Evidence for the Effectiveness of Sustained, Teacher-Led Physics Professional Development (AAPT/PTRA)

Following the 1983 "Nation at Risk" report and the widespread concern about the state of high school science teaching, the leaders of the American Association of Physics Teachers began to consider a professional growth program led by high school teachers. Established in the summer of 1985, the American Association of Physics Teachers Physics Teaching Resource Agents (PPAT/PTRA) was the first NSF grant in which the PIs were high school teachers. One hundred and two experienced physics and physical science instructors, two from each state and the District of Columbia, gathered in Flagstaff, Arizona, for a rigorous summer institute. The primary focus was on implementing low-cost experiments and demonstrations to augment existing curricula. With little standardization the program was not as effective with changing the methodology of instruction of physics and physical science. The subsequent NSF grants of PTRA+, Urban PTRA and Rural PTRA focused on standardizing both the content and pedagogy, increasing hours of contact with participants to seventy-five to over one hundred and follow up sessions during the school year. Attendees of the summer camps received stipends, travel, housing, equipment and graduate credit.

The Urban grant gathered both qualitative and quantitative data via pre and posttests and formative questionnaires from the PTRAs attending summer institutes as to how the summer institute prepared, them to:

- Provide outreach participants with hands on activities
- Develop outreach participants' knowledge of core physics concepts
- Assist outreach participants with integration of activities into their existing curricula, understand student thinking and common misconceptions and examine teaching strategies and pedagogy.

Outreach Workshops and Participants, by Location

	Number of Workshops Reported	Average Number of Contact Hours	Average Number of Topics per Workshop	Total Number of Participants†	Total Participant Hours
Urban Center					
Houston	11	6.1	1.2	260	1,583
Washington DC	11	6.1	1.2	96	585
Salt Lake City	7	6.1	1.0	98	602
Chicago	7	6.0	1.6	97	582
Dallas	7	5.4	1.4	86	467
Queens, NYC	7	5.1	1.0	151	776
San Francisco/Oakland	6	6.0	1.2	103	618
Cleveland	6	6.0	1.0	79	474
Philadelphia	3	20.0	1.3	69	1,380
New Orleans	3	10.0	2.0	35	350
Brooklyn, NYC	3	4.0	1.0	47	188
Pittsburgh	1	54.0	3.0	15	810
Boston	1	35.0	1.0	20	700
Denver	1	30.0	3.0	20	600
Jersey City	1	18.0	3.0	19	342
Orlando	1	12.0	1.0	7	84
St. Louis	1	3.0	1.0	21	63
Non-Urban	37	6.7	1.5	356	2,396
Total	**114**	**7.6**	**1.4**	**1,579**	**12,016**

NOTE: Average number of participants = 14

Percent of Outreach Participants Feeling Well Prepared† in Each of the Following

	Pre (N = 971)	Post (N = 467)	Diff.
Kinematics	52	69	17*
Waves and sound	49	66	17*
Using toys to teach concepts in physics/physical science	38	54	17*
Newton's Third Law	56	72	16*
Dynamics	53	69	16*
Simple machines	52	68	16*
Incorporating teacher demonstrations in your science instruction	61	76	15*
Energy	59	73	14*
Momentum	53	67	14*
Incorporating laboratory activities in your science instruction	61	74	13*
Electricity and electric circuits	46	57	11*
Heat and heat transfer	52	61	9*
Electrostatics	39	48	9*
Incorporating the use of computer-interfacing devices in your science instruction	23	31	9*
Gravity	59	67	8*
Geometric optics	30	38	8*
Incorporating calculator-based labs in your science instruction	26	34	8*
Physics of fluids	25	33	8*
Incorporating the use of cooperative learning, in your science instruction	56	63	7*
Magnetism	43	50	7*
Radioactivity/nuclear science	23	30	7*
Incorporating the use of the World Wide Web in your science instruction	39	45	6*
Incorporating the use of graphing calculators in your science instruction	21	26	6*
Color and vision	33	38	5*
Lightwave communication	20	26	5*
Astronomy	22	26	4*
Elementary particles	34	38	3
Incorporating the use of the ripple tanks in your science instruction	21	25	3
Physics of music	20	21	1
Incorporating the use of the Global Positioning System in your science instruction	11	12	1
Physics of medicine	10	11	1

† Includes those indicating 4 or 5 on a five-point scale ranging from 1 "Not well prepared" to 5 "Very well prepared."

* Post-workshop percentage statistically higher than pre-workshop percentage (one-tailed z-test, $p < 0.05$).

Qualitative statements from Outreach Participants as to the quality and impact of the Urban summer workshops.

I appreciate having access to other physics teachers, as my school doesn't have any, and they've really helped clarify concepts for me.

My math background meant I needed support, but after the workshops, I'm a stronger physics teacher and my students benefit too. The hands-on demonstrations were much more effective than just reading labs.

PTRA provided valuable equipment and many activities for my classes, and I've learned a lot—especially about topics like sound that I didn't know before.

PTRA is better than other PD experiences because it's applicable to what I teach and I can use the activities in class. I'll keep going and getting ideas.

Other professional development is not science oriented. This is more towards my subject, and I find it more useful. It compares [to other professional development offerings] very well.

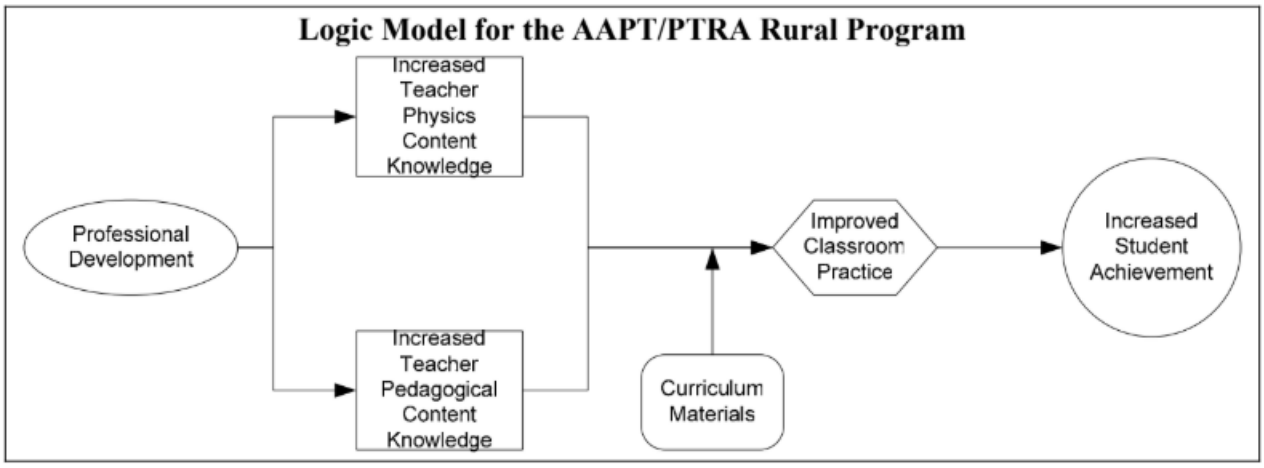
I have gone to the state science convention, and I try to go to workshops there and keep up. It compares really well; you get ideas and make things.

They make you feel comfortable; they treat you professionally.

The Rural grant broadened the scope of the Urban grant by incorporating 5E learning cycles, assessing participants before and after summer outreach institutes, and evaluating students taught by outreach participants during the subsequent school year. The primary objective of the AAPT/PTRA Rural project is to support isolated and underserved rural teachers by leveraging the experience, expertise, and resources of the established PTRA program. This initiative seeks to provide these educators with opportunities for professional growth in physics content, instructional technology, and proven teaching methodologies. Furthermore, participating teachers will form a professional, collaborative network.

To achieve these objectives, the project utilizes a trainer-of-trainers model. The first tier comprises PTRAs, who are typically distinguished physics educators. During a week-long PTRA Institute, PTRAs receive training to conduct workshops covering a broad range of physics topics. These workshops generally span six hours and emphasize familiarizing trainers with classroom activities outlined in the workshop manual. The institute also facilitates networking and the exchange of ideas focused on classroom instruction and effective workshop leadership. The principal aim of the summer institute is to equip PTRAs with the knowledge and skills necessary to successfully lead outreach programs for rural teachers.

With this focus the AAPT/PTRA summer institutes goals shifted to the following



The Rural Grant included assessments for the participants and students of participants. From 2004 to 2005 school year forty-nine teachers from summer institutes with 1550 students took pre and post tests on the topics of kinematics, dynamics, momentum and energy. Results were analyzed using a matched pair. There was a marked difference in the pre-to-post test scores for students whose instructors attended two summer institutes as opposed to students whose instructors had only attended one summer institute. The success of the PTRA program led other states to implement the PTRA model. One such institution was the Idaho State University. The AAPT/PTRA program was extended through MSP grants for thirteen years.

The rationale for the successful implementation of professional development was why the AAPT/PTRA model was chosen. AAPT/PTRA is recognized by the physics community as the most successful long-term program for PD of physics and physical science for K-12 educators. PTRA provided a cadre of experienced PD providers and mentors, assessment instruments, and infrastructure for PD. In addition, the AAPT/PTRA project has had a successful working relationship with ISU and Idaho teachers from 2004 to 2017.

The APEX Grant the Alliance for Physics Excellence (APEX) Project (2013-2017) funded by National Science Foundation Mathematics Science Partnership grant DUE 1238192 has several unique aspects. As a statewide professional development project, APEX served 68 high school teachers who teach physics.

Prior PTRA workshops have documented the effectiveness of the PTRA PD model and leaders. In the summer of 2016, the PTRAs provided PD to over 100 teachers at the University of West Georgia. The results of the workshop presented in the report to the Department of Education included the following statistics:

- Self-reported data for changes in pedagogical understanding and confidence showed positive gains for all measures. The greatest gains were in developing scientific models, Integration of STEM into the curriculum, and guiding students through investigative lab extensions.
- Relative to middle school content assessment, 77% had statistically significant gains in content understanding.
- Results of pre and post classroom observations were quite dramatic. In every case, the means increased as rated in the spring and the following fall observations, presumably because of the summer intervention. Of the ten items on the O-TOP, six were determined to be statistically significant at a level

of 0.001. The effects of teaching experience on student achievement have been found to be significant, and the compounded positive effect of having a series of accomplished, experienced teachers for several years in a row offers the opportunity to reduce or close the achievement gap for low-income students and students of color10. Research has shown that to affect pedagogical change and increase confidence in content, teachers need PD that allows teachers an opportunity to process new information

- The PTRA approach has been to provide multiple PD sessions over extended periods with a cadre of teachers from novice to master teacher, thereby forming a network of support for teachers entering their careers but also encouraging the exchange of ideas and approaches at all levels.

Taken together, four decades of AAPT/PTRA programming demonstrate that sustained, teacher-led professional development grounded in research-based pedagogy, strong content preparation, and ongoing community support leads to meaningful changes in teaching practice and improved student outcomes. Across Urban, Rural, MSP, and APEX initiatives, evidence consistently shows that extended engagement, standardized instructional frameworks, and a trainer-of-trainers model build teacher confidence, deepen content knowledge, and foster professional networks that reduce isolation—particularly for underserved and rural educators. The documented gains in pedagogical practice, content understanding, and student learning underscore the effectiveness and scalability of the PTRA model. These outcomes, coupled with the program's established infrastructure and history of successful partnerships, position AAPT/PTRA as a proven and sustainable platform for advancing physics teacher professional development and for addressing persistent inequities in access to high-quality STEM education.