunted down all of the people on our list; not all were in our village. Sometimes we had to pull more than one hair from a subject. The hair had to have a nub of skin on the bottom in order to obtain a DNA from it. Once we had all of our samples we had to process the DNA using centrifuge machines, pipettes, and gel electrophoresis. All of this technology has come a long way since I graduated from college in 1989. The two students were just as excited as the teachers about using the equipment and seeing the results. I can’t remember all of the details, but we were able to see the importance of DNA evidence and how the pk91 gene is present in some nationalities and not in others. More than remembering details, what I remember was how great it was to collaborate with high school students and to actually help each other discover new techniques and knowledge. We read the lab techniques together, and struggled to make sense of them together.

This village was also important to me because I am using some of what I learned to create a middle school elective at St. John Vianney Catholic School. The class is called Catholic Crime Scene Investigation or CCSI. I begin the class each semester with a modified version of the case of the missing computers. We do not own gel electrophoresis equipment so we use a kit for identifying the blood type for several samples of fake blood and we use different kinds of craft scissors for the box cutters and knives. The students have a great time processing the crime scene and using scientific techniques to solve the crime. I follow it with a series of activities that are related to how forensic scientists process different kinds of evidence. The village ends with a two-week project in which the students process a murder scene in my classroom. I recreate the death of a saint from history. The first year I did this, other teachers played the roles of suspects and the murderer, and provided students with evidence to help solve the case. My teacher colleagues left hair, footprints, fingerprints, and fake blood at the scene. The students used the techniques they had learned to process the crime scene and solve the murder. They tried to figure out the name of the saint and which of the suspects committed the crime. After the first year, students who had taken the class before helped to set up the new murder scene and served as the suspects, witnesses, and murderer for the next class. The whole campus talks about the murder and everyone wants to know who did it in the end and how the kids solved the crime. It creates great excitement for science.

The Photography Class with Penny Dolin was the best village, and it was the last village in which I participated. Each week the village began with a short PowerPoint presentation relating science and technology to the art of photography, history of photography, photographic techniques, and digital photography. This was followed by hands on activities with cameras and lighting equipment. We worked in teams because there were two camera set-ups available. While one group or pair was using the cameras, the others observed or planned what they would do when it was their turn. We used each other as models for different kinds of photographic techniques. Some of these techniques included: painting with light, using strobe lights to produce multiple images on one picture, slow motion photography, portrait photography, using a trigger to release the shutter at the exact moment an object hits the water in a fish tank, and using a ring stand and pipette to photograph drops of water. We also learned how to use editing programs. Penny Dolin did an amazing job at combining photography, technology, and science. My favorite projects were the slow motion photography and painting with light.

I decided to change one of the classes I teach into an elective that combines many of the topics from the village as well as some mathematical concepts, to include: angle of incidence of light, geometric shapes in nature, f-stops, and shutter speed. I knew that I did not have the same
technology available nor did I have access to the computer lab to include the editing and poster-making techniques that we learned. Also, because our electives only meet once a week for 45 minutes, I had to be creative with the projects I put together. I am now offering the course to a group of students in grades 6–8.

Nancy Foote

Nancy is currently a middle school science teacher at San Tan Elementary in the Higley Unified School District in Gilbert, Arizona. A teacher for 23 years, she has taught middle and high school mathematics and science, 5th grade self-contained gifted classes, and has worked as a principal and curriculum specialist. Nancy holds National Board Certification in the area of mathematics and is a recipient of the Presidential Award for Excellence in Mathematics and Science Teaching. She has presented hundreds of workshops for teachers and administrators in the areas of literacy, mathematics, science, and technology integration. With a B.S. in chemistry from Loyola University and M.Ed. in Education from Arizona State University, Nancy is a lifelong learner who continues to take classes on any topic that piques her interest. She also participated in the Zero G Northrop Grumman Weightless Flight of Discovery for teachers. Because of her vast knowledge of the sciences and her excellence in teaching, Nancy was selected to be a scientist for the STEM in the Middle Project, a P³ spinoff.

P³ Villages Participated In:
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009); Documentary Film Design and Post-Production (Fall 2009); Aviation: Flight Training (Spring 2010); Engineering Design: Rockets and Robots (Summer 2010); Photography: Creativity and Technology (Fall 2010); and Web Weaver (Spring 2011)

Story: Prime the Pipeline Impact

I am concerned about childhood obesity. Having been a teacher for 23 years, I have seen a dramatic change in the exercise levels of kids. Running, jumping, and playing ball used to be the norm. Several recesses a day and daily Physical Education (PE) were part of the regular routine. Now we have PE once or twice a week. Running, jumping and ball playing games are now mostly done on a video game machine. When I began the Documentary Film Design and Post-Production Scientific Village, I was not thinking about childhood obesity as much as I was thinking about how intimidating it was to work alongside high school students. I was worried that they would be better at this than I was – and I was a teacher. They, after all, are digital natives and I am the immigrant. We were challenged to write, film and edit a documentary film. Little did I know that the high school students would become my biggest allies and that this Village would provide me with a vehicle to address my concern regarding childhood obesity.

In this Village I learned how to write a script, use ambient or artificial light to light a scene, film angles, and edit. If all I had learned was how to edit a film, that would have been enough, but I learned so much more. When deciding on a topic for my film, I chose “The Five Dollar Solution to Childhood Obesity – a Pedometer.” I decided to empower students in my class to make the film and taught them everything I learned from the lead scientist in P³. My students got to write and record

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the film. They set up the camera angles, held the microphone, and interviewed the students. I edited the film since we learned techniques in the Village too advanced for them to do.

In terms of videography, I found that my students were engaged and energized by this project. They were interested in the geometry of the lighting. They were curious about how a camera could actually record a picture – the science behind the film. They struggled with writing a script for their film but worked together and pushed through. Two years later they still talk about the film and tell me about something they learned in their mathematics class or their science class that they recognize because of this Village.

In terms of health, each of my students was given a pedometer on the first day of school and I challenged them all to walk 10,000 steps a day. We kept close track of the number of steps they took and calculated how far the class, as a whole, travelled. The use of the pedometer made a dramatic change in my students, and the documentary film we made showed others how the use of a pedometer changed the fitness habits of my students and their families.

In the Documentary Village, some of the high school students were unable to record their own video, so they used the raw footage my students shot and edited it in a different way. It was amazing to see what the finished product was and how different it was from what I imagined. Working with high school students and the undergraduate mentors was intimidating at first, but they quickly became my support system and resource guides. It is because I was working with students as learning peers that I first got the idea to bring this into my own classroom. I am not sure if I would have done that had it not been for P³.

After the first P³ session, I was comfortable learning alongside high school students. It became okay to not be the holder of all of the knowledge. I no longer felt vulnerable or embarrassed asking one of them for help. The high school students were patient – often explaining the same thing to me repeatedly. They were friendly and funny, and I think that I spotted a future teacher or two in the mix. The undergraduate mentors showed the same patience as the high school students, but they also showed a deep concern for my comfort and my understanding. I learned a lot about being a teacher by being a student.

I’m afraid to fly. I do it – and I pretend like it doesn’t bother me – but I really don’t enjoy it. When I found out that P³ was offering an Aviation Scientific Village, I knew that I had to stretch myself beyond my comfort level to be a part of it. The science of flight allowed me to understand more fully what was happening before, during, and after a flight. I became curious and wanted to learn more about aviation. I shared my new-found knowledge and curiosity with my students and soon they were doing the research and informal class presentations as their interest piqued as well.

With my fear of flying a little bit under control, I applied for a grant to take a Zero G Northrop Grumman Weightless Flight of Discovery. To my surprise I was accepted and flew on G-Force One (“the Vomit Comet”). Without the Aviation Village in P³, I would not have applied to take that flight. And while I still am not crazy about flying, I’m a lot more comfortable.

My students were intrigued and energized by my Zero G experience. Newton’s Laws of Motion came alive for them. They began to truly understand the laws and apply them to their study of motion. They wanted to take a Zero G flight too, and when I explained that this was reserved for teachers and scientists, several students declared their intent to become scientists.

My professional life is richer and deeper as a result of Prime the Pipeline. My lessons include real world applications and my expectations for my students – and for myself – are higher. My network of professionals who can enhance my lessons has increased exponentially. My students will be the real proof of the success of P³ when they become the scientists, technicians, engineers, and mathematicians of the future.
Reflection on Connections Courses for Teachers:

The Connections Courses were a valuable use of my time. I have a clearer understanding of exactly what the university needs my students to study and at what level of mastery. I met people who are direct contacts for my students as they prepare to become scientists and engineers. Because of my new found knowledge and confidence gained through P³, I have had more than $20,000 in grants successfully funded. During the Connections Course on grant writing, I presented my own grant writing strategies and resources, teaching other teachers how to be more competitive. Many were inspired to write proposals and gain financial resources for their schools.

Richard Franzen

Richard is currently a dual-certified teacher at Mesquite High School in the Gilbert Unified School District in Gilbert, Arizona, where he teaches Advanced Placement Calculus, Pre-Calculus, and Geometry. Richard also teaches College Algebra, Calculus and Linear Algebra at Chandler-Gilbert Community College, and coaches high school baseball and chess. Richard received his B.S. in Mathematics from Purdue University and has a Master’s degree in Education from the University of Phoenix. In addition to teaching, coaching and being a father, Richard is attending Arizona State University as a Biochemistry major with hopes of attending medical or pharmacy school.

P³ Villages Participated In:

Wind Energy: Harness the Wind (Fall 2009); See C: Advanced Computer Programming (Spring 2010); Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010); and Biotechnology: The Case of the Mystery Genes (Fall 2010)

Story: My Transformation

Before I began the P³ project in 2009, I wasn’t quite sure what to expect. Upon entering the project, I was blown away. The project not only revolutionized the way I looked at education, but it has transformed my perspective on science and technology. Ultimately, it has inspired me to pursue continuing education in biochemistry and medicine.

During my first semester in P³, I was assigned to participate in the Wind Energy Scientific Village. I assumed I would be helping out with teacher aide activities and “housekeeping chores” since I was a teacher. To my surprise, I was assigned to learn, collaborate, and engineer a design for a wind turbine along with other teachers and high school students. The village was split up into teams, with each team consisting of roughly an equal number of teachers and students. The teachers and students had various backgrounds, had different areas of expertise, and came from a variety of high schools in the area. Some commuted from as far as an hour away. To my amazement, I discovered that the students and teachers were on a level playing field within each team. The teachers, with their subject expertise, wisdom, and leadership ability were not necessarily the strongest components of a team. Students, with their imagination, motivation, and ability to create without influence were some of the brightest and best leaders of each team. The experience gave me pause, and forced me to reevaluate my assessment of students’ abilities and potential. It was then that I recognized the value of project-based learning and the need for high standards in my classroom. I immediately took this experience back to my classroom and began to transform my lessons from traditional, static lessons to dynamic, application-based lessons.
In a later semester, I was assigned to the Wind Turbines and Wind Tunnels Scientific Village. The project was interesting, relevant, and inspiring. I personally witnessed the transformation of students from observers to learners to designers. The team approach to the project is like nothing I’ve ever experienced, and my greatest epiphany came when I realized how much I have personally learned from the project. The integration of traditional classroom learning with hands on design and development, experimentation, and often times trial and error, all in a team environment, allowed me the realization that this particular mode of learning was by far the most effective. After continuing to implement this style of learning in my classroom, I not only saw immediate improvement in my students’ performance, but I witnessed an increase of interest in the subject matter that I was teaching. The bottom line was that P³ made me a better teacher.

The final semester that I worked in P³, I was assigned to work in the Biotechnology Scientific Village. Knowing next to nothing about Biology, I felt immediately challenged by the subject matter. The village employed actual tools and techniques used for crime scene investigation and DNA analysis. It required a plethora of knowledge and background to understand the concepts behind the techniques. After working in the village for several weeks, I began to recognize the transformation of my group from clueless spectators to competent scientists. It was quite remarkable that such a transformation could occur in such a short amount of time, but it did. Although at the time my heart was with wind energy, I slowly began to understand and appreciate the experience I gained in the Biotechnology Scientific Village. My interest in biotechnology did not end with the conclusion of P³, and in the summer of 2011, I enrolled as a Biochemistry student at Arizona State University. I am currently in my fifth semester in the program, am earning a perfect 4.0 GPA, and will be applying to medical and pharmacy school in fall 2013.

My experience in P³ was invaluable. It transformed me from a good teacher to a great one, and has inspired me to seek a new career path in science and technology. Without the influence of P³, I would not have gained the rich experiences that I have been able to bring back to my classroom and my students, and I would most likely not have been inspired to pursue a career in medicine. I can only imagine how the experiences of P³ have inspired and shaped other students and teachers and have given them the tools to help them pursue their dreams.

Bill Gibson

Bill teaches physical science and chemistry at Cesar Chavez High School in the Phoenix Union High School District in Phoenix, Arizona. He was born and raised in Texas and New Mexico, discovered photography early in life, and worked as a photographer for about 10 years before becoming a teacher. After moving to the Pacific Northwest, he acquired his teaching credentials for high school biology, chemistry, and mathematics. Bill has taught science and mathematics in Washington, California, and Arizona.

P³ Villages Participated In:
Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009); Wind Energy: Harness the Wind (Summer 2009); Exploration of Scientific Puzzlers and What We Can Learn from Them (Fall 2009); Engineering Design: Rockets and Robots (Spring 2010); Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010); and You Shoot YouTube (Fall 2010)
Story: The Wind Turbine Villages

I found the Wind Turbine Scientific Village so productive and interesting that I asked to participate in two sessions. While the topics discussed in each session were related, I collaborated with students in different activities each time, and my role varied depending on the dynamics of each group within the Village.

The students I worked with did not come from my school, so I only saw them face-to-face in connection with the Prime the Pipeline Project. We attempted to work together online using Blackboard software supplied by the University, and Google Groups. We also used Google Earth and professional-level databases to locate potential wind farm sites and to make a rough determination of the feasibility of building a wind farm in that location.

In terms of what I learned, I updated and refined my general knowledge of mathematics and science as related to wind turbines, which have been an interest of mine for decades. But more centrally, I developed a higher opinion of the value of engineering as a context for teaching mathematics and science to a general population. 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. Combine this rich community with a structure that ensures that all members of the group have the opportunity to contribute what they can through working together. Less skilled and experienced members learn, and more skilled and experienced members dig deeper into their expertise to communicate what they know, how they know it, and how and why they do what they do.

My experiences in the Wind Turbine Scientific Villages and other villages in the Prime the Pipeline Project provided me with a model for an authentic and effective approach to education. In my classroom, I design laboratory-based projects that provide the material for group and individual analysis and discussion. I now incorporate more engineering design elements in the activities I plan, and I try to give the minimum amount of direct instruction in procedures that I think the work groups can design and document themselves. Generally, students are able to learn more and to understand and remember what they do in the laboratory when they do it themselves, and in their own way.

Working with High School Students:

Most of the students I worked with in the Prime the Pipeline Project were fluent in academic language, and some were adept at mathematics. I found the attitudes of the students I met in the Project to be active and curious. It was rewarding to experience their responses as well as their concerns.

The University undergraduate student mentors were always able to contribute and help, from setup to cleanup, and provided valuable assistance in the process of working through the problems we encountered along the way.

Reflection on Connections Courses for Teachers:

During the Connections Courses for Teachers, I learned about useful resources such as online grant programs and publications. Most valuable to me was the chance to discuss with the professors how to write a technical engineering report, and the current state and the future potential of wind energy. Learning about their research helped me with my own.

I gave the information about grants for classrooms that I learned of through Prime the Pipeline to my colleagues and collaborated in applying for funds for basic supplies and for art supplies that my school district can no longer afford. I received a scholarship to pursue National Board Certification, which requires up to three years and $6,000 to achieve. Later, I was fortunate to be asked to develop and lead a middle school enrichment program for STEM in the Middle along the lines of the Prime the Pipeline Project. My focus was on "Falling and Flying." I incorporated engineering design in this program for grades 5-8 students.
Amy Gingell

Amy is currently the K-12 Science Coordinator for the Gilbert Public Schools in Gilbert, Arizona. Prior to her appointment as coordinator, Amy was a chemistry teacher for 16 years at Highland High School in Gilbert. Amy graduated from the University of Arizona with a B.S. in Education, majoring in Biology and minoring in Chemistry. She completed her Master’s degree in Educational Leadership at Northern Arizona University. She is a National Board Certified Teacher of Chemistry.

P³ Villages Participated In:
Film and Media Production: Lights, Camera, Action! (Spring 2009); Film and Media Post-Production: Video Editing (Summer 2009); Exploration of Scientific Puzzlers and What We Can Learn from Them (Fall 2009); Engineering Design: Rockets and Robots (Spring 2010); Aviation: Flight Training – The Sequel (Summer 2010); and Biotechnology: The Case of the Mystery Genes (Fall 2010)

Story: My Reflections
I was a participant in the Prime the Pipeline Program for all but one session of the program. I had the opportunity to work with many high school students, teachers and college faculty during my experience and to me that was the one of the best parts of the experience. I work with students and teachers every day while I am teaching, but what I experienced from the P³ projects was how differently P³ teachers and students look at the same problem. It was amazing to see the minds of students operated as we worked through the problems. I also expanded my personal content knowledge in addition to the knowledge I learned about how students learn.

My favorite educational experience from the program was the design of the robots in the engineering design project. I learned that engineering is not only about technology, but how to design a solution to a problem. In building our robots, there was information we had to know and some computer technology we needed, yet it was also about how to solve problems and the process of how to design and redesign. I am currently the K-12 science coordinator for my district, a job I acquired after my time in the P³ project. The experience with design and engineering has been invaluable. I have begun evaluating the K-12 Framework for Science Education and the Next Generation Science Standards which both have a specific emphasis on engineering design. Being in the position of a learner in P³, going through the design process helped me think about what science projects and programs should look like for students in our district. Without the experiences from the perspective of a learner that I received in P³, I would not be as well prepared to implement these new engineering standards.

On a personal note, I have to say that I have been most affected by the two film villages, Film and Media Production and Film and Media Post-Production. I was resistant to these villages at first because I thought they didn’t relate to my teaching life or to the work I would do with students. I did complete a required film project with my AP Chemistry students, and to my surprise, the end product was creative and fun for my students and for me. More importantly, my personal experience with film has changed because of my involvement in these two villages. I now look at films and their creation in a completely different way. I stay for the credits at the movies to see who was involved in putting the film together. I think about lighting and sound and how they can alter my opinion of a film. I consider why a director would make a choice to position the camera in a certain way. If you asked what most surprised me about the P³ program, it would be how much I now enjoy watching a film!
The goals of this program were to increase student learning and to update teacher content knowledge in STEM fields. My experiences, although many did not apply directly to my teaching field, did allow me unique experiences to learn. It is often said we learn by doing and P³ is a wonderful example of this idea. I did things I had never done before, I talked to students in ways I had never done before, and I had experiences I would never have had the chance to have. For example, because of P³, I am now part of a small group of people who can say they safely landed a 747-jet (simulator) on the runway of Sky Harbor. We just don’t talk about the take-off that occurred after that successful landing. I am not returning to college to be a film major or an airline pilot but I was given the valuable opportunity to be a learner again. We should all be so lucky to have these experiences. I think the young people who went through this with me might just be the people who land the real planes at Sky Harbor or direct the next great film that entertains me. For that alone, I believe this was a wonderful program for all involved.

Ramon Gutierrez

Ramon teaches special population students in Santa Cruz Valley Union High School District and Desert Winds High School in the Casa Grande area of Arizona. Services include support in all academic areas with emphasis in STEM and Language Arts classes. Ramon did his undergraduate work in Mathematics and Autism at Central Arizona College, Rio Salado College, and the University of Arizona. He earned an M.A.Ed.in Special Education, Cross-Categorical from the University of Phoenix.

P³ Villages Participated In:
Aviation: Flight Training (Spring 2010); You Shoot YouTube (Summer 2010); Scratch, C and iPod Development (Fall 2010); and Web Weaver (Spring 2011)

Story: Fly High Regardless of Cerebral Palsy

From the first Village in which I participated, I was captured by the concepts of how to stimulate high school students' interest in science, technology, engineering, mathematics, and business, and how to provide tools for teachers so that they can incorporate problem-solving and technology in instructional settings. Through the P³ Project I was able to create a new club in my school and make technology available for my cerebral palsy students.

My P³ adventure began with the Aviation: Flight Training Scientific Village, where Jim Anderson and Al Mittelstaedt, our professional guides and pilots, taught us the general aspects of instrument flying. They demonstrated the basic instruments in an airplane cockpit and allowed us to explore how flight simulators are used to train pilots. One of the highlights was how they combined groups of teachers and students and had them work together as teams. While working together with the high school students, I realized I wanted to do something like this with my own students. I shared my experiences with students in my classroom and asked them to create a project related to aviation. They suggested making paper airplanes and parachutes. With this in mind, I designed lesson plans to focus on the concept of speed using paper airplanes and parachutes made from varying materials and of different sizes. We had a lot of fun the day we went out to test our airplanes and parachutes!

Next, I was able to work with the well-known professor, Tim Lindquist. In his Scratch, C and iPod Scientific Village, he demonstrated easy to develop programs using free software. I chose Scratch, which is a multimedia scripting environment. And, as the programmers said, “Scratch is a
programming language that makes it easy to create your own interactive stories, animations, games, music, and art -- and share your creations on the web.” Scratch gave me the tools to design a game for one of my students with cerebral palsy, orthopedic impairment, speech/language impairment, and severe cognitive disability. He is able to express basic needs when questions are presented in the yes/no format. With the severe spasticity and hyper-tonicity throughout his trunk, limbs and oral-motor area, he has very limited control, but he can reach the computer’s touch screen. Due to the high cost or lack of availability of software programs, free programs like Scratch provide great opportunities for my students to participate in enjoyable activities. When I presented my student with the project I designed for him, he gave me the best present a teacher can receive from his student: a smile.

Continuing with my adventure, my third experience was the You Shoot YouTube Scientific Village. Chris LaMont provided us with hands-on experience by teaching us theory, the practice of good shooting, editing, and then how to upload videos onto the YouTube website. Again, working together with students made the experience more enjoyable. High school students have lots of energy and they are not afraid to innovate. Due to the knowledge I obtained in the villages, I was able to input technical information in a special education project on my school’s website. We needed to provide an example of the special education transition process. As a group, the special education department brainstormed ideas and agreed to make a short film of a student who is planning on being a parachute trainer after his high school graduation. The film was a success at our transition meeting held by the Arizona Department of Education, and administrators in other schools even wanted a copy of the DVD! We saw more opportunities for the special education students to participate in a new project so we formed a club where students can learn, practice, and develop entrepreneurial, administrative, and technology skills. We named it “Transition Club’ and it is now an official club at the Santa Cruz High School.

My last adventure was with Srividya Bansal and her Web Weaver Scientific Village. Professor Bansal led us through the world of interactive website design using Adobe Dreamweaver and Flash software. She helped us step-by-step and as a final project, we designed and published a website. For this project I wanted a website where I could share free websites for students with disabilities with the teachers in my school.

I cannot deny that I was addicted to the Prime the Pipeline projects. I felt lucky to have had the opportunity to participate in this wonderful program. These adventures enlightened me on how I can use science, mathematics, and technology to improve the awareness of our high school students about the STEM fields and how can I improve my teaching with the use of technology.
Karen Jacques

Karen currently teaches life science, economics, and social studies at Chandler Early College, an alternative program of the Chandler Unified School District in Chandler, Arizona. The school is located on the campus of Chandler-Gilbert Community College. Jacques is a graduate of the University of Wisconsin in Madison. She earned a B.A. in Economics and graduate credits in Curriculum and Instruction. She received her Teaching Certificate while interning in Minnesota. She holds an M.A.Ed. in Adult and Continuing Education from the University of Phoenix.

$P^3$ Villages Participated In:
Engineering Design: Rockets and Robots (Spring 2010); Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010); and Biotechnology: The Case of the Mystery Genes (Fall 2010)

Story: Engineering Design: Rockets and Robots

The world of robotics is science fiction, imagination, and fantasy all rolled into one. It is also science, technology, engineering, and mathematics, and that’s what I experienced in the Engineering Design Scientific Village. The culminating event of the village was a robot tournament at the Showcase Open House. We had eight meetings to design, build, and test our robots.

My team consisted of two teachers and three high school students. Our first meeting introduced us to problem solving as engineers. We had to examine a possible engineering problem from the following standpoints: “Do we have all the information? Probably not.”; “Can the problem be solved? Not all problems can be solved.”; “Is there more than one solution? There may be many solutions.” Once these parameters were acknowledged, we went on to hypothesis testing following the steps of the Scientific Method, analytical modeling using engineering analysis, and finally, engineering design. Breaking the project into these components showed me how painstaking a process engineering design is. Our first project was to design and launch an air rocket. The team worked together to design and produce a rocket. We considered weight, materials, diameter, shape, fins, and overall length in our design. Then each team’s rocket was launched and its greatest height measured. We naturally competed to find out which rocket flew the highest. We learned collaborative skills, observation skills, and in my case, brushed up on some long unused mathematics skills.

Next we were introduced to our mini-sumo robot kits. The kits included everything we would need to build our robots from inside out. We had to wire up the circuit board, plug in the components, power up the chip, write and download our own program, and watch the motors respond - or not. Then we had to troubleshoot to figure out why something was not working. The most challenging part for me was writing and downloading the program. I am fairly adept at using the communication power of computers, but writing programs was not anything I had done since the Commodore 64! The students were much better at working with the computer.

Once we had the motor working, we had to come up with a design that could win. The robot mini-sumo contest was simple. We had to build a robot that was no larger than 4 inches by 4 inches and weigh no more than 1.3 pounds. The goal for each robot was to push its opponent out of the Mini-Sumo Ring. This ring was 30 inches in diameter, one inch high, and flat black with a one-and-a-half inch white border. This was an elimination tournament. The winner of each match challenged other winners until only one robot remained. Our robot made it through three rounds before being pushed out of the ring.
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; you have to be able to see how they relate and solve problems. In my own classes, I have chosen lessons and activities that integrate these fields and encourage more hands-on learning. I have also made greater use of virtual learning and experiments. I see the success my students achieve when their learning is made relevant and immediate. One delight in teaching this way is the interest and excitement I see, not only in my students, but also in myself.

Not so long ago, teachers would impart knowledge to students and would rarely learn from their students. In the Engineering Design Village, students and teachers collaborated in problem solving. The instructors assigned problems, discussed possible solutions, and helped us reach successful conclusions. They were always there to answer questions, and nudge us in the right direction, as was the student mentor. Perhaps this kind of collaborative learning took a little longer, but it left us with greater satisfaction in learning. In addition, students, and even teachers, are not usually exposed to what working professionals do once they land that first job. This was an opportunity to experience the actual work of an engineer. Building our mini-sumo robot gave us a chance to try out different types of engineering: electrical, mechanical, computer programming, industrial, and robotic engineering. I probably won’t build another robot, but I can share the thrill of seeing the robot I helped create push another mini-sumo robot out of the ring.

Personally, the Prime the Pipeline Project has expanded my horizons in teaching. I have had the opportunity to work with Chandler-Gilbert Community College to develop an “outdoor classroom” to explore sustainability. January 2012 will see the first permanent building in partnership with SRP. One of the projects will look at delivering water to the desert. My students and I will be volunteering in this project for years to come. Professional educators cannot live and teach in a vacuum. What I learned and what I experienced with the other teachers, students, and instructors in the Prime the Pipeline Project has and will continue to impact my teaching during the rest of my career.

Reflection on Connections Courses for Teachers:

During the Connections Courses, teachers met for an additional two hours each day and delved into some of the topics educational professionals need to think about to become better teachers. One of the topics was Assessing Student Thinking. This discussion gave me concrete techniques to help me make my classes better and more interesting to students. More importantly, it made me realize again my responsibility not only to teach students, but also, to just talk to them. Students want to feel connected to teachers (and they learn better, too). What better way to get them involved than to answer their questions and show them that their thoughts and ideas are important to you. Once you have that connection, they will listen when you tell them what they need to learn to be productive members of our fast-changing society. Through Prime the Pipeline Project, I have learned about jobs that will be available to those educated in STEM disciplines. My job is helping students succeed in the 21st Century.

Other valuable topics included Assessing Science and Mathematics Integration and Modeling. Both of these discussions brought home to me how important a teacher’s ideas, goals, and enthusiasm are for students. If we as teachers do not get excited by what we are teaching and how important it is for the future, why should our students care? To that end, I have added several hands-on labs and projects that stretch students’ learning. They start out reluctantly, but soon the questions start. My school is a non-traditional one that delivers classes via computer and book, paper, and pencil. Adding assignments aimed at developing students’ critical thinking skills in life science, economics, and government is an outgrowth of the Connections Courses.
Ruchi Joshi

Ruchi earned a Master’s Degree in Mathematics. She has taught all levels of mathematics, grades 9-12 at Superior High School in the Superior, Arizona School District #15, for over 12 years.

**P³ Villages Participated In:**
- Cellular Communications Network Design: Can You Hear Me Now? (Spring 2009)
- Film and Media Post-Production: Video Editing (Summer 2009)
- Wind Energy: Harness the Wind (Fall 2009)
- Engineering Design: Rockets and Robots (Spring 2010)
- Biotechnology: Forensics and DNA Fingerprinting (Summer 2010)
- Technology Remix: Village People Music Lab (Fall 2010)

**Reflection on Connections Courses for Teachers:**

The Connections Courses for Teachers made me realize that there are many different ways to approach a problem. I learned from my fellow teachers about how to apply changes to my own teaching. I am still teaching the same mathematics courses as before, but have invented new ideas and techniques using technology resources so that my students get motivated to learn. The cross connections with other curricula makes it interesting for my students. They like it better and I can challenge them. Also, I find my students are very tech savvy; they like projects and assignments they can present through electronic media, so I have broadened my submission criteria. I now give my students assignments where they explore and find answers on their own, and have the freedom to choose how they want to present, with print media or electronically. Lastly, after learning about grant writing, I have received funding totaling $2900.

Hena Mehmetaj

Hena came to the United States in November 1993 from Albania and recalls that in her country, she never had any technology, not even a calculator. Hena is a secondary mathematics teacher in the Roosevelt School District in Phoenix, Arizona where she has been teaching for 8 years. She strives to make math enjoyable for all students. She holds a master’s degree in education.

**P³ Villages Participated In:**
- 3D Virtual Modeling for Emergency Services (Summer 2009)
- Advanced Game Simulation: Visual Programming and Gaming with Scratch II (Fall 2009)
- Aviation: Flight Training (Spring 2010)
- Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010)
- Technology Remix: Village People Music Lab (Fall 2010)

**Story: The Benefits of the Prime the Pipeline Project**

Being part of the Prime the Pipeline Project and participant in five villages has helped me to become a better teacher, adjust my thought processes, and improve my style of teaching. Although I participated in several villages, I will describe the Summer 2010 Wind Turbines and Wind Tunnels Scientific Village where we learned how to use wind to produce energy.
Before I was part of this project, I thought that the teacher was the most important factor in students’ understanding. From being in this project, my thoughts have completely changed. I saw that high school students, with little direction, can do much better working independently. When I asked a student to help me with a computer program, I saw the light in his eyes. Working with teachers allowed students to be free from fear of teachers and for teachers to appreciate the talents of students.

Integrating science, mathematics, technology, and engineering was complicated for me. I love mathematics but I am weak in the area of technology. I became better through working with students whose engagement in this program was 100%. We worked as a group and all members contributed their knowledge to make the wind turbine model work. The students were even more passionate than the teachers.

There were six groups in my Village. Our project was not progressing as quickly as we expected it to. We all were disappointed, but the students were very upset. We, the teachers, told students not to worry and we would try again, and we did. We changed the size and the angle of half of the water bottles that we used to accumulate the wind. We succeeded. The Arizona State University professors were very helpful to everybody and explained many formulas. They described how our state wants to ‘go green.’

Laura Petersen

During P³, Laura was a full-time Mathematics and Psychology teacher at Hamilton High School in the Chandler Unified School District in Chandler, Arizona. Now, she teaches Psychology and Education courses online for Rio Salado College and Ashford University. She has a B.A. in Psychology with a minor in German from UCLA and a Master’s degree in Secondary Education from the University of Phoenix. She is certified to teach secondary mathematics and psychology in both Arizona and California. In her spare time she continues to take courses in all subjects that catch her interest. She recently participated in the Zero G Northrop Grumman Weightless Flights of Discovery for teachers at the recommendation of Nancy Foote, a P³ teacher from Higley Schools, who was the first to fly!

P³ Villages Participated In:
Documentary Film Design and Post-Production (Fall 2009); Aviation: Flight Training (Spring 2010); Scratch, C, and iPods (Summer 2010); Photography: Creativity + Technology (Fall 2010); and Web Weaver (Spring 2011)

Story: What a Great Program!

It would be difficult to choose just one village or one experience that was my favorite in the program. I would have loved to participate in every village, had that been possible. For teachers, specifically, this program offered us a chance to learn more about fascinating topics in a low-pressure environment with a variety of learners.

One of the unique aspects of this project was that it combined high school students and high school teachers as learners working together. When asked, many teachers reported that they were initially hesitant at this prospect. I, however, was excited and wondered why more opportunities like this did not exist. In today’s world, age does not necessarily correlate with knowledge, skill, or
talent. Many of today’s experts in a field are the very young because their passion has led to practice, experience, and growth beyond that of anyone their senior. Perhaps being on the younger side in my profession makes it easier to bridge any gaps, but I can say that working with high school students was one of my favorite aspects of the program. I got to know many students from schools other than my own and saw just how interesting, unique, optimistic, bright, and talented they are. I also got to know some of my own students a bit better by working with them outside of my classroom. Making connections among colleagues, between teacher and student, and between village leaders and participants is one of the most important aspects of this project aside from the important STEM experience we all gained as a result of engagement in the hands-on projects.

During P³, I learned many new things about STEM fields and sought out villages that would allow me to develop my creative side and learn more about the tools available. For example, in Documentary Filmmaking, I learned about lighting, videography, and working with Final Cut Express to edit films. In Scratch Programming, I learned how to use Scratch and the basics of game programming and computing language. To create my team’s sprites (characters) I also developed skills with drawing programs outside of Scratch. In the Photography village, I learned how a camera really works. There is so much more technology behind snapping a photograph than I ever realized. We were able to use special cameras and techniques to do high-speed video and photographs to create video clips and images just like those shown on television. Toward the end of the Village we worked with Adobe CSS programs to create rich, multimedia PDFs. This only whetted my appetite for more. In the Web Weaver Village, I learned about HTML programming, Flash, Dreamweaver, and all the components that go into designing, creating, and hosting a webpage.

Back in my classroom at Hamilton High, I was able to incorporate many new things that I learned in these villages to enrich my instruction and inspire my students. For example, I showed my Photography rich PDF to my students and the classes of some of my colleagues. This excited many students who wanted to see what amazing things can be done and how beautifully they can be presented using software available from Adobe. I then adjusted assigned projects to require more use of technology and project-driven group collaboration. I loved how in the P³ program we were never given a list of facts, definitions, or rules. Instead, we had a large goal to work toward and we learned as we went along. This type of learning was more organic and engaging. I started to model this more in my own classrooms as well.

In conclusion, participating in the Prime the Pipeline Project was enlightening and extremely beneficial. I learned, I was challenged, I made connections, I was inspired, and I grew as a person and teacher. Since this project ended, I have started teaching online at the college level, am helping edit this book, and continue to develop my creative skills by taking classes on Adobe InDesign, Illustrator, Photoshop, and Flash. On top of it all, I am starting a local tutoring company to help students K-12 achieve their academic goals.

Shannon Prince

Shannon received an undergraduate degree from Northern Arizona University in Biology in 2001 with an emphasis in Education. She holds an Arizona secondary teacher certificate in Biology. She received a Master’s degree in Education Curriculum and Development in 2004 from Northern Arizona University and completed her administration certificate in 2009. For the past 10 years, Shannon has been a high school biology teacher at Hamilton High School in the Chandler Unified School District in Chandler, Arizona.
**P³ Villages Participated In:**
Aviation: Flight Training – The Sequel (Summer 2010); and Biotechnology: The Case of the Mystery Genes (Fall 2010)

**Story: Biotechnology: The Case of the Mystery Genes**
The second Scientific Village I participated in was Biotechnology: The Case of the Mystery Genes. I was excited to join this village since biotechnology is one of the fastest growing areas within the field of biological science. I did not have much experience with the equipment needed to explore DNA while I was an undergraduate working towards my biology degree. Forensic science has become a popular theme in American pop culture and many of my students have taken an interest in this field. I felt like I needed to become familiar with the equipment used in the field of biotechnology so that I could better explain this area of science to my students. This Village allowed me to explore the equipment and perform many of the activities that the students at my high school were experiencing in their biotechnology classes.

This Village was designed to introduce STEM topics through forensic science. We first performed microscopy labs where we analyzed different materials that were found at a simulated crime scene and had to deduce the prime suspects. One piece of evidence left at the crime scene was hair. These hair samples led us to learn about the process of DNA fingerprinting. I had previously taught this concept to my biology students, but their practice was only with paper and pencil. I was excited to learn how to use each piece of technology so I could share with my students how this is done in a real laboratory. During the Village we practiced amplifying DNA with a PCR (polymerase chain reaction) machine and then performed DNA gel electrophoresis. Our group had to become familiar with using a micropipette to measure small quantities of liquid and how to stain using buffer solutions. The equipment we were using is expensive so it was important for us to learn proper protocol and safety. Each night I felt challenged by the task given to us by the university scientist. It motivated me to ask questions, practice, and improve my technique. My group consisted of three teachers with different backgrounds and one high school senior. This student was currently in AP Biology at her school and had some previous experience with the labs. She guided the teachers through each step and showed us the technique she learned from her class. This was a cooperative group and we were a learning community where each of us shared our strengths toward a common goal. It never felt like there was a separation between the teachers and the students. We shared those roles while focusing on the problem at hand.

The second half of the Village consisted of applying our knowledge of DNA technology to the solution of a problem. We chose to investigate genetically modified (GMO) foods. I was excited to research this topic since there is a lot of a controversy surrounding GMO food in the American diet. As we conducted our research, we discovered that corn is one of the most prevalent GMO crops in the United States. We then designed an experiment around the testing of GMO corn in different corn cereals. We relied on each other to apply the different DNA technologies we learned from the forensic experiment to our experiment. I looked forward to coming to the Village so I could see the results of our testing that led our group to more questions like, “Does organic food contain GMO’s?” I noticed the mentors and the university scientist (Pushpa Ramakrishna) were also excited for us to share results.

The entire time I was involved with P³ I shared what I was learning with the high school students I taught at Hamilton High. They started asking me questions about the data on Wednesday mornings, knowing I had gone to P³ the day before. They wanted to know the results. I believe it generated a “buzz” among other students who began checking out the class as a possible choice for their upcoming year. The end result for me was that I was able to become more familiar with
different DNA techniques and better understand the process of DNA fingerprinting. I now feel more confident using the equipment at school and guiding students in lessons on this topic.

At the completion of the Biotechnology Scientific Village, the university scientist asked if I would be interested in teaching biology classes at the community college. I am now in my second semester at the community college teaching Biology 100, in addition to my high school responsibilities. I am able to connect curricula from high school to college and see how to better prepare my students to be successful. One area I have concentrated on is transforming lab exercises to have more depth and application to science.

I was attracted to the P³ program because the villages were designed to be different from the traditional classes to which I had been exposed. I enjoyed working in mixed groups (high school students/teachers) in a discovery learning method. I have been able to grow professionally by participating in this program.

**Reflection on Connections Courses for Teachers:**

The most valuable information I learned from the Connections Courses for Teachers was the information on grant writing. I was completely unaware of how many grants are available and how to access them. It was inspiring to hear stories from the other teachers on how they were successful in obtaining a grant and helping their schools and students. Since the Pipeline Project, I have transitioned into teaching a different course at Hamilton High School. I now teach Human Biology and am in the process of developing more laboratory activities for the course. The class requires a large amount of material, which can be costly for my school. I plan to incorporate what I learned in the Connection Course on grant writing and other teacher opportunities to create more in-depth activities for the course and gain support for the materials and other resources I need.

**Kathryn Riley**

Kathryn teaches computer media and technology to middle school students at Akimel A-al Middle School in the Kyrene School District in Phoenix, Arizona. Helping students create videos, web pages, and more using Adobe Flash, Fireworks, and Dreamweaver software, Riley also works with students to produce an all-digital, all-color yearbook and a video-based campus news magazine. She has been teaching since the late ‘70s. Riley is a National Board Certified Teacher for Career and Technical Education/Early Adolescent through Young Adulthood and has been an Adobe Education Leader for seven years.

**P³ Villages Participated In:**

Cleanroom Science and Model Development: Clean Your Room (Spring 2009); Film and Media Post-Production: Video Editing (Summer 2009); Documentary Film Design and Post-Production (Fall 2009)

See C: Advanced Computer Programming (Spring 2010); Biotechnology: Forensics and DNA Fingerprinting (Summer 2010); Photography: Creativity + Technology (Fall 2010); and Web Weaver (Spring 2011)
I was very excited to see that one of the Scientific Village choices was Documentary Film Design and Post-Production. I have been working with video on my own for over 15 years and was looking forward to learning industry standards and proper techniques in this field. The professor for this village was Chris LaMont, an independent filmmaker who won an Emmy for a student production, co-founded the Phoenix Film Festival, and directed the documentary film *14 Days in America*.

The Village participants were high school mathematics and science teachers, high school sophomores, and two middle-school technology teachers, including myself. We began the Village by breaking into groups of four, teachers and students mixed, and being asked to interview and film each other. We were not given any instructions on how to use the video cameras or what type of framing to use. I think this is a good introductory activity that lets the professor know what knowledge, if any, the participants have in terms of shooting video. We shot our interviews and then watched them as a village. In this way we got to know a little bit about each other, and Professor LaMont talked about the proper way to shoot an interview for documentaries.

In the next session, our groups were given camcorders and tripods and we practiced shooting interviews of each other making sure the camera was the correct distance away and practicing where the interviewees’ eyes should look. In another hands-on session, we learned about lighting. I had purchased two expensive light kits within the past 10 years to use with my students but never really knew how to use them until my participation in this Village. In this session each group had a camera, a light kit, and a tripod and we each took turns being interviewed and adjusting for correct lighting.

We continued learning about the different parts of documentary filmmaking and soon we had to decide on a topic to shoot. I coach volleyball and my 8th grade team had won the championship as 7th graders, so I decided to shoot video as our season continued to see whether or not another championship was likely. Using what I had learned in the Village, several of my students and I began filming our volleyball games. We used the lighting and interview techniques I had learned to interview several of the players before and after games during the season. The footage turned out to be very professional and I was pleased with the results.

I had hours of footage and had to create a documentary that was 5 to 6 minutes long. During the last several village sessions, Professor LaMont instructed us in video editing using Final Cut Express. I edited my volleyball documentary and was ready for the showcase only to discover that my video was 20 minutes long. I had to cut 14 minutes. I think the biggest challenge when creating a film is deciding which clips to use and which to cut to keep the within the specified time limit. I learned that it takes about an hour of editing work for every minute of the movie!

While I participated in this Village, I was able to take what I learned and use it with my 8th graders. I created a project where they would shoot a 5 to 6 minute documentary on a subject that dealt with school or middle school students. The project was very successful and the best documentaries my students shot focused on the gum problem in the school. My students interviewed staff as well as other students and shot video of gum stuck in various places around the campus. We ended up showing three of the gum documentaries on our school news show and I received many positive comments about the films from staff members. The student film-makers were thrilled.

When I first applied to be a part of the Prime the Pipeline Project, I did not realize I would be working with high school students. I soon found out that the students in this group, who looked like typical teens, were actually geniuses in disguise. They were amazing. I learned as much working with them as I did from the professors in the villages. The students I worked with were mature, creative, and got the work done. We worked together discussing ideas for our videos and how to shoot the videos. During the editing process, I helped a student working on a dance documentary to...
edit her video. I discovered that she was part of her high school news show and since I run the news show at my middle school, we spent time sharing ideas that we had for our shows.

In each village there was an undergraduate mentor. The mentor in the Documentary Film Village was amazing. It takes a lot of time to set up videos, edit footage, and move digital movie files. This mentor did all of this for us and for our professor. He was so patient and polite and would stay after the village session to help anyone who needed it. He would come early to make sure all the equipment was working and ready for us to use during the village time. I know he spent hours of his own time to move our huge movie files from our computers to different hard drives. This mentor was an integral part of why this village was successful.

My whole experience in the Prime the Pipeline Project was amazing and I use what I learned in the villages to create projects for my sixth, seventh, and eighth grade students in my classes.

Reflection on Connections Courses for Teachers:

During the summer villages, we had a couple of hours each afternoon to collaborate and share with other teachers in the program. The most valuable information presented to us was about grants and funding. I was not aware of the number of opportunities there are for teachers to receive funding for their technology, mathematics, science, and engineering projects. Not only did we learn about the grants, we learned how to apply for the grants and we were even offered assistance by Carole Greenes when we were ready to write a proposal.

I applied for funds from USA Today and Office Depot to have my students participate in a program called Dream Up. I received the grant and my students received the USA Today newspaper each day and workbooks dealing with careers. The point was to help middle school students start thinking about their interests, talents, and career options. The final project of the grant was to have my students write 500 word essays describing their dream jobs. I found out in September 2011 that one of my sixth grade students was one of five winners in the nationwide program. She won for an essay she wrote on wanting to be a chemist. Because she was a winner, USA Today and Office Depot will be making it possible for her to spend a day in her dream job. I received a call from a professor at Arizona State University congratulating me on the win and asking if this student wanted to spend a day at Arizona State University.

David Sprague

David is a retired Electrical Engineer who left Intel Corporation in 2006 after 23 years of service. At Intel, he was a Principal Engineer and held leadership roles in engineering and business. David has a B.S. in Electrical Engineering and a Master’s degree in Secondary Education. Currently, he teaches Engineering at Chandler-Gilbert Community College in Chandler, and Statistics at Highland High School in Gilbert, Arizona. He was sponsor for the 2012 Arizona state champion Highland High School FIRST Robotics FTC Team.

P³ Villages Participated In:
Cleanroom Science and Model Development: Clean Your Room (Spring 2009); 3D Virtual Modeling for Emergency Services (Summer 2009); Advanced Game Simulation: Visual Programming and Gaming with Scratch II (Fall, 2009); Engineering Design: Rockets and Robots
Story: My Personal Reflection

As an engineer and new teacher, I was anxious to bring technical concepts and technology into the classroom. After hearing the initial presentations from Prime the Pipeline leaders, this project seemed like an excellent opportunity to get help finding ways that I could achieve my goal.

The Scratch Programming village showed us a “free to use” object-oriented programming language developed at the Massachusetts Institute of Technology (MIT). This computer language was developed for middle and secondary students as a way to learn how to program computers. Scratch programming became one of the projects for my second year algebra class. Students are exposed to how an x-y coordinate system is used on the computer screen and how logical reasoning is employed in programming a computer. This is a very engaging activity for students.

My next two villages were also very useful to me in my teaching. At my high school, I was assigned to take over the engineering program based on Project Lead the Way curriculum. I taught two engineering classes: 1) Principles of Engineering using many of the same concepts discussed in the Engineering Design Village. 2) In cooperation with Arizona State University’s Polytechnic campus, my high school offered the University’s EGR 101, Introduction to Engineering. Many of the concepts covered in EGR 101 were also those explored in the Engineering Design and Wind Turbine villages. So, my Principles of Engineering students were able to learn about and design compressed air rockets and sumo robots just like first year university engineering students. ASU Polytechnic has been expanding the number of high schools offering ERG 101, so in spring 2011, I organized (with support from ASU faculty) a Sumo Robotics Tournament for all high schools offering the course. The tournament was held at the ASU Polytechnic campus with more than 100 high school engineering students attending.

My other Project Lead the Way engineering class (Introduction to Engineering Design) benefited from the Wind Turbine village in two major ways. First my school district applied for and was awarded a $40,000 education grant from the Arizona Department of Education. The proposal was based on the information gained from the Wind Turbine village and my adaptation of the village for my high school engineering class. The grant funds enabled my school district to purchase a Stratasys uPrint three-dimensional printer, an engineering server, and a functional wind tunnel that was built by ASU Polytechnic mechanical engineering students. So with procurement of the equipment, we were able to implement the adapted Wind Turbine curriculum. The high school engineering students designed and built Autodesk Inventor wind turbine models on their computers. They were able to use these models to build physical parts using the 3D printer. With standard parts and the custom 3D printer parts, students built functional wind turbines. They used their turbines with the wind tunnel to validate performance and improve their designs. The grant and our project were both made possible by the information provided to me in the Wind Turbine Village.

Even my Chandler-Gilbert Community College class has benefited from the information, ideas and techniques I picked up from Prime the Pipeline. This program was very beneficial to me and allowed me to bring technical concepts and technology to my students.
Cheryl Vitale

Cheryl is a 7th grade science teacher at Bogle Junior High School in the Chandler Unified School District in Chandler, Arizona. She taught 8 years in the Gilbert School District before moving to the Chandler schools. Cheryl has a B.A. in Elementary Education, a Master’s degree in Curriculum and Instruction, Teaching and Learning, and is National Board Certified in Early Adolescent Science. She has an endorsement in science and a mathematics specialization.

P³ Villages Participated In
Trauma Simulation: A Virtual Journey through the Human Body (Spring 2010); Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010); Biotechnology: The Case of the Mystery Genes (Fall 2010)

Story: My Personal Reflection

The Prime the Pipeline Project experience has had a major impact on my teaching style and has changed the way that I write and design lessons for my Grade 7 students. I realized while participating in the P³ program that it is so important to educate our students not only about basic science information, but also about how science is related to their lives, future, and careers. The professors with whom I had the pleasure of working with impressed me in the way that they connected their fields of study to the future and to the wonderful careers that lie ahead for our students.

All three of the villages in which I participated had special features that were important to me as an educator. It was a great experience working side by side with high school students and high-quality professors. The camaraderie and team effort was very rewarding. I have to admit that the Engineering Lab was my favorite Village. It was rigorous and motivating as we designed and tested a wind turbine. The engineering professors were a joy to work with! The ASU engineering laboratories were excellent environments for all of us to design and build our turbines. Not only was the “hands on” experience excellent, but the professors also took the time to cover the background behind previous inventions and their successes. I enjoyed learning about this type of energy source and the possibility of using wind turbines in certain geographic locations.

Participation in P³ helped me realize how important it is to teach thematically. Science, Technology, Engineering and Mathematics are a natural combination. Now that the new Common Core State Standards are being implemented, I can see how the methods in this program will fit perfectly. P³ has made such a positive impact on me, my students, and my school, that I am honored to be the chair of a newly formed STEM Committee. I am delighted that the Chandler Unified School District has agreed to allow Bogle Junior High launch a new STEM vision for our campus. We are kicking off our program with a Summer Camp that will include three weeks of fun and exciting STEM activities for incoming seventh grade students. We will be working with the Arizona Science Center on our summer camp program. The program will continue during the next school year as an extracurricular club and the long-term vision is to incorporate STEM into our regular curriculum. Bogle’s principal, Susan Avey, and our STEM committee are writing grants to help support the cost of this program. So far, we have a donation from Orbital Sciences Corporation. We are excited that this local company has decided to join us in our efforts to motivate our students in their studies of science, technology, engineering, and mathematics.
Thank you ASU for inspiring me to take on this STEM challenge at our school. I am so thankful that I was able to participate in the Prime the Pipeline Project and have enjoyed sharing what I learned with my colleagues and students.

**Interviews with Scientific Village Leaders**

**Professor John Black**

**P³ Scientific Village Led:**

Exploration of Scientific Puzzlers and What We Can Learn from Them: Optical Illusions, the Properties of Light and Human Vision (Fall 2009)

1. **How did your Village enhance student and teacher knowledge of STEM concepts?** Sadly, science is often taught as a collection of information, concepts, or knowledge. My purpose in leading this Village was to communicate to the students and teachers that science is a curiosity-driven process that starts with unanswered questions and produces new concepts and knowledge. I wanted them to see scientists, not as just experts who have learned specialized knowledge, but as people whose work is driven by their own curiosity about unanswered questions. During each session I tried to present startling and puzzling phenomena that would provoke questions in their minds - questions that have not yet been adequately answered by scientific research.

2. **How did you feel about working with high school teachers and high school students together as collaborators?** I found that both students and teachers were engaged and challenged by the “scientific puzzlers” that I presented. Because of this, I did not see much difference in the manner in which they participated in the give-and-take discussion during the Village, aside from the fact that the teachers seemed somewhat less inhibited.

3. **Did you alter your teaching methods for this project?** Unlike other classes, my main objective in this program was to provoke curiosity and discussion by presenting a wide variety of interesting and/or puzzling phenomena. Rather than simply explaining the phenomena to the villagers, I challenged them to offer their own explanations. When a villager asked for an explanation, I often offered a hint, and then asked the villagers how that might be relevant. In examples where science has not adequately explained particular phenomena, I simply told the villagers that.

4. **Have you altered your teaching as a result of the project?** I rarely have an opportunity to be this free in choosing the material that is to be presented in class. It did encourage me to take a somewhat freer approach to teaching basic subjects.

5. **Do you have any other observations, comments, or reflections that you would like to add?** This is the first time that I have taught high school students. I was very impressed with their quality, and I was pleasantly surprised at how well they stayed engaged. This was a very enjoyable experience.
6. What STEM projects are you currently working on? I am currently mentoring a team of students who are working on an assistive device called the Note-Taker, which allows secondary and post-secondary students who are legally blind to see presentations at the front of their classrooms, and take handwritten notes as easily, and as fast, as fully-sighted students. This team of students recently won Second Place in the Microsoft World Imagine Cup Competition, which brought together student teams from 67 countries. (I call it an Olympics Competition for nerds.)

Professor Mark Henderson

P3 Scientific Villages Led:
Wind Energy: Harness the Wind (Summer 2009/Fall 2009);
Engineering Design: Rockets and Robots (Spring 2010);
Engineering Design: Wind Turbines and Wind Tunnels (Summer 2010)

1. How did your Villages enhance student and teacher knowledge of STEM concepts? The combination of short talks and long exercises to reinforce the talks helped aural, visual and kinesthetic learners. We used problem-based learning as we do in the standard engineering curriculum. As we continued building projects, the villagers had questions and issues arose that provided a springboard for additional STEM concepts. For example, when we got the vertical axis wind turbines to work, the LEDs that were lit from the power generation pulsed. We took the opportunity to hook up an oscilloscope so the villagers could see sinusoidal waves and traced them back to exactly where on the turbine they originated - the magnets moving over the copper coils and from that we could talk about Faraday's Law.

2. How did you feel about working with high school teachers and high school students together as collaborators? During the first session, we asked the teachers to observe instead of participate. That was a mistake. When the teachers started participating and didn't dominate, instead letting the students figure things out for themselves, things went better. Some teachers really got into it and worked at the same level as the students and took suggestions, and those were the best teams. Some of the other teams struggled.

3. Did you alter your teaching methods for this project? I'm not sure I changed teaching methods since I had never taught wind turbines before, although we did do a project in the Village measuring wind on the Hopi reservation which I was able to use as the context for the project: Design a wind turbine for a village on the reservation. We discussed culture and technology and business aspects, but the core project was to design and test a prototype wind turbine.

Brad Rogers and I team-taught and that was the first time we had taught together. He played the role of scientist discussing wind-related physics principles while I guided villagers to consider customer needs, economics, and land utilization.

4. Have you altered your teaching as a result of the project? I don't think I altered my teaching necessarily, although I alter it nearly every time I teach a class in some way to try out new exercises and projects.
5. Do you have any other observations, comments, or reflections that you would like to add? 

The villagers had to erect a wind assessment tower and use trigonometry and physics to make it straight. They were all very proud of their towers, and being the first exercise in the Village, brought the teams together toward a very simple common goal. I would like to find other, similar projects to promote teamwork before the real project work starts.

6. What STEM projects are you currently working on? We have started a new major, Technological Entrepreneurship and Management, at ASU’s Polytechnic campus, which is STEM-strong. I am teaching product development and the students have to design a new product using the process steps described in the course. The curriculum includes 45 credits of STEM courses, which is a lot. The students have to build a prototype to prove that the product is promising and that it works.

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Professor Timothy Lindquist

P³ Scientific Villages Led:

Visual Programming and Computer Game Design with Scratch (Summer 2009); Advanced Game Simulation: Visual Programming and Gaming with Scratch II (Fall 2009); See C: Advanced Computer Programming (Spring 2010); Scratch, C, and iPods (Summer 2010)

1. How did your Villages enhance student and teacher knowledge of STEM concepts? We had key STEM concepts wired into everything. For example, through manipulation on a plane and dealing with x and y coordinates, we had mathematics and computational (or algorithmic) thinking built into the problem domain of creating online games. Computational thinking can be as simple as giving someone precise directions about how to accomplish a task. This is how we give computers commands to execute. Understanding sequences of steps and how to go about solving those steps is used for mathematical and nonmathematical problems. Villagers were using mathematics without necessarily realizing it as they sought to design and program their computer games.

2. How did you feel about working with high school teachers and high school students together as collaborators? Initially, I did not think it would work at all. I really didn’t. I thought this was going to be impossible to deal with because there will be two sections of the village: students, who will probably have problems picking things up, and teachers, who will probably already have had a lot of the stuff and find it boring. I was totally surprised to find that it worked great. In some capacities, students were mentors for the teachers and in some capacities, the opposite was true. With a variety of backgrounds in computing, sometimes the students would help teachers who did not have much experience. Then in terms of approaching a problem, I found that the teachers had better problem solving skills and were able to mentor students by asking them questions to lead them through a problem solving approach.

One challenge I observed was with attention span. My feeling was that students had shorter attention spans than did the teachers. Students seemed to be done for the day before teachers were. Maybe as you get older you are able to stick on task for a longer period of time.
3. Did you alter your teaching methods for this project? Yes, I did. The feedback was different than it is in most of the courses that I teach for credit. In this program, the feedback I gave was oral and largely informal, which is a radical departure for me. There was no real written feedback and I am not really sure that it was as much of a learning experience without having that written, formal feedback, from a teaching and learning perspective. Many students are motivated by learning, but sometimes students are also motivated by other things like grades or praise and you have to account for that variety in motivations.

4. Have you altered your teaching as a result of the project? I think the project helped me clarify better the notion of “in demand” or project-driven learning. And I do not just mean project-centered, but project-driven. In other words, I assign a project and there are a bunch of concepts involved in solving or completing that project, but I let the project drive when and how those concepts get uncovered. I found myself clarifying in my mind what it really means to be project-driven and I think that has had an effect on my teaching.

5. Do you have any other observations, comments, or reflections that you would like to add? Well, it was a lot more fun than I thought it was going to be! It really was. The interaction I saw was great. I think the best thing that we could do as a university is to have as many faculty as possible involved in these kinds of experiences with high school teachers and high school students. I recently read an article that indicated that the states in our country that are most successful in terms of getting students to graduate from college are those where the interface between each educational level is blurred. The easier the transition, the more successful students are, and in my 25-26 years of experience at Arizona State University I have worked very little with high school students and teachers. It would be great for high school teachers to better understand the material and expectations of the university and be able to help students move through that transition. There is a two-way exchange of information that can be very helpful. The more I know, the better, and vice versa.

Professor Colleen Megowan-Romanowicz

P³ Scientific Village Led:
Cellular Communications Network Design (Spring 2009)

1. How did your Village enhance student and teacher knowledge of STEM concepts? Students and teachers learned about the science and economics concepts that underpin cellular communications network design.

2. How did you feel about working with high school teachers and high school students together as collaborators? This worked well, although the teachers were initially a bit hesitant to engage as equals with the students. By the end of the first Village meeting, teams functioned well with one another and I think both students and teachers had bought into the design. There was general acknowledgement and comfort with students’ greater expertise with certain technology aspects of the project assignments. If anything, the teachers left the hands-on work to the students. I would like to have seen them a little more willing to risk hands-on engagement, but as it was the first Village experience, I understand why they may have been reluctant.
3. **What STEM projects are you currently working on?** I am currently working on two STEM projects. One is an NSF-funded project that has three major elements underway at the moment—a content-intensive sustainability-themed Master of Natural Science (MNS) degree program for Middle School STEM educators, a Middle School STEM College-for-Kids program, and a professional development network for STEM teachers (STEMnet) that meets at Arizona State University. The other STEM project is the Situated Multimedia Arts Learning Laboratory (SMALLab), a digital physical learning environment that is currently installed in five schools and is used to teach a variety of science concepts.

**Professor Robert Pahle**

**P³ Scientific Village Led:**
3D Virtual Modeling for Emergency Services (Summer 2009)

1. **How did your Village enhance student and teacher knowledge of STEM concepts?** The 3D Virtual Modeling Scientific Village introduced students and teachers to a variety of technologies like visualization, databases, programming, and networking. The context for the Village was the support of a variety of emergency responders like fire, police, and facilities management. The focus area was predominantly the Arizona State University Polytechnic campus, but there were also regional components. Groups presented their work at the Showcase.

From a STEM perspective, students and teachers were able to explore a holistic workflow of 3D content creation up to the point of web-based delivery. During the time of the project, the villagers were able to gain hands-on experience with the necessary tools. All tools were freely available online. Therefore, teachers and students could work with the material learned during P³ in their day-to-day environment.

2. **How did you feel about working with high school teachers and high school students together as collaborators?** It was a very good experience working with high school students and teachers. The students were interested and ready to work on the given problem sets. If the students were unable to complete certain tasks, the teachers were very helpful in supporting and guiding them in the right direction. In some situations the teachers were more reluctant than the students to work on certain aspects of the project (for instance, programming). However the students were able to compensate with enthusiasm and trial and error.

3. **Did you alter your teaching methods for this project?** Yes. More basic concepts had to be explained.

4. **Have you altered your teaching as a result of the project?** Yes. I'm using group work in my classes as a default method.

5. **Do you have any other observations, comments, or reflections that you would like to add?** Sometimes the students were easily distracted. This, and the fact that we couldn't log onto our
computers during the first session, led to an overall delay. It seemed as if we wouldn't be able to finish the project in time, so I was really surprised at how efficiently the villagers were able to produce excellent results by the end of the project.

6. What STEM projects are you currently working on?
Currently I'm working on decision environments for complex problem sets. We are building a computer framework called the Complex Systems Framework (CSF). The CSF allows us to take existing simulations, combine them into workflows, and expose inputs and outputs onto easy-to-understand web-based dashboards. Those, in turn, can be used by high-level decision-makers to explore complex scenarios of relevant problems. The goal is to improve the quality of decisions and, therefore, policy and actions related to our daily lives.

Professor Pushpa Ramakrishna

P³ Scientific Villages Led:
Biotechnology: Forensics and DNA Fingerprinting (Summer 2010)
Biotechnology: The Case of the Mystery Genes (Fall 2010)

1. How did your Villages enhance student and teacher knowledge of STEM concepts? One of the goals of the Biotechnology Scientific Village of the P³ summer program was to communicate the excitement from the forefront of research in order to motivate students about biotechnology. Students and teachers learned 1) basic microscopy techniques through a forensic microscopy laboratory and performed DNA fingerprinting to solve crimes; 2) new methodologies of genetic engineering and the state-of-the-art research in this burgeoning new field; and 3) how to analyze genetically modified foods. In addition, they were given opportunities to isolate cheek cells and analyze their cheek cell DNA.

The villagers had an opportunity to conduct independent research projects. They came up with the idea of what to test, the causal question for their independent research. They formulated the hypotheses and designed experiments.

The teachers and students were given the opportunity to think and work like real life scientists. It was exciting for them! The level of research of the high school students was similar to the level of graduate students.

2. How did you feel about working with high school teachers and high school students together as collaborators? I thoroughly enjoyed working with the high school teachers and students. One of the perks of offering the Village was to also work closely with the undergraduate mentors. The students were of a very high caliber and they held their own with the dynamic teachers. I had two teachers and two students in each group and they seemed to work collaboratively on the independent projects.

It was interesting to study the group dynamics of the mixed groups. In one group, a teacher took over the project and led the group. In all other groups, it was the students who took the leadership roles for the projects. They all seemed to work well together. The mentors and I tried to make the Village
as upbeat and interesting as possible, and I think our passion for biotechnology seemed to rub off on the villagers.

3. Did you alter your teaching methods for this project? I did not really alter my teaching method for the village. I use a lot of active learning strategies in my college classes. I have been at the forefront of collaborative learning, service learning, and the use of technology in the classroom. I love to try whatever methodologies enhance student learning. I like to challenge my students with critical thinking questions and endeavor to build a community of learners. I used the same approach in the Pipeline Project.

4. Have you altered your teaching as a result of the project? Not really. Probably working on the Pipeline Project gave me more confidence to try out independent projects with my undergraduate students. I am trying out a dynamic semester-long lab this year (which I describe more in question #6).

5. Do you have any other observations, comments, or reflections that you would like to add? Pipeline was an amazing project where teachers and students work together collaboratively on independent STEM projects. There was both minds-on science and hands-on science going on at the same time! A student got so carried away with her project that she brought every vegetable/fruit from her garden and she was checking to see if they were genetically modified.

6. What STEM projects are you currently working on? As a class project at Chandler-Gilbert Community College, I held a competition for a gene cloning and sequencing module. Undergraduate students brought their favorite plants and isolated DNA. They amplified the DNA by using original and nested PCR methodologies. Based on the results, all students in the class promoted and marketed their plant. Finally, after a class vote, two plants were chosen for cloning and sequencing. If the experiments work, the plans are to publish the results on the NCBI website with students being authors! Isn’t that cool that there is a possibility that our students are going to be authors if all the experiments work! I am committed to good teaching practices. That implies a constant willingness to look for what works and what doesn’t. After all, development of new pedagogies is infectious because it highlights the underlying connections between creation and dissemination of knowledge.
P³ has been a big part of my life for the past few years and I can say that I would not be the same person I am today if not for this project. There is a lot involved in being a mentor in P³, but being the lead mentor was a completely different experience.

I have always enjoyed the dynamics within each village among instructors, mentors, teachers, and students. This really created a unique and exciting place to work. It allowed for some interesting and different ideas to be presented. Seeing the high school students help the teachers was something that does not happen often in regular classrooms, but was common in P³. The high school students were usually the most creative or innovative in the group, but the teachers had the fundamentals that the students sometimes did not have. This balance helped many groups accomplish more than they would have otherwise. Combining this with instructors who worked with them to keep things rolling and answer their questions created a powerful learning environment.

As a mentor, I was able to foster relationships with the high school students and see them grow and change over a number of years. I was able to see many of them not only advance in school and their understanding of concepts, but also see them grow as people. I know a few students who, after they graduated from high school, were employed in STEM-related projects (outgrowths of P³, like STEM in the Middle, under the direction of Dr. Greenes) because of their participation in P³. The students in P³ opened my eyes to what everyone is capable of when they are put in the right environment and when they strive to succeed. The students we had in the project did some of the most inspired work I have ever seen, from an application on the iPhone for food allergies, to short movies, to the design of battle bots.

After a couple of semesters as a mentor in the program, I was promoted to the Lead Mentor position. With more responsibility, I encountered new opportunities to grow as a leader. For example, I developed a training session for the other mentors. During training, I worked with them to ensure that they knew what was expected of them. It gave me an opportunity to help others learn how to mentor students and how to work in an environment with many different groups of people. This training helped the mentors perform better in the villages they assisted. The training I provided not only helped the mentors, but also helped the village participants do better overall. They were not only learning, but having fun as well. Knowing that I was able to impact so many in such a positive way is a very rewarding feeling.

Through this program, I was able to become more involved with the faculty in my department. With that involvement, I was able to get to know a few professors as well as become more comfortable talking to professors and administrators. This has helped me in many ways and will hopefully allow me to help others in the future.
Program Evaluation

The Prime the Pipeline Project (P$^3$): Putting Knowledge to Work Scientific Village Approach was evaluated and shown to be highly effective in: 1) increasing the number of high school students who take more and more advanced courses in STEM fields in high school, and continue on to college and major in those fields, and 2) updating secondary school teachers in their own and sister STEM fields.

Performances in Scientific Villages

Learning by village participants (students and teachers) in our Scientific Villages was evaluated with pre-and post-village assessments. To evaluate, 163 P$^3$ participants served as their own controls on scientist-designed pre- and post-assessments over the life of the project that included 28 villages. Results indicated significant growth in knowledge and skills for the participants (Wilks’ Lambda $= .323$; $F_{(1,138)} = 289.29$; $p < 0.001$) from pre-test ($M_{pre} = 39.32$) to post-test performance ($M_{post} = 72.62$). Increases from pre- to post-test scores ranged from a low of a 25% increase to more than 250% improvement.

Additional assessments captured students’ perceptions of their Scientific Village experiences and the impact of P$^3$ on their STEM coursework and plans for post-secondary education. Participants rated their overall satisfaction with the village experience consistently high using a 5-point Likert scale ($M = 3.86, SD = 0.54$). They also gave high ratings to their village leaders (faculty and mentors) ($M = 4.04, SD = 0.89$) as well as to the project-based learning approaches that were used ($M = 4.18, SD = 0.81$). Participants also rated the village experience as very useful ($M = 4.13, SD = 0.56$). Written comments addressed the practical and creative approaches to teaching STEM concepts, the integration of technology into village activities, the exposure to industry-quality equipment and software, and the short lectures, as being most beneficial. Quantitative findings were in concert with and at higher levels than students’ self-reported interests in STEM careers (58%) and post-secondary college majors in STEM fields (69%) on the Students’ Post-secondary Options survey which they completed at the end of their junior year of high school. Analyses of final transcripts and high school course selection demonstrated that all P$^3$ students remained on track in science and mathematics course completion.

Project Goals and Progress with Achieving the Goals

**Goal 1.** Increase students’ interest in and success with the study of mathematics and science in high school.

**Goal 2.** Integrate workplace technologies, communication, collaboration skills, and critical thinking and risk-taking behaviors in the project-learning environment.

**Goal 3.** Increase student awareness of STEM and business vocations, university preparatory programs and their own talents as related to these fields.

Goals 1, 2 and 3 were addressed through pre-and post-village assessments (described above), and through statistical comparison of the intervention group of 33 P$^3$ students with the matched control students on several dependent measures. Those measures included: 1) overall high school GPA, 2) the number of advanced (e.g., honors, AP, and dual enrollment) courses completed in high
school, 3) the number of STEM courses completed in high school, and 4) GPAs in those STEM courses. These were in addition to surveys and interviews.

Multivariate analysis of variance (MANOVA) was conducted to determine differences between the two groups of students. This was followed by univariate $F$ tests to determine differences between the P$^3$ intervention group and the control group. A one-way MANOVA revealed a significant multivariate main effect for group, (Wilks' Lambda = .816; $F_{(4,65)} = 3.671; p = 0.009$), partial eta$^2$ = .226, with the power to detect the effect being 0.938. Thus the hypothesis that the P$^3$ intervention was effective was strongly confirmed by the univariate results indicating differences between the P$^3$ intervention group and the control group, favoring P$^3$ students.

Results from final transcripts strongly favored P$^3$ students with respect to dependent measures: number of accelerated courses (AP, Honors, Dual Enrollment) taken ($M_i = 5.80, M_c = 2.65; F_{(1,68)} = 9.44; p = 0.003$) and number of STEM or business courses taken ($M_i = 9.74, M_c = 5.03; F_{(1,68)} = 18.17; p < 0.001$). In addition, P$^3$ students were more likely to take courses beyond graduation requirements ($p < 0.04$), including Chemistry (86%), Physics (71%), Pre-Calculus or Calculus (54%), Advanced Biology (54%), Anatomy and Physiology (23%), and Engineering (17%). Noteworthy is that P$^3$ students took more than 75% of these STEM or business courses at the advanced placement or honors level.

In December 2011, at the end of the first semester after high school graduation, there was additional evidence from follow-up interviews that P$^3$ intervention students 1) were more likely to enroll in higher-education settings ($p = 0.019$); 2) were more likely to self-identify as working toward STEM or business majors (95% versus 64% for controls); and 3) had gained more financial support (e.g., scholarships, tuition waivers, stipends) than their matched control counterparts. Specifically, 21 P$^3$ students (75%) received over $430,000 in scholarships and potential aid with four students receiving full 4-year scholarships to attend colleges in STEM or business-related fields.

By June 15, 2012, we had made contact with 28 of our 33 students in the intervention group. Of those, 25 were enrolled in four-year colleges or universities and three were at community colleges. Of the 28 P$^3$ students, 19 entered college with STEM majors and persisted in those majors through their freshmen year. Majors identified were: Biochemistry (Pre-Med), Biological Sciences (2), Biochemistry, Biomedical Engineering, Chemical Engineering, Computer Information Systems, Computer Science, Electronic Media and Film, Geology, Health/Life Sciences, Marine Biology, Mathematics/Spanish, Neuroscience, Nursing, Nutrition, Plant Sciences, Political Studies/International Relations, and Science/Math (double major). Of the four not in STEM majors, one is in political science and three have no declared majors. Of the five that did not enter higher education, two are employed, one is in the Marines, and two did not graduate high school until May 2012. One of the two is now (2013) a Mathematics major at ASU, and the other is in Community College.

Goal 4. Update teachers in content (concepts and skills) in their own and related fields, technology, pedagogy, and STEM and ICT career opportunities.

Goal 4 was addressed through analysis of teacher performance on village assessments that showed major increases in knowledge from pre- to post-test in each village, as described before. Goal 4 also was addressed through the Connections Courses each summer. Mechanisms for collecting data on P$^3$ teacher behaviors that may have been influenced by participation in the Pipeline Project included: 1) pedagogical surveys, 2) one-on-one interviews, 3) participant satisfaction surveys, 4) artifacts from their students (e.g., papers and lab documentation of project work, photos of student projects, lesson plans, and videos), and 5) classroom observations and debriefings after the conclusion of the project in the two years of the no-cost extension. During interviews and
through observations of classroom teaching behaviors, it was evident that teachers involved in P³ were changing their teaching methods.

At the P³ meeting in fall 2011, teachers were asked to reflect on their experiences in the Scientific Villages and the Connections Courses, and the impact of this experience on their teaching. Stories from those who responded are included in this book in the section, Reflections from Teachers.

**P³ is Recognized**

The success of P³ was recognized in October 2010 by the Arizona Center for Afterschool Excellence as an Outstanding Afterschool Program. In May 2011, P³ was one of two ITEST Projects posted on the NSF website as an Exemplary Project for National Lab Day. In spring 2011, *STEM in the Middle (SIM): It Takes a Village* was funded by the Helios Education Foundation. An outgrowth of P³, SIM is a 3-year project designed to engage grades 5-8 students in Club STEM project-driven learning activities, and update grades 5 – 8 mathematics, science and technology teachers through the SIM Teacher Scholars Program. In fall 2012, the PRIME Center at Arizona State University, that directs both the P³ and SIM projects, was once again recognized as having Outstanding Afterschool Programs in Arizona by the Arizona Center for Afterschool Excellence.
The Practice, Research, and Innovation in Mathematics Education (PRIME) Center at Arizona State University received the 2012 Outstanding Afterschool Program Award of Excellence from the Arizona Center for Afterschool Excellence, and a certificate of recognition from Arizona Gov. Jan Brewer. The award and certificate were presented to PRIME Center Staff during the Arizona Statewide Afterschool Conference.

The award was based on the PRIME Center’s two programs: Prime the Pipeline Project (P³), Putting Knowledge to Work for high school students, funded by the National Science Foundation (2008-2013), and STEM (Science, Technology, Engineering and Mathematics) in the Middle’s Club STEM for students in grades 5-8, funded by the Helios Education Foundation (2010-2013).

Both programs offer explorations, designed and led by scientists, to engage youth in the solution of long-term challenging problems that require them to learn and apply key concepts, skills and reasoning methods of science and mathematics, engineering design principles, and workplace technologies.

Among the projects for high school students were wind turbine design, development of computer apps for the iPod and iPad, composition of music using various software, solution of crime scenes using forensic techniques, and flying and landing a plane in a flight simulator.

Among the STEM in the Middle Projects were Sumo robot design and competition, design of computer-based 3-D models of buildings and parks, study of why objects fly, and design and construction of Rube Goldberg contraptions. In both projects, students are introduced to STEM careers. Both programs have components designed to deepen teacher content knowledge in their own and related fields, as well as expand their talents for conducting STEM explorations with students in their classes and designing and offering enrichment programs for students in their schools and districts.

Among the unique features of the Pipeline Project is the “Scientific Village” approach in which high school students and high school teachers worked side-by-side as learners and explorers. Unique in both projects, is the requirement that students confront complex problems, and they are given sufficient time-on-task to discover solutions. In both projects, mentors (ASU STEM undergraduates and high school STEM students) assist the scientist leaders, help the villagers, and for students, serve as role models of successful and enthusiastic learners. Both projects have extensive and intensive research components.

Results of evaluations show that inquiry-based explorations of challenging ideas, where students learn at point of need, are more effective than the lecture-and-then-apply instructional approach for understanding and retention of fundamental concepts, skills and reasoning methods in the content areas.

For more information about the projects, go to: http://prime.asu.edu
Appendix

Project Brochure
The Pipeline Story
Fruit Cocktail

Same type of fruit are the same price. What is the price of each?

- Apple ___________
- Banana ___________
- Orange ___________

Page It

Joe was paid one cent per page to number the pages of a book beginning with page 1.
For his last job, he was paid $9.99.

How many pages are in the book?

Wild Cubes!

1. A large rubber band is given to 1000 congruent small cubes. The large cube is painted blue, but each small cube is not painted. What percent of the small cubes are unpainted?

2. A large cube is painted red and then cut into 1000 small (1 by 1 by 1) cubes.
   - How many of these smaller cubes are painted red on at least one face?
   - How many of these smaller cubes are painted red on at least two faces?

3. A little with edges measuring 1 cm is dipped into red paint. The cube is then put into a bag containing 100 blue cubes not labeled. After shaking the bag, what is the probability that the cube is selected?

   a. The cube is not red.
   b. The cube is red but has its faces painted.

   What is the probability that the cube is red but has at least 25% of its surface painted?

4. What is the volume of the larger cube if it is shown that the number of small cubes in a large cube is shown that the large cube is made up of smaller cubes. How many faces of the large cube were painted?

Wild Cubes Continued

5. A wooden cube is painted red and then, with each edge, divided into congruent cubes. If the small cubes are placed in a bag and one cube is drawn from the bag without looking, what is the probability that it will have at least one red painted face?

6. You have a set of cubes of different lengths. The cubes can be arranged to make a larger cube or to make a rectangle with an equal number of cubes on the top and bottom. What is the least number of cubes you can have?

Use an 8" x 11" piece of paper. Create a net that can be folded to produce a cube. What is the volume of the largest cube you can create?

Remember to make sure that the net is properly folded to form a cube.
The Pipeline Story

You look in the distance and you see these five sports balls. They all look the same size.
1. Which one is closest to you?
2. How did you decide?
The Pipeline Story 101
Video

A short video was produced about the Prime the Pipeline Project (P³). The video may be accessed on the P³ website at primevillages.asu.edu, or by clicking the link below.

Prime the Pipeline (P³): Putting Knowledge to Work Video

Photo Gallery

[Images of various activities at Prime the Pipeline]

Showcase presentation
Teachers collaborate in the Engineering Design Village
Villagers shoot footage for their movies in the Documentary Film Design Village
Villagers in the Scientific Puzzlers Village
Professor Anderson helps a villager land her plane using the flight simulator in the Aviation Village
Villagers test samples in the Biotechnology Village

Villagers tour ASU Polytechnic’s Aviation facilities

Villagers collaborate in the Engineering Design Village with lead scientist and engineer, Mark Henderson.
Villager constructs turbine components in the Wind Energy Village

Tim Gunty, lead mentor, assists a villager in the Photography Village

Leader Chris LaMont and villagers pose with Sparky, ASU’s mascot, in the Film and Media Post-Production Village

Villagers make creative photographs in the Photography Village

Villagers collaborate on their team project in the You Shoot You Tube Village

Villagers work together in the Music Technology Village
References


prime the pipeline project (P³): putting knowledge to work

project overview
Prime the Pipeline Project (P³): Putting Knowledge to Work is designed to increase high school students' interest in studying science, technology, engineering, mathematics and business (STEM-B), while encouraging them to pursue careers in these fields.

High school mathematics and science teachers learn alongside students as they update their knowledge of concepts and skills in STEM-B areas.

Village members work collaboratively on long-term projects that require the practical application of mathematics, science, engineering, and business principles as well as critical thinking skills. They use cutting-edge technology to solve complex problems such as how to create an alternative to high-pollution energy sources.

Villagers present their project work at end-of-term Showcase events. Families and community members are invited to visit displays and learn about projects.

it takes a village
Scientific villages are a key component of Prime the Pipeline. Students and teachers are assigned to learning communities of about 24 participants.

Project villages consist of:
- High school students
- Secondary school teachers in science, engineering, mathematics, technology, and business
- ASU faculty in STEM-B fields
- ASU undergraduate students who serve as mentors
- Scientists from business and industry

project goals
- Increase students' success in mathematics and science
- Develop students' skills in workplace technologies, communication, collaboration, and critical thinking
- Increase students' awareness of STEM and business careers, university programs in these areas, and their talents in these fields
- Update teachers' content knowledge and skills in STEM-B fields, technology, teaching methods, and STEM career opportunities
- Expand parents' knowledge of STEM-B careers, the preparation necessary for these careers, and their children's talents in these areas

village leaders
Project leaders are scientists from business and industry and senior university faculty with years of experience in STEM fields. Students and teachers learn directly from these experts using industry standard software programs and equipment.