

Science Education at Fairchild Tropical Botanic Garden

A comprehensive environmental training pipeline that extends from early childhood through advanced graduate education

Fairchild Tropical Botanic Garden is recruiting and training a new generation of professionals in environmental science. Through a series of interconnected educational programs that span from early childhood through Ph.D.-level graduate studies, we are encouraging awareness of the environment, developing leadership in environmental science, and diversifying the scientific workforce.

A strong science, technology, engineering and mathematics (STEM) workforce is becoming increasingly important for our nation's economy, infrastructure, and environment. America's education agenda is focused on an urgent need for a population that is more STEM literate and prepared for scientific careers. However, one of our nation's major challenges is finding tools to encourage diverse populations to pursue STEM careers, particularly in fields related to the environment.

The children of South Florida have traditionally experienced limited training in science and little exposure to careers in the environment. Starting with early childhood education, young children are afforded few opportunities to engage systematically and thoughtfully in learning science. On average, less than 10% of instructional time is spent on teaching science in the early grades. Science instruction occurs sporadically and the science activities that are used by teachers in early science instruction tend to inhibit inquiry and reflection on the part of young children.

Fairchild has an opportunity to greatly enhance science education in our community and identify and encourage talented young scientists. Our world-renowned K-12 science education programs include a majority of students from groups that are traditionally underrepresented in the sciences. More than 100,000 local K-12 students are enrolled in our programs this year (including the Fairchild Challenge, Explorer, and Discovery programs), and approximately 75% of those students are from underrepresented groups.

Diversity in the Scientific & Environmental Workforce

Scientific innovation will be the key to addressing future global environmental threats and building a sustainable future. The pace of scientific innovation is directly linked to the diversity of ideas, perspectives, and life experiences within the science workforce. At Fairchild we are building programs to engage and train students from a broad range of backgrounds starting at an early age.

In 2005 the National Environmental Education Advisory Council developed eight recommendations to enhance environmental literacy and boost the environmental science community in the US. Two of the most important recommendations were to "Broaden the audience and leadership of the environmental education field." And "Build public understanding of the value of environmental education and increase the number and diversity of talented young people pursuing environmental careers." Additionally, the National Science Foundation, in their 2006-2011 Strategic Plan, identifies diversity as their top priority. The goal is to "expand efforts to increase participation from underrepresented groups and diverse institutions throughout the United States in all NSF activities and programs."

Miami-Dade County, one of the five poorest metropolitan areas in the nation, has the fourth largest Public School District. Our 353,000 students make up a minority majority: 61% Hispanic, 27% black, 9% white, 3% other. Because of the diversity of Miami-Dade County's population, Fairchild has an opportunity to combat the ethnic and socio-economic disparity in science and environmental education and careers.

With more than half of our residents born outside the United States, many families in South Florida are just becoming aware of the academic resources available locally. All students, but particularly underrepresented

minorities and women, need encouragement to pursue science activities from an early age, and continued support and mentoring through the pipeline (American Association of State Colleges and Universities, *Strengthening Science and Mathematics Pipeline for a better America*). At Fairchild we have the unique ability to connect South Florida's students with opportunities and resources in the environmental sciences.

South Florida is an ideal region to develop talent in the environmental sciences. Our community is passionate about the environment and deeply connected to the tropics. Within our local K-12 school system we have highly talented environmental educators who have been great partners with us in the Fairchild Challenge. Within our local universities, FIU, the University of Miami, and Miami Dade College, we have world-class programs in biology, environmental studies, and horticulture.

Guiding principles:

Recent research by the American Academy for the Advancement of Science, National Science Foundation, and the Center for Diversity and the Environment has focused on methods for building and diversifying our nation's scientific workforce through targeted education programs. Reports of those studies are available online*. Based on those results, we developed five core education principles:

1. Basic scientific and environmental concepts must be introduced early and reinforced continuously throughout the education process.
2. Inquiry-based education helps students develop creativity and enthusiasm for discovery, key attributes of successful innovators.
 - a. K-12 students will recognize and appreciate the importance of science in society when they have the opportunity to work with mentors (e.g. advanced students and professional scientists) on research projects that are relevant on a local and global scale.
3. Mentorship is crucial for engaging and encouraging students from demographic groups that are traditionally underrepresented in the sciences.
4. Establishing a balance of competition and collaboration prepares students to work effectively within the scientific community.

Core Concepts

1. Tropical Biodiversity and Exploration
Overview: Many of the world's plants, especially in the tropics, remain undiscovered or poorly understood. In nature or in botanic gardens, biodiversity research can help us fill those gaps.
2. Plant Animal Ecology
Overview: As we work to conserve nature, we need to understand and protect the natural interactions among plants and animal species.
3. South Florida Environments
Overview: Even within urban areas like Miami Dade County, we must value of natural ecosystems and prospects for conservation.
4. Biological Imagery
Overview: taking a close, detailed look at plants and animals can help us understand the intricacies of the natural world.
5. Growing, Propagating and Conserving Plants
Overview: Agriculture, gardening, and plant conservation all depend on our ability to make plants grow and reproduce.
6. Economic Botany
Overview: Humans are totally dependent on plants for the most basic needs. The more we explore the botanical world, the more uses we discover for plants.

Fairchild's Educational Role in South Florida

Fairchild's education programs provide unique opportunities for students of all ages to learn about the natural world, appreciate the beauty and value of nature, and promote environmental literacy and stewardship. Using the environment as an integrating concept, Fairchild offers a diversity of programs for students in grades pre-K through 12 that aim to enhance science education through interdisciplinary, inquiry-based learning. These programs are the result of cooperative efforts, led by seasoned educators on staff and involving input from program volunteers, teachers, students, science and curriculum specialists from Miami-Dade County Public Schools (M-DCPS) and research and horticulture staff.

The Fairchild Challenge & the Science Education Pipeline

The Fairchild Challenge is a unique school-based environmental education program whereby students are engaged and actively involved in environmental education and stewardship, beginning in elementary school and continuing through college. Through repeated exposure to highly experiential and inquiry-based environmental education from an early age, the Fairchild Challenge is influencing and empowering a diverse generation of scientists, researchers, educated voters, policy makers, and environmentally-minded citizens. Promoting the Challenge program through schools maximizes youth involvement and weaves attention to nature into the daily lives of young people, regardless of age, race, religion, socio-economic status, or ability. The intended impact of the Challenge is to increase the percentage of students pursuing advanced degrees in the sciences and successfully bring them into STEM careers, specifically those related to the environment.

The program is a free, interdisciplinary competition that is aligned with state educational standards and is embedded in Miami-Dade County Public School's educational pacing guides. Through the program, students actively learn, explore and devise creative and effective responses to some of the most pressing environmental issues of our time. With competitions in various disciplines, the annual menu of options uses the environment as an integrating context for learning. Research shows that the observed benefits of using the environment as an integrating contexts are: (1) better performance on standardized tests; (2) measures of academic achievement in reading, writing, math, science, and social studies; (3) reduced discipline/classroom management problems; (4) increased engagement and enthusiasm for learning; and (5) greater pride in and ownership of accomplishments.

Challenge contest options allow students to engage in the following projects: research, debate and devise solutions to environmental issues; create environmentally themed artwork; work in and with their community to raise environmental awareness; learn from their elders; conduct habitat restoration at schools; implement green initiatives at home, school and in the community; creatively write about nature; and work with professionals throughout the region to explore science careers.

The Fairchild Challenge has been influencing and empowering a diverse generation of scientists, researchers, educated voters, policy makers, and environmentally-minded citizens. By offering the program at the school level, the Challenge maximizes youth involvement and weaves attention to nature into the daily lives of young people, regardless of age, race, religion, socio-economic status, or ability. We are engaging tens of thousands of urban youth whose disconnect from nature is vast. In Miami-Dade County, large culturally and socio-economically diverse populations have overscheduled agendas, limited access to green spaces, and routinely turn to indoor, electronic, sedentary entertainment - a recipe for significant deficit and disengagement with nature. The intended long-term impact of the Challenge is to increase the percentage of students pursuing advanced degrees in the sciences and successfully bring them into STEM careers, specifically those related to the environment.

Because of the local success of the Fairchild Challenge, Fairchild has begun to offer the program as a replicable model to other cities throughout the US and abroad. The eagerness with which dozens of national and international sites have taken up this offer reflects the program's resonance in diverse social settings. The goal of the Fairchild Challenge National Movement is to build the environmental education capacity and impact of the Fairchild Challenge program by defining, capturing, celebrating and showcasing best practices of the Miami-model and currently active sites.

By engaging, educating and utilizing our scientists as experts and facilities as living laboratories, we implement standards based STEM content effectively and thus use the Challenge as the vehicle to encourage diverse populations of students to pursue careers in science. Through the Fairchild Challenge, students are given a “kick start” to STEM education from Pre-K through post secondary education. Since the Fairchild Challenge is an interdisciplinary education model, it allows all areas of STEM to be integrated into the school curriculum, extra curricular activities, the home and the community. The Fairchild Challenge helps students make the connection between subjects, disciplines, and areas of interest.

Evaluation of Fairchild Challenge Outcomes

The Fairchild Challenge continuously tracks and evaluates program outcomes by administering frequent teacher and student surveys, facilitating teacher discussion forums and interviews, maintaining e-mail communication, conducting direct observations of the program at various school sites, and monitoring the quality of student entries. Evaluations for the 2012-2013 program year focused on four key aspects: content, administration, communication, and effectiveness. Implementation of these evaluative strategies allowed us to analyze student and teacher feedback to the following questions: "What effect do we have on students' environmental awareness, scholarship, and stewardship? How many students, teachers and schools are we reaching, and to what extent?"

The survey results indicate that 70% of high school students and 73% of middle school students became more interested in and appreciative of the environment following their participation in the Fairchild Challenge. Furthermore, 77% of high school students and 82% of middle school students found that their knowledge of the environment increased since participating in at least one Fairchild Challenge option. In addition, 75% high school students and 78% of middle school students that participated in the Fairchild Challenge indicated an increased willingness to preserve the environment.

The surveys executed at the end of the program reported that 83% high school students and 85% of the middle school students could state ways in which plants are important. Of the student participants, 73% of the high school students and 76% of the middle school students stated that they could persuade others to take action to help the environment as a result of their participation in the Fairchild Challenge. Moreover, 66% of middle and high school students reported that the Fairchild Challenge gave them new ideas by seeing the work of other participants. In all, 69% high school students and 80% middle school students surveyed would like to compete in the Fairchild Challenge next year.

Teachers surveyed noticed a change in student environmental attitudes. Eighty-five percent of the 39 high school teachers and 91% of the 55 middle school teachers surveyed noticed an increase in student interest in the environment. Consequently, 79% of the high school teachers and 81% of the middle school teachers also noted an increase in student environmentally friendly behaviors following their participation in the Fairchild Challenge. Teachers also learned from this program; 90% of the high school teachers and 93% of the middle school teachers surveyed stated that their knowledge of the environment and environmental issues had increased; and more than 96% of them intend to participate in the Fairchild Challenge in the coming school year. The teachers were also satisfied with the program's curriculum integration to the state curriculum standards; 97% of the high school teachers and 95% of the middle school teachers surveyed agreed that the Challenge was a worthwhile use of class time.

Fairchild's Explorer & Discovery Program

The Fairchild Explorer Program, a series of grade-specific field studies at the Garden, immerses elementary age students in hands-on activities designed to unearth their inner scientist and help them understand the natural world. These activities include: embarking on a "root to tip" plant hunt, examining rainforest tools and toys, learning about photosynthesis and propagation and exploring many ecosystems through a narrated tram and walking tour.

Fairchild's Discovery Program offers a selection of guided and independent field study activities for students in grades 3-12 to enhance science and multidisciplinary environmental education. By exploring science, art and technology, students take a trip to "botany and beyond." This program gives teachers the opportunity to tailor their students' Garden experience. The menu of age-appropriate activities include using GPS units, maps and compasses to navigate the garden; identifying butterflies and their host plants; exploring the art exhibited in the Garden; discovering the diversity of the plant kingdom. The program is designed to meet Sunshine State Standards and assist in the preparation of students for the Florida Comprehensive Assessment Test (FCAT).

Higher Education, Mentorship, & the Pathway toward Careers in Science

In partnership with Florida International University, Miami Dade College, and the University of Miami, we are developing opportunities in higher education for the talented students graduating from our K-12 programs. These opportunities include degree programs in biology, environmental science, and natural resource management. All three of our partner universities also offer multidisciplinary programs that combine science with degree programs in arts and the humanities. We are targeting students from underrepresented demographic groups and providing opportunities for them to connect with world-class professionals in active research projects. As students work toward college degrees, they participate in the Fairchild Challenge programs as mentors for middle and high school students. The students we recruit locally from our K-12 programs are particularly effective role models for the youth of our community. Our goal is to recruit 10 undergraduate students per year for a total of 40 students in our program simultaneously.

For more than 30 years Fairchild has hosted graduate students who specialize in a wide range of topics in botany, tropical biodiversity, and conservation. We now have 16 masters and Ph.D.-level graduate students enrolled in Florida International University and the University of Miami. All of our graduate students work closely with the Fairchild Challenge, serving alongside the undergraduate students as mentors for middle and high school students. They also work closely with the undergraduate students and help them develop specialized skills in science. Upon graduation, our masters and Ph.D. students secure jobs in environmental organizations, universities, and the federal government, where they work to preserve the environment and conserve biodiversity.

Beginning in 2011, we developed a unique Graduate Assistantship program where select graduate students are awarded Teaching Assistantships (TA) opportunities at Fairchild as opposed to teaching at the university. These students work with the Fairchild Challenge to mentor budding scientists, develop research opportunities for schools and learn how to better communicate their science to the greater community. Currently we have six TA positions

* American Academy for the Advancement of Science, National Science Foundation, and the Center for Diversity and the Environment Online Reports:
<http://environment.yale.edu/news/5175> & http://ehrwweb.aaas.org/mge/Reports/Report1/AGEP/AGEP_report.pdf