Encouraged to strengthen connections of mutual interest by suggestions from programmatic reviews and discussions, the Physics Teacher Resource Agents program (PTRA) and QuarkNet held a design workshop for a collaborative program. Six master physics teachers and one university faculty member met at Fermilab to develop the following strategy.

Intro

**AAPT/PTRA** is a program designed to and has demonstrated effectiveness to improve physics teacher competency, content knowledge and confidence. Experienced master teachers who understand the challenges faced in today’s classrooms offer workshops on physics content and teaching techniques for in-service/pre-college teachers and second-career professionals. PTRA can also provide ideas for opportunities to do laboratory activities, tips on classroom demonstrations and presentations, updates ad new approaches for state standard topics, introduction to new topics and teaching strategies and a colleague to contact for encouragement and suggestions. PTRA provides topical manuals that serve as teacher resources.

**QuarkNet** is a national program designed to and has demonstrated effectiveness to partner high school science teachers with particle physicists working in experiments at the scientific frontier. QuarkNet is a multi-decade-long program where key experimental projects of interest, such as the LHC, are entering one of the most exciting and important periods during the five years of this proposed program. QuarkNet comprises 52 centers located at universities and laboratories around the country. Staff oversees the maturation of a center into an inclusive and engaging community of researchers providing mentors and a support group to meet the needs of today’s educators. QuarkNet is led by a group of teachers, educators and physicists with many years of experience in professional development workshops and institutes, materials development and teacher research programs.

Needs

Teacher content knowledge in mathematics and science is closely linked to student performance.1 Science teachers who have improved content knowledge and deepened pedagogical reasoning have had student achievement improve.2 Only 35% of high school physics teachers have a major or minor degree in physics, and 11% have major or minor degree in physics education.3 Thus, the majority of physics teachers do not have significant coursework in physics and are underprepared to teach it effectively.

Participation in a significant professional development program has been demonstrated to help underprepared teachers reach the level of mastery necessary for high student achievement. According to a 2003 study completed by Horizon Research, Inc. on K-12 Mathematics and Science Education in the United States4, high-quality science teacher professional development must include five essential elements; specifically, a focus on science and mathematics content knowledge, an emphasis on active learning, promotion of content coherence, a large amount of training sustained over time, and encouragement of collaboration among teachers. To have an impact on a teacher’s content knowledge and teaching requires a minimum of 100 hours of in-service professional development. It is for this reason that the PTRA program has devised a program that consists of a series of articulated workshops over a four-year period that provides thirty-six workshop hours per year that focus on both physics content and effective pedagogy.

Well-prepared teachers have confidence, content knowledge and pedagogical skills to provide learning as referenced in NSES and Next Generation Science Standards. QuarkNet teachers are by and large already well prepared. Bringing them into a research community provides something more, a direct experience with scientific research. The elusive Higgs or speedy neutrinos are topics that teachers are prepared to discuss as they help students understand scientific discovery and the potential discoveries in the LHC era. Making real scientific data available to teachers and their students brings the excitement of modern physics to classrooms. Data show that these students gain a new framework for science. They understand how new knowledge is discovered and how scientists talk about their work. The AAPT/PTRA program has the experience and proven ability to increase the pool of highly qualified teachers who can benefit from the opportunities provided by QuarkNet.

Goal

To support and create opportunities for underprepared teachers to learn physical science/physics content and pedagogy, to gain confidence as a physical science/physics teacher, and to become part of a physics learning community with a goal toward providing the necessary environments for students to learn.

Outcomes

Teachers will know and be able to discuss and explain physics concepts.

Teachers will express improved confidence in:

 Physics content covered in the program.

 Using physics instructional materials, lab equipment, and software.

 Guiding inquiry-based learning.

Teachers will join QuarkNet at the end of three years.

Students will know and be able to:

 Discuss and explain physics content.

 Demonstrate an ability to engage in scientific practices and discourse.

Students will demonstrate an improved attitude and appreciation toward science.

Program Description

Part 1: Existing AAPT/PTRA curriculum to be used in the proposed professional development program will be updated and expanded to bring it in alignment with Next Gen Standards, new instructional technology, and to include modules that incorporate aspects of modern, nuclear and particle physics as part of the I2U2 proposal.

Part 2: QuarkNet and PTRA will collaborate to design and deliver workshops for a target group of high-school teachers who lack a strong background in physics content and/or teaching techniques. These workshops will incorporate materials from both projects to increase the teachers’ confidence, content knowledge and pedagogical skills. The workshops will lead the teachers through a three-year progression, starting with kinematics and ending with participation in the local QuarkNet center. Local, mentoring research physicists will provide additional support and content expertise in these workshops.

The proposed PTRA/QuarkNet collaborative workshop series for teachers in the target group will occur at existing QuarkNet centers. Up to eight centers per year can join in the first three years of this program. The local QuarkNet center will recruit participants for these workshops and continue to host workshops for their existing teachers. Depending on the QuarkNet center program, all teachers will get together in academic year follow-on activities.

The project relies on local PTRA leaders who will join local QuarkNet centers. As such, they will participate in existing QuarkNet activities. These professional leaders will help current QuarkNet teachers explore pedagogy and collaborate with local QuarkNet leadership to plan and deliver workshops for the new target teacher group. Certain modern physics topics lend themselves to study in the context of classical physics. *For instance, teachers can use conservation of energy and momentum to reconstruct the decay of a particle. The workshops will incorporate these modern physics examples as appropriate.*

The proposed timeline for a QuarkNet center’s participation in this new collaboration follows:

**Year 0**

 Announce the program.

 Select participant centers from among local centers that apply.

(Must identify the PTRA leader who will join the center or QuarkNet teacher who will become PTRA leader if no local PTRA leader is available.)

 PTRA leader attends the local QuarkNet workshop and the national QuarkNet Boot Camp and joins QuarkNet T&L Fellows group or QuarkNet teacher attends PTRA training.

Plan new summer workshops.

**Year 1**

Recruit up to 20 teachers to form the new target group.

 Deliver five-day workshop for new target group to explore teaching kinematics and dynamics.

 Deliver five-day workshop for existing QuarkNet teachers.

**Year 2**

 Deliver five-day workshop for existing target group to explore teaching momentum and energy.

 Deliver five-day workshop for existing QuarkNet teachers.

**Year 3**

 Deliver five-day workshop for existing target group to explore teaching electricity and magnetism.

 Deliver five-day workshop for existing QuarkNet teachers.

**Year 4 and beyond**

 Merge teacher groups and continue five-day QuarkNet workshops.

This plan describes the life cycle of this new project at a particular QuarkNet center. The project proposes to invite up to eight existing QuarkNet centers to start this cycle in 2013. Eight more centers will start in 2014 and the final eight centers in 2015.

Evaluation

Staff will work with outside evaluators to use instruments and strategies developed and thoroughly tested for use with AAPT/PTRA professional development to assess the impact and effectiveness of the collaborative program. Formative assessments will include but not be limited to surveys, pre-post-tests, and interviews. Summative evaluation will include confidence and attitude surveys, surveys of teacher practices, and statistical analysis of content knowledge acquisition of participants and students.

Elements of the evaluation plan will include:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Goals | Expected outcomes | Activities to achieve goals | Data collection | Who collects | Evaluation criteria |

1. Darling-Hammond, *Teacher Quality and Student Achievement: A Review of State Policy Evidence*, Education Policy Analysis Archives, 8, 1, 2000.
2. Heller, Daehler, Shinohara & Kaskowitz, What makes professional development effective? Results from a national sample of teachers, *American Educational Research Journal*, 38(4), 915-945, 2004.
3. American Institute of Physics, Statistical Research Center, High school teachers: physics background, <http://www.aip.org/statistics/trends/highlite/hs1/figure3a.htm>.
4. See <http://www.horizon-research.com/insidetheclassroom/reports/looking/>.