SPECIAL FOCUS ON STEM LEARNING

beyond the pipeline

STEM Pathways for Youth Development

by Gabrielle H. Lyon, Jameela Jafri, and Kathleen St. Louis

As framed by national education policy priorities, the dominant metaphor describing participation and achievement in science, technology, engineering, and mathematics (STEM) is a "pipeline." The STEM workforce requires a "pipeline" of future scientists, engineers, and mathematicians. This pipeline begins in childhood and carries students through high school, college, and master's degrees, ending with a doctorate and a career in a STEM discipline. In this metaphor, students have a single path: they must develop an interest in STEM by middle school, choose particular courses in high school, and continue consistently and progressively with STEM study in college in order to end with a degree and career in STEM. The disproportionate exit from participation in STEM by minorities and girls throughout school and college, resulting in their underrepresentation in STEM careers, is referred to as the "leaky pipeline" (Alper, 1993; Blickenstaff, 2005; Jayarante, Thomas, & Trautmann, 2003; Leboy, 2008; Watt, Eccles, & Durik 2006).

In addition to the "pipeline" framed by national policy, a widespread set of American cultural assump-

GABRIELLE H. LYON, Ph.D., is the cofounder and senior explorer of Project Exploration, a nationally recognized nonprofit organization dedicated to changing the face of science by ensuring that students of color and girls have personalized experiences with science and scientists. Lyon has nearly two decades of experience as an education activist, convener, and nonprofit leader. She received her Ph.D. from the University of Illinois at Chicago.

JAMEELA JAFRI, director of Youth-Science Pathways at Project Exploration, aligns curriculum and instruction to Project Exploration's Youth-Science Pathways approach and trains scientists working in Project Exploration programs. She recently returned from Damascus, Syria, where she completed a Fulbright Fellowship examining perceptions of science among underprivileged women. She holds a master's degree in secondary science education from Teachers College, Columbia University.

KATHLEEN ST. LOUIS, Ph.D., is chief program officer and a member of Project Exploration's senior leadership team. She has spent 14 years addressing issues in urban education. Currently, she spearheads Project Exploration's Youth-Science Pathways growth and implementation strategy, partnership development, program design, and evaluation. Kathleen earned her master's degree and Ph.D. in science education from Teachers College, Columbia University.

tions dictates who should "do" STEM. An extensive study undertaken by Public Agenda in Kansas and Missouri found that:

> [P]arents and students are aware of the importance of math, science, and technology for local and national competitiveness, but … they nevertheless do not view them as a vital key to personal opportunity and see no pressing reason to push hard for better results. (Kladec & Friedman, 2007, p. 7)

A growing body of research shows that students who do not find personal meaning or relevance in STEM will not pursue STEM beyond what is required in school (Basu & Barton, 2007; Campbell, Denes, & Morrison, 2000; Costa, 1995; Jeffe, 1995; Lynch, 2000; Lyon, 2010; McClure & Rodriguez, 2007; Zacharia & Barton, 2004).

Engagement, Capacity and Continuity: A Trilogy for Student Success (Jolly, Campbell, & Perlman, 2004) explores why successes in individual programs do not translate into student achievement in STEM at a systemic level:

> Stand-alone efforts that try to improve student academic performance or increase student interest in certain careers will only have limited success. It is the combination of engagement, capacity, and continuity that is essential to real progress. (Jolly et al., 2004, p. 18)

Although the theoretical framework proposed by Jolly and colleagues offers an alternative to the pipeline, the engagement, capacity, and continuity (EEC) trilogy fails to take into account systemic obstacles facing students who have traditionally been overlooked by STEM engagement initiatives. Middle and high school students of color and girls—particularly those from low-income families and schools—are disproportionally excluded or dropped from the STEM pipeline at formative moments in their academic trajectories. Their opportunities to get and stay engaged in science are limited due to structural barriers: registration fees, lack of prerequisite knowledge, competitive application processes, inability to demonstrate pre-existing interest in science, poor literacy skills, lack of transportation, and a dearth of accessible opportunities (Lyon, 2010).

If one of the goals of quality STEM education, particularly in out-of-school time (OST), is to provide greater opportunities for engagement by populations traditionally underrepresented in STEM fields, then the pipeline is a limited—and limiting—framework that undermines young peoples' needs for multiple entry and "re-entry" points and for a continuum of opportunities that support their full social and intellectual development. Issues faced by students from populations historically underrepresented in science need to be addressed through intentional program design strategies matched with systemic policies. The pipeline framework fails to move this agenda forward.

For students traditionally underrepresented in the sciences—students of color, girls, students from low socioeconomic backgrounds and from under-resourced schools, and those who struggle academically—barriers inherent in the pipeline framework preclude not only equitable participation in STEM but also, more importantly, opportunities to see themselves as practicing STEM professionals. Moving beyond the pipeline is not only necessary for program design; it is an imperative for educational equity.

Issues faced by students from populations historically underrepresented in science need to be addressed through intentional program design strategies matched with systemic policies.

Based on lessons learned from more than a decade of OST STEM programming for urban youth, Project Exploration proposes an alternative to the pipeline: Youth-Science Pathways. Youth-Science Pathways enable program providers to move beyond "pipeline" priorities to design for outcomes in which STEM learning experiences support young people's social and emotional development. Changing the metaphor from a pipeline to pathway transforms the purpose of the educational effort: rather than an endeavor in which students' experiences support STEM academic and workforce outcomes, STEM experiences are put to work in the service of youth development.

Project Exploration

Project Exploration is a Chicago-based nonprofit education organization dedicated to making science accessible to students of color and girls through long-term relationships and personalized experiences with science and scientists. Founded in 1999, Project Exploration works to change the face of science. As of 2012, Project Exploration annually served approximately 350 middle and high school students in the Chicago Public School system. By spring 2012, 1,200 students had participated in our programs. These students were primarily African American and Latino; more than 50 percent were girls, and nearly 50 percent were first-generation college-bound students. Most students participated in Project Exploration programs for three to five years.

Project Exploration programs are relationship based; they are designed around specific, intentionally structured relationships among students, staff, and scientists. Staff members serve as youth development specialists and program facilitators. They focus on recruiting students, fostering and supporting long-term relationships with students, and creating effective STEM learning environments. Students are expected to bring their curiosity and experiences to programs and to participate in shaping curriculum based on their interests. Scientists share their work and their curiosity about the world, run meaningful activities related to their professional endeavors, and share personal stories and their experiences with career development as STEM professionals.

Engaging Under-Represented Students in STEM

In 2009, Project Exploration enlisted researchers from the Center for Research, Evaluation, and Assessment (REA) at the Lawrence Hall of Science to undertake a 10-year retrospective study of the effect of Project Exploration programs on alumni's interest and participation in science and on their educational and career aspirations and attainment. Through an online survey and in-depth interviews, researchers identified factors that affected students' decisions to get involved—and stay involved—with science and with Project Exploration (Chi, Snow, Goldstein, Lee, & Chung, 2010).

Project Exploration participants were significantly more likely to graduate high school, go to college, and major in science than their peers. They attributed their persistence in school and science to participation in Project Exploration programs (Chi et al., 2010). Specific study findings included the following:

- 95 percent of alumni had graduated high school or were on track to graduate—nearly double the overall rate of Chicago Public Schools.
- 60 percent of alumni enrolled in a four-year college were pursuing degrees in STEM-related fields.
- 60 percent of alumni who graduated college had a degree in a STEM-related field (Chi et al., 2010).

In addition to these quantitative results, qualitative feedback provided insights into program characteristics that helped or hindered participation. Meaningful work with scientists and long-term relationships with caring adults were critical factors in students' decisions to persist in Project Exploration and in STEM (Chi et al., 2010). Participants described the factors that mattered most:

- Someone knew their name.
- The program "never ended."
- They learned how to write.
- They were in the news locally and nationally for their adventures and accomplishments in STEM.

From our staff's perspective, the most important finding was that students in Project Exploration demonstrated increased science capacity; positive youth development; and meaningful engagement in a community of practice that nurtured relationships while helping them learn from one another, envision careers in science, and conceptualize their futures.

> Meaningful work with scientists and long-term relationships with caring adults were critical factors in students' decisions to persist in Project Exploration and in STEM.

When asked what Project Exploration should do in the future, students told researchers they wanted opportunities to explore a broader range of scientific disciplines and career options and to investigate disciplines in depth once their curiosity was piqued. They also asked for transparency regarding advanced program and leadership opportunities. Although many students stayed involved with Project Exploration for four or five years, the 10-year study showed that they did not always know what programs were available and what was required to participate in advanced opportunities or leadership experiences.

Patterns of Participation

From anecdotal evidence, surveys and interviews with students, staff members' experiences, and data from Project Exploration's database, a pattern emerged of episodic engagement in Project Exploration, STEM, and higher education (Chi et al., 2010). Although some students came to Project Exploration programs continuously through middle and high school, many students participated episodically. In terms of higher education, first-generation college-bound students often did not explore the possibility of attending college until late in their senior year. Some students graduated from high school and immediately enrolled in a four-year institution, but some did not. Some students attended community college on an intermittent basis, while others entered the workforce or armed forces before returning to school. Some students began college, ran into obstacles (financial, disciplinary, personal, or medical), and dropped out, only to return to higher education in a new setting after time had elapsed.

The REA study demonstrated that Project Exploration's science education model had a significant and lasting effect on students' educational and career achievements. Project Exploration's relationship-based youth science model demonstrates what access to science can look like for minority youth, girls, and students who are not academically successful. Furthermore, REA findings strongly suggest that, even when students begin STEM participation late in their high school careers or participate episodically, they can—and often will—pursue STEM beyond high school and continue to be involved as adults, if given ongoing opportunities to stay connected.

Core Design Elements and Practices

Project Exploration's youth science model consists of a set of *core design elements* paired with *core practices*. These elements and practices form the backbone of our pedagogy for youth who are least likely to get and stay involved with STEM. Rooted in a progressive social justice agenda, Project Exploration's *core design elements* are:

- **Equity.** Our programs are intended to make science accessible to students traditionally underrepresented in STEM. Specifically, we target students of color and girls who come from under-resourced public schools or low socioeconomic status neighborhoods and those who struggle academically or socially.
- **Relationships.** We believe that learning is based in relationships. Our staff employs a highly personalized approach, with an emphasis on supporting long-term relationships among students, scientists, and staff through middle school, high school, and beyond.
- **Students at the center.** Project Exploration students are known to adults as individuals in terms of what they like and what they are curious about, as well as by what they can do in STEM. Students co-create curriculum based on their interests. Activities and materials are introduced in ways that make STEM accessible for all students, particularly those who struggle academically.
- **Access to experts.** Content is taught primarily by STEM professionals and guided by their questions and research. We collaborate closely with scientists to shape program experiences around authentic science and around the scientists' career paths and individual identities. Participants build social capital through relationships with passionate STEM professionals who are driven by curiosity.
- **Meaningful work.** In each program, students work toward a culminating public project. Experiences across programs are interconnected to encourage long-term involvement with STEM and the Project Exploration community, rather than to meet specific academic or workforce readiness goals.

All programs, regardless of STEM discipline-specific curricula, share the following *core practices*:

- Staff members facilitate STEM learning by creating the learning environment and supporting students' understanding of science as a process.
- Content is taught by scientists and STEM professionals.
- Students write every day together using a structured reading and writing process.
- Participants choose topics of interest and the medium through which they share their learning with others.
- Staff members connect students' experiences with their school lives through ongoing communication with teachers, principals, and families.

Outcomes That Matter

In our experience, the young people who are least likely to get involved with STEM participate in opportunities based on relationships rather than on workforce development goals. The demands of their lives mean they need opportunities that are non-linear but readily and regularly available. When the work in STEM programs is authentic, personally meaningful, and facilitated by caring adults, students will stay involved over many years, even if they do not intend to become scientists. Students who participate in such experiences have the opportunity to consider STEM in higher education and as a career; many of them actually do so, though these outcomes are not the primary program goals.

Successful involvement with STEM can emerge not only in the form of a STEM degree or career, but also in the form of ongoing STEM involvement on the part of adults who are also involved in public policy, journalism, home health care, parenting, traveling, or volunteering at a community-based organization, to name just a few examples from the lives of our alumni. This long-term outcome stands in stark contrast to what counts as "success" in the pipeline approach.

We used Project Exploration participant engagement in STEM as a basis for defining our youth outcomes:

- Engagement in communities of practice, in which students feel welcomed and are part of a community of learners
- Increased science capacity, developed by providing students with authentic experiences that foster increased knowledge
- Strengthened socioemotional attitudes, developed by focusing on socioemotional capacity and resilience

In order to serve more students, Project Exploration staff wanted a conceptual framework that would capitalize on lessons we learned from the 10-year study and from student feedback in order to facilitate equity and access. As documented by the REA 10-year study (Chi et al., 2010), episodic participation over many years and the cumulative positive impact of relationship-based programming stand in stark contrast to the educational process prescribed by the pipeline metaphor. Frustrated with the limitations of the pipeline as a conceptual framework, Project Exploration set out to create a metaphor that would serve our mission and students' real-life experiences.

Moving beyond the Pipeline

Reviewing existing literature and templates, we found a few sources that resonated strongly with our program sensibilities. The learning principles of Learning in Afterschool (2012) and the Partnership for 21st Century Skills (2009) helped bolster our youth development conversation. The *Atlas of Science Literacy* from the American Association for the Advancement of Science (Project 2061, 2007) and Jason Zimba's (2009) "Five Areas of Core Science Knowledge'" informed our articulation of STEM competencies.

However, neither Project Exploration's social justice agenda or nor the youth science model at the core of our approach were represented in these materials. In addition, staff believed that working through the development of a framework would provide a meaningful learning experience. The team decided to create a conceptual framework to answer the question, "What's worth knowing and experiencing at Project Exploration?" Staff developed project goals:

- We should capitalize on our long-term relationships with students. We know students for years, not just one or two weeks in the summer or for a few months after school.
- The final product should be the journey itself. We need to value and support non-linear experiences and episodic participation. Kids' real lives need to be part of the equation.
- Experiences in STEM should be expansive. Rather than serving workforce development as their primary purpose, STEM experiences should serve as building blocks for youth development and the creation of social capital.
- Roles among students, scientists, and staff—and especially opportunities for student leadership development—should be transparent and explicit.
- Students' interests and curiosity should drive their choices and their progress in learning.
- Staff should be able to talk with students about their learning progression and to show them and their families what skills and competencies they are developing and can build on.
- Evaluation should be meaningful and should relate to the programs and our goals for students.

Project Exploration's Youth-Science Pathways emerged from this discussion. Built on our youth science model, the Pathways framework combines a set of complementary learning strands, called Discover-Explore-Pursue, with a set of competencies presented in our Youth-Science Matrix. Youth-Science Pathways merges best practices in youth development with the concept of science as inquiry. Students do not work in the service of STEM by, for example, participating in science in order to become scientists, engineers, and mathematicians. Rather, STEM experiences are put to work in the service of students' academic, social, and emotional development.

Learning Strands: Discover-Explore-Pursue

In addition to mastering content, learning science involves proficiency in the skills of scientific inquiry. Opportunities to *discover* something new, *explore* various aspects of it, and *pursue* a specific question are hallmarks of the inquiry process. Each phase is part of a reiterative inquiry cycle, as illustrated in Figure 1. Project Exploration programs fall along three complementary strands.

Discover programs:

- Introduce students to a broad range of scientific disciplines and topics
- Enable students to develop and practice the basic principles of science and scientific inquiry

- Build student confidence and lay the foundation for long-term relationships among students, Project Exploration staff, parents, teachers, and scientists

Explore programs:
- Focus more specifically on discrete disciplines and inquiry methods
- Expand critical thinking, collaboration, public speaking, and investigative approaches
- Empower students to articulate their interests and create their personal science identities

Pursue programs:
- Equip students with skills and experiences to pursue science in higher education and the workforce
- Include an in-depth investigation in a research-based setting
- Build advanced scientific proficiencies as well as leadership and decision-making skills
- Allow students to develop highly personal, one-on-one working relationships with scientists

As complementary opportunities, Discover-Explore-Pursue programs enable participants to build content knowledge and work toward mastery of a topic in a linear, progressive fashion. A Youth-Science Pathway consists of a collection of program experiences over time.

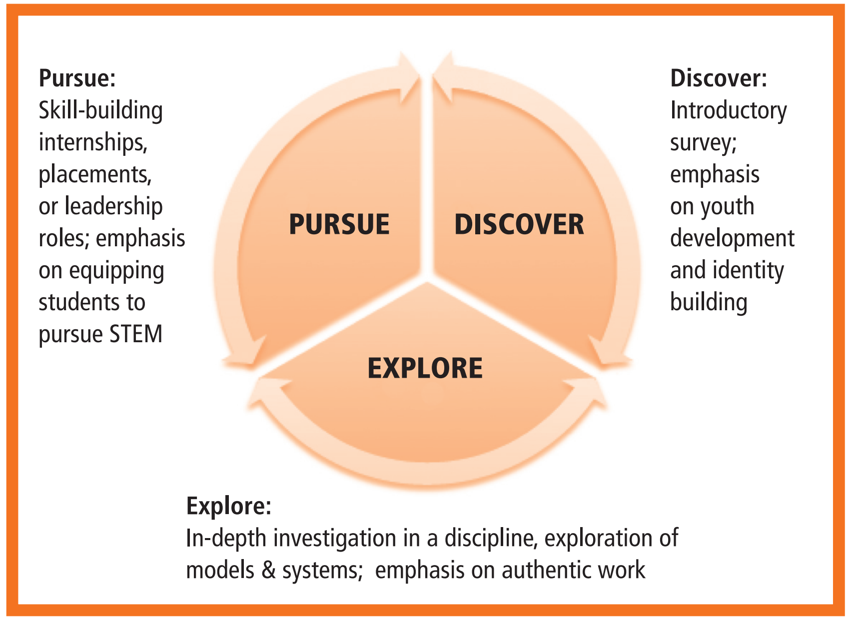


Figure 1. Discover-Explore-Pursue Framework

Table 1 offers an example of an individual student's content-based pathway in forensics. As the student participates in each program, he or she is not only progressively learning content knowledge and career requirements, but also developing self awareness that can help him or her make informed decisions about what he or she is interested in and why. Because participants are encouraged to choose particular programs based on their curiosity, and because Project Exploration focuses on long-term relationships rather than on single experiences, the strands support students to take ownership of learning and to be active members of the Project Exploration community.

Youth-Science Pathways makes Project Exploration's relationship-based approach explicit and transparent. As illustrated in Figure 2, the level of initiative and engagement required of participants, as well as of staff or scientists, changes with each program strand. In Discover programs, the responsibility to develop program activities is on the staff member who recruits students and takes the lead in shaping the program. In Pursue programs, students and scientists are both expected to work more independently: students set their own learning goals, and scientists work with students on authentic projects in the field or in labs.

Now that we had a transparent way to describe and diversify programs, our staff

Table 1. Youth-Science Pathway: Forensics

DISCOVER	EXPLORE	PURSUE
Discover Forensics March 2011 Survey experience over five full days in spring break **Science Digest** October 2011 Half-day introduction, on a Saturday, to what it's like to be a forensic scientist for a government agency	**Forensic Investigators** Summer 2012 Two-week summer immersion program with a culminating "court case" presentation	**Summer Internship** Summer 2012 with Illinois State Police **Team Leader** Spring 2013 Leading other youth in the Project Exploration program Forensics Investigators

turned to articulating a continuum of competencies to ensure that participants progress intellectually, socially, and emotionally throughout their involvement with Project Exploration.

Youth-Science Matrix: Progressive Competencies

When Project Exploration opened its doors in 1999, funders, parents, students, and scientists asked, "Are you a *youth development* organization or a *science education* organization?" The question has persisted. Rather than choosing one or the other, we believe that competencies developed through science learning and youth development are complementary and strengthen each other. Researchers such as Joseph Durlak (Durlak & Weissberg, 2007) have shown that afterschool programs that use evidence-based youth development practices are the most effective in producing positive outcomes. The 10-year study of Project Exploration (Chi et al., 2010) demonstrated that, by intentionally fostering socioemotional skills—such as communication, self-confidence, self-efficacy, teamwork, cooperation, and leadership—while immersing students in high-caliber STEM programs, Project Exploration enables participants not only to learn science, but also to translate their experiences into future aspirations and achievement.

With the Discover-Explore-Pursue learning strands in hand, staff broke into two teams to examine both youth development assets and competencies in science inquiry, selecting competencies that aligned with Project Exploration program practices. The teams agreed on three ideas:

- Scientific inquiry is a way of understanding the natural world.
- Positively focusing on youth competencies and social and emotional skill-building while exploring STEM will equip students for success in life.
- Critically conscious youth are empowered to identify challenges to, and strategies for achieving, equitable participation in science.

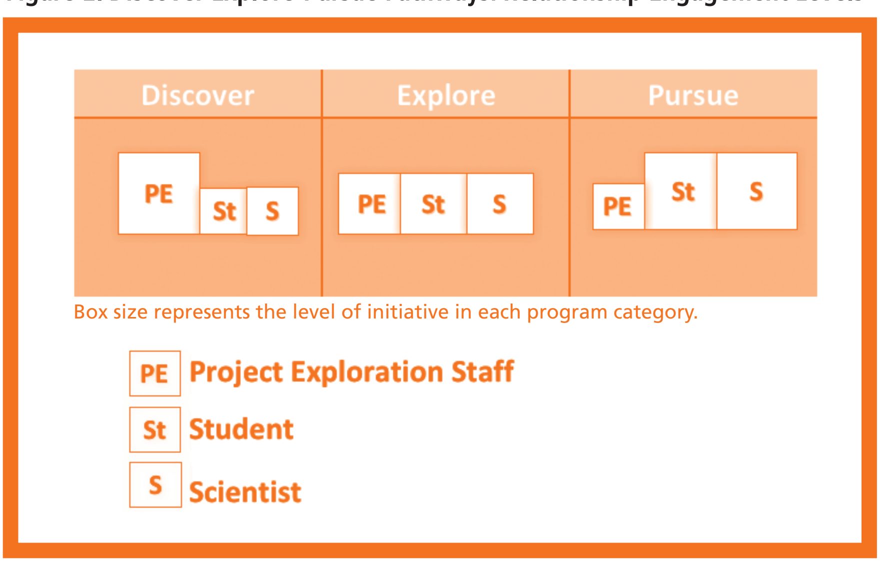
The team emerged with a set of 14 competencies that spanned youth development and STEM inquiry:

- Building models
- Understanding math
- Building scientific knowledge
- Investigating
- Understanding science as a social endeavor
- Observing
- Reflecting
- Collaborating
- Taking initiative
- Being curious
- Communicating
- Being part of a community
- Developing leadership
- Developing self-identity

The competencies integrate science process skills and youth development assets. When Discover-Explore-Pursue strands are mapped across these competencies, the result is the Youth-Science Matrix, excerpted in Table 2. The matrix outlines basic scientific and youth development competencies we expect each student to explore in all programs, with increasing sophistication across Discover, Explore, and Pursue opportunities.

The Youth-Science Matrix describes an explicit ecosystem for designing programs along learning strands. This tool gives staff and scientists a common language for discussing and designing experiences, content, and skill development activities. It enables staff to move away from hidden or implied curricula toward being explicit with scientists, facilitators, and students. For example, scientists who are interested in doing

Figure 2. Discover-Explore-Pursue Pathways: Relationship Engagement Levels



CORE COMPETENCIES	EMERGING SKILLS		
	DISCOVER	EXPLORE	PURSUE
BUILDING MODELS	• Using models as analogies to represent natural phenomena that may be too small or large to observe (e.g., atom, solar system)	• Learning to accurately scale natural phenomena (e.g., evolutionary time, cells, bacteria) • Developing ways to accurately represent and describe abstract ideas	• Considering alternative models to explain the same phenomenon • Learning how models of a specific discipline have changed over time • Using models to make and test predictions (e.g., computer, mathematical)
BUILDING SCIENTIFIC KNOWLEDGE	• Learning basic vocabulary related to the nature of science (e.g., observations, data, experiment) • Learning major concepts that are shared among scientific disciplines (e.g., evolution, energy flow, interconnectedness)	• Learning discipline-specific vocabulary • Learning to use discipline-specific tools • Discussing major concepts and principles within a specific discipline	• Mastering the use of some discipline-specific tools • Using scientific vocabulary and principles to pose questions and formulate responses
USING MATH	• Using simple algebra to collect data • Using numerical data to describe and compare data • Using simple tools of measurement (e.g., scales, rulers)	• Reading and presenting numerical information through graphs and charts • Using mathematics to solve a problem	• Quantifying statements • Learning to interpret data using quantitative methods (e.g., statistics)

Table 2. Youth-Science Matrix Excerpt

outreach with our participants often have a hard time understanding how to teach content so that it is embedded in youth development assets. Using the Youth-Science Matrix as a guide, scientists know in advance whether they are working to help participants Discover, Explore, or Pursue. They have an outline for developing activities to build skills and competencies that cut across science and youth development. The matrix provides transparency for students by helping them understand what programs are available now and in the future, what competencies they can develop, and what is expected of participants. It also serves staff as a rubric for program evaluation.

Youth-Science Pathways: Learning Strands across a Matrix

The Youth-Science Pathways framework, built on progressive learning strands paired with a competencies matrix, enables young people to develop STEM literacies as well as social, emotional, and leadership fluency. The aims of the Youth-Science Pathways framework are fourfold.

The first goal is to increase access to and transparency about program opportunities. While striving to maintain flexibility, Pathways provides clear, customizable options. In addition to helping students set clear goals and understand what is expected of them in Project Exploration programs, the Pathways framework also supports longer-term aspirations for high school graduation, college, and career.

A second goal is to build and enhance continuity across the program landscape. Responding to student interests is a fundamental cornerstone of Project Exploration's program design. However, as we expand, it is critical that students, scientists, and teachers agree on certain competencies or skills, both academic and developmental, that will be addressed in each strand of programming. The Pathways framework enables us to be explicit about our experiential goals for students and about their learning along the way. These competencies create a dashboard for internal and external program evaluation. Standardizing program design facilitates students' progress, bolsters the development of STEM capacities, and reinforces the community of practice.

A third goal of Youth-Science Pathways is to design with episodic participation in mind. Students whose lives outside of school make regular, linear participation in school or in OST programs a challenge need opportunities to participate in a welcoming community based on curiosity rather than on prerequisites. The Pathways approach assumes that it is never too late to participate—or to return.

The Pathways approach capitalizes on relationships with scientists and on institutional partnerships to ensure that students build social capital. Project Exploration works with diverse STEM professionals who come from universities as well as from public and private sectors. Students not only are exposed to a variety of careers and working environments but also can get connected and develop diverse networks of relationships.

The learning strands and competencies matrix of Youth-Science Pathways facilitate OST experiences that are critical not only for STEM pursuits, but also for healthy adulthood. Youth need sustained opportunities in STEM, and their engagement needs to be progressively sophisticated in order to develop both technical and socioemotional skills. Youth-Science Pathways provides an architecture within which students can explore successive and diverse experiences in STEM while also getting support for their development as young people. The Pathways framework enables program providers to reconsider the value of STEM experiences in terms of youth development over time. Young people know that they have multiple options and are empowered to make decisions that will support their growth and learning.

What's Next

The work of bringing Youth-Science Pathways to life has just begun. New programs are being mapped against the Discover-Explore-Pursue learning strands. This approach is envigorating our ability to be strategic about partnerships with STEM professionals and about communication with our students. But we have much more work to do. A pipeline model can be evaluated quantitatively in terms of STEM degrees granted and STEM careers launched. A pathways approach requires fresh thinking about what matters most—and to whom and why.

In the short term, we are developing program indicators, observation rubrics, and evaluation templates that will provide feedback for program providers and youth participants and will inform the organization's strategic planning. We are exploring critical questions such as:

- How do we use Pathways to support individualized learning plans for participants?
- Can we develop a transparent and youth-friendly tool that allows students to be aware of their own assets and monitor their skill development?
- How can we use the matrix to assess skill development for formative evaluation during programs as well as for summative evaluation afterward?
- What are the implications of the Pathways approach for staff recruitment, retention, and professional development?
- In what ways can data inform how we refine specific paths?
- What longitudinal data will be most important to collect?

Youth-Science Pathways enables program providers to move beyond the STEM "pipeline" to support youth development goals as well as STEM learning. Instead of putting students to work to serve STEM workforce demands, it puts STEM education to work to expand possibilities in students' lives.

Acknowledgement

The authors would like to acknowledge staff members who participated in departmental retreats that led to the thinking summarized in this article, including Amaris Alanis Ribiero, Kristin Atman, Mikki Brown, Katina Leaks, Mary Elizabeth Perez, Elsa Rodriguez, and Virginia Spitzer.

References

Alper, J. (1993). The pipeline is leaking women all the way along. *Science, 260*(5106), 409–411.

Basu, S. J., & Barton, A. C. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching, 44*(3), 466.

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter? *Gender and Education, 17*(4), 369–386.

Campbell, G., Denes, R., & Morrison, C. (2000). *Access denied: Race, ethnicity, and the scientific enterprise.* New York, NY: Oxford University Press.

Chi, B., Snow, J. Z., Goldstein, D., Lee, S., & Chung, J. (2010, December). *Project Exploration: 10-year retrospective program evaluation summative report.* Berkeley, CA: Center for Research, Evaluation and Assessment. Retrieved from http://www.projectexploration.org

Costa, V. B. (1995). When science is "another world": Relationships between worlds of family, friends, school, and science. *Science Education, 79*(3), 313–333.

Durlak, J. A., & Weissberg, R. P. (2007). The impact of after-school programs that promote personal and social skills. Chicago, IL: Collaborative for Academic, Social, and Emotional Learning. Retrieved from http://www.casel.org

Jayaratne, T. E., Thomas, N. G., & Trautmann, M. (2003). Intervention program to keep girls in the science pipeline: Outcome differences by ethnic status. *Journal of Research in Science Teaching, 40*(4), 393–414.

Jeffe, D. (1995). About girls' "difficulties" in science: A social, not a personal matter. *The Teachers College Record, 97*(2), 206–226.

Jolly, E., Campbell, P. B., & Perlman, L. (2004). *Engagement, capacity, continuity: A trilogy for success.* New York, NY: GE Foundation.

Kladec, A., & Friedman, W. (2007). *Important, but not for me: Parents and students in Kansas and Missouri talk about math, science and technology education: A report.* Public Agenda Foundation. Retrieved from: http://www.kauffman.org/uploadedfiles/important_but_not_for_me.pdf

Learning in Afterschool. *Project position statement*. Retrieved from http://www.learninginafterschool.org/documents/PositionStatement.pdf

Leboy, P. (2008). Fixing the leaky pipeline. *The Scientist, 22*(1), 67.

Lynch, S. J. (2000). *Equity and science education reform*. Mahwah, NJ: Lawrence Erlbaum.

Lyon, G. (2010). *Project Exploration's personalized curriculum: Fostering access and equity in science out-of-school.* Unpublished PhD thesis. University of Illinois, Chicago.

McClure, P., & Rodriguez, A. (2007). *Factors related to advanced course-taking patterns, persistence in science, technology, engineering and mathematics, and the role of out-of-school time programs: A literature review.* Coalition for Science After School.

Partnership for 21st Century Skills. (2009). *21st century skills map: Science*. Retrieved from http://www.p21.org/storage/documents/21stcskillsmap_science.pdf

Project 2061. (2007). *Atlas of science literacy, Vol. 1 and* 2. Washington, DC: American Association for the Advancement of Science.

Watt, H. M. G., Eccles, J. S., & Durik, A. M. (2006). The leaky mathematics pipeline for girls. *Equal Opportunities International, 25*(8), 642–659.

Zacharia, Z., & Barton, A. C. (2004). Urban middle-school students' attitudes toward a defined science. *Science Education, 88*(2), 197–222.

Zimba, J. (2009). *Five areas of core science knowledge: What do we mean by "STEM-capable?"* Paper prepared for the Carnegie-IAS Commission on Mathematics and Science Education. New York, NY: Commission on Mathematics and Science Education. Retrieved from http://opportunityequation.org/standards-and-assessments/what-do-we-mean-by-stem-capable