# Annual Evaluation Report for Rural Physics Teacher Resource Agents

## Covering Period from June 2005 to April 2006

**Sherri L. Fulp**
**Eric R. Banilower**

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Submitted to:

George Amann
193 Primrose Hill Road
Rhinebeck, NY 12572

Karen Jo Matsler
3743 Hollow Creek
Arlington, TX 76001

Warren Hein
American Association of Physics Teachers
One Physics Ellipse
College Park, MD 20740-3845

Jim Nelson
4345 NW 36th Drive
Gainesville, FL 32605

Jan Mader
2223 5th Avenue, SW
Great Falls, MT 59404

Submitted by:

Horizon Research, Inc.
326 Cloister Court
Chapel Hill, NC 27514-2296

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# Executive Summary

In July of 2005, the AAPT/PTRA Rural Project gathered 73 PTRAs at the University of Utah in Salt Lake City for the annual AAPT/PTRA Leadership Institute. The major goal for the summer institute is to provide the PTRAs with the knowledge and skills needed to effectively lead outreach institutes for rural teachers. The AAPT/PTRA project offered eight workshops during the Summer Leadership Institute, covering topics such as inquiry, graphical analysis, physlets, and geometric optics. Data collected on a post-institute questionnaire indicate that a majority of PTRAs rated the instruction in each workshop as high in quality. The data also show that the institute had a positive impact on the PTRAs feelings of preparedness to integrate the content of the workshops into the professional development they lead for outreach teachers. Still, even after the AAPT/PTRA Leadership Institute roughly 2 out of 5 PTRAs indicated a substantial need for additional training in how people learn, technologies for physics instruction, common misconceptions/student thinking in physics, and research on and strategies to implement the principles of effective professional development.

The project operated 34 Rural Regional Sites during its fourth year, serving a total of 680 outreach teachers in rural summer institutes. Fifty-five percent of these teachers attended a follow-up session during the school year. In terms of meeting the project's goal of providing three years of professional development for outreach teachers, 144 of the 418 outreach participants in sites that have existed for at least three years have attended rural institutes for at least three years. However, the data show that the project has made major improvements in retaining outreach participants; 50 percent of participants in sites inaugurated in 2003 have attended for three years, compared to 15 percent in sites started in 2001 and 24 percent in sites started in 2002.

By linking data across years from an outreach participant questionnaire, HRI examined changes in participants' feelings of preparedness and reports of classroom practices. Analyses show that participants' perceptions of their pedagogical preparedness were significantly higher after one year of AAPT/PTRA professional development, with another significant increase after a second year of AAPT/PTRA professional development. Participant perceptions of their physics content preparedness were significantly higher after one year of professional development, but did not increase significantly after a second year of professional development.

Results from a teacher content knowledge impact study provide additional evidence that the AAPT/PTRA rural project is having a positive impact on participants' physics content knowledge. An assessment focusing on ideas in force and motion was administered to all teachers attending a summer rural institute, once at the beginning of the institute and again at the end of the institute. The study found that teachers scored about 6.5 percentage points higher on the post-test than on the pre-test (an effect size of 0.60 standard deviations), getting approximately 2 more out of the 28 items correct on the post-test than on the pre-test.

The AAPT/PTRA Rural Project also appears to be having an impact on how physics is being taught. Outreach participants' report of their frequency of use of investigative teaching practices increased significantly after one year of AAPT/PTRA professional development. The extent to which teachers create an investigative classroom culture also increased significantly after one

year of AAPT/PTRA professional development. In addition, participants' use of traditional teaching practices was significantly lower after two years of professional development than prior to participation.

**Recommendations**

The key to the AAPT/PTRA Rural Project's success is preparing the PTRAs to provide high-quality professional development in outreach workshops. One of the strengths of the project is that most, if not all, PTRAs have strong physics backgrounds and a great deal of experience teaching physics prior to joining the project. Another strength of the project is the collection of instructional resources that has been amassed in the creation of the AAPT/PTRA manuals. These manuals are the foundation of the outreach workshops, and the outreach participants highly value receiving the activities in them. However, leading professional development requires skills above and beyond those required to be successful in the classroom and even the best activities won't improve student learning if they are not implemented properly. It is in these areas that HRI offers the following recommendations to the project.

- **The project should consider systematically providing additional pedagogical content knowledge information with each of the AAPT/PTRA manual activities intended for use in the rural institutes.**

  In addition to being familiar with the mechanics of implementing an activity in the classroom, teachers should know several things to maximize the effectiveness of an instructional activity, including:

  - The specific learning goal(s) addressed by the activity;
  - Where in the instructional sequence the activity should be placed (i.e., what instruction students should have prior to and after experiencing the activity);
  - The conceptions/misconceptions students are likely to have prior to experiencing the activity, as well as which misconceptions the activity confronts;
  - Likely student responses to the activity (both correct and incorrect); and
  - How to wrap-up the activity to increase the likelihood that student sense-making occurs.

  Without this type of information, outreach participants may implement an activity without having a clear idea of how the activity adds to the conceptual storyline of a unit, resulting in "activity for activity's sake" (i.e., doing hands-on, but not minds-on). Although some PTRAs may integrate these aspects into their workshops, systematically building this information into the AAPT/PTRA manuals would increase the likelihood that all PTRAs do so.

  In addition, the project should consider providing PTRAs with a template cover sheet for activities that would include areas for the above information to be completed during the outreach workshop. Providing the PTRAs with such a template would emphasize the need for them to address these areas in their outreach workshops, and would provide a mechanism for the outreach participants to record this important information.

- **The project should continue to work on developing the PTRAs' abilities to facilitate high-quality professional development.**

  Just like students need opportunities to practice and receive feedback on the skills they are expected to master, the PTRAs need opportunities to practice and receive feedback on their professional development facilitation skills. Providing the PTRAs with these opportunities may require decreasing the Institute's focus on familiarizing PTRAs with classroom activities and increasing the focus on practicing and receiving feedback on leadership skills (e.g., leading discussions, informally assessing participants' understanding, helping outreach participants examine student work/focus on questioning strategies). These changes may require the project leadership to increase their work with the AAPT/PTRA Leadership Institute workshop leaders, helping them incorporate what is known from physics education research and the research on effective professional development.

# Introduction

This report summarizes the activities and findings of Horizon Research, Inc. (HRI) in its external evaluation of AAPT's Physics Teacher Resource Agents (PTRA) Rural Project since June 2005. During the period from June 2005 to April 2006, HRI has:

- Administered pre- and post-institute questionnaires to the PTRAs attending the 2005 PTRA Institute;
- Administered a questionnaire to all teachers who attended the 2005 Rural Regional outreach institutes;
- Interviewed a random sample of nine rural outreach participants;
- Assisted the project in developing and administering (in a pre-test/post-test design) a force and motion content assessment to outreach participants attending Rural Regional institutes focused on kinematics and dynamics; and
- Assisted the project in developing of and administering a student assessment in a study of the impact of the AAPT/PTRA Rural Project on students.

This report is divided into four main sections. The first provides an overview of the AAPT/PTRA Rural project and a description of the key questions guiding the evaluation. The second presents data on the 2005 PTRA Institute, including PTRAs' expectations for the institute, their perceptions of the quality of the professional development, and the impact of the institute on their preparedness to lead rural institutes. The third section reports data collected on the rural outreach institutes held during the summer of 2005. These data include a description of the 34 rural institutes, the teachers attending them, and the impacts of the institutes on teachers, their teaching, and their students. The final section summarizes the key findings and presents HRI's recommendations for the project.

# Overview of the AAPT/PTRA Rural Project and Evaluation

As stated in the grant proposal, the primary aim of the AAPT/PTRA Rural Project is to "serve isolated and neglected rural teachers by building on the experience, expertise, and resources of the existing PTRA program. The project will provide opportunities for these teachers to grow professionally in physics content, in the use of technology for instruction, and in established teaching strategies. Additionally these teachers will develop into a professional and supportive network." To accomplish these goals, the project has adopted a trainer-of-trainers approach. The first tier consists of the PTRAs, typically accomplished physics teachers. At annual week-long AAPT/PTRA Leadership Institutes, the PTRAs are trained to present workshops on a wide variety of physics and pedagogical topics. Most institute workshops are six-hours in length and focus on familiarizing the PTRAs with the classroom activities in the AAPT/PTRA manual. The institute also provides opportunities for the PTRAs to network and share ideas related to the classroom and to workshop leadership. The major goal for the summer institute is to provide the PTRAs with the knowledge, experience, and skills needed to effectively lead outreach institutes for rural teachers.

PTRA-led rural institutes, the second tier, are typically five days long and are intended to focus on one or two core physics topics (e.g., kinematics and dynamics). In addition, the project has included two, day-long follow-up workshops in the model. These follow-up workshops are intended to give the second tier outreach participants an opportunity to revisit concepts and skills from the preceding summer institute and to share and reflect on their efforts at incorporating what they learned into their classrooms.

The rural institutes include a strong technology component, seeking to introduce outreach participants to a number of the tools that can be used to support physics instruction, including graphing calculators and calculator/computer-based laboratory activities. These institutes also give rural teachers, who are often the only science teacher in their school, an opportunity to network with other science teachers. At this second tier, the project expects to have an impact on rural teachers' understanding of important physics content and their use of effective teaching strategies. Further, the project hypothesizes that these changes will lead to impacts in student learning.

The evaluation plan for the AAPT/PTRA Rural project contains both formative and summative components, focusing on seven key questions:

1. How successful is the project at recruiting and maintaining a cadre of PTRAs, including teachers from the areas being served by the rural sites?

2. To what extent do the AAPT/PTRA Leadership Institutes prepare PTRAs with the physics and content-specific pedagogical knowledge needed to present outreach workshops?

3. To what extent do the AAPT/PTRA Leadership Institutes prepare PTRAs with the leadership skills and professional development strategies that will enable them to design and implement extended high-quality professional development workshops that provide in-depth examination of physics content and standards-based teaching strategies?

4. How successful is the project at initiating and maintaining the network of Rural Regional Sites, including recruiting, training, and providing on-going support to each Rural Regional Coordinator?

5. How successful is the project in reaching the goal of providing 108 hours of professional development (over three years) to under-served rural teachers and what is the quality of that professional development?

6. What impacts does the project have on outreach participants' attitudes, physics and pedagogical preparedness, and classroom practices?

7. What impact does teachers' participation in the rural institutes have on their students' achievement in physics?

Although the project is not yet complete, data collected during the project's fourth year provide insight into the project's progress in reaching its goals.

## Preparation of the PTRAs: The 2005 PTRA Institute

As noted above, the goal of the AAPT/PTRA Leadership Institute is to equip the PTRAs with the knowledge and skills necessary to provide high-quality, effective professional development for rural teachers. The skills and knowledge needed by the PTRAs include:

- In-depth understanding of physics content;
- Knowledge of, and experience using, effective physics teaching strategies;
- Knowledge of effective professional development strategies/adult learning theory; and
- Skill at designing and implementing high-quality professional development.

One of the major strengths of the project is that most, if not all, PTRAs join the project with a good deal of expertise in the first two areas (the project seeks to attract expert teachers to join the PTRA ranks). Thus, the Leadership Institute can place a greater emphasis on the latter two areas, which are often difficult for teachers transitioning to the role of professional development providers to master.

The Leadership Institute incorporates a variety of activities, including presentations by physics professionals, a session in which PTRAs share a favorite classroom activity or demonstration, and opportunities for networking. However, the main component of the institute is a set of workshops that focus on various physics topics, technological tools (e.g., graphing calculators), and/or teaching strategies (e.g., inquiry, modeling). These workshops are developed by selected PTRAs, members of the project leadership, and/or other interested and knowledgeable members of the physics education community. Most of these workshops are six-hours long, though a few are as few as three or as many as twelve-hours in length. The workshops provide opportunities for the PTRAs to experience a sample of the classroom activities included in the AAPT/PTRA manuals, and a forum to discuss physics content, classroom practices, and issues of leadership.

In July of 2005, the project gathered 73 PTRAs at the University of Utah in Salt Lake City for the Leadership Institute. This year, four new PTRAs, recruited from the ranks of rural outreach participants, attended the institute. The project offered eight workshops during the 2005 PTRA Institute, covering topics such as inquiry, graphical analysis, physlets, and geometric optics. This section of the report focuses on the quality and impact of the Leadership Institute using data collected from the pre- and post-institute questionnaires.

### The PTRAs

The pre-institute questionnaire gathered a variety of data from the PTRAs, including demographic characteristics and information on their learning needs as professional development providers. Sixty PTRAs responded to the pre-institute questionnaire, a response rate of 83 percent. Table 1 shows the demographic characteristics of the responding PTRAs. Sixty-eight percent of the respondents were male, and all were white. Half taught in suburban schools, and 35 percent taught in rural schools. Seventy-eight percent taught physics and/or physical science during the 2004–05 academic year and nearly three-quarters have over 20 years of teaching experience. The majority of attendees became PTRAs prior to 1997; 14 percent have become PTRAs since the beginning of the rural project in 2002.

**Table 1**
**Demographic Data for PTRAs Attending the 2005 Summer Institute**

| | Percent of Responding PTRAs (N = 60) |
|---|---|
| **Physics/Physical Science in 2004–05 Academic Year** | 78 |
| **Gender** | |
| Male | 68 |
| Female | 32 |
| **Race/Ethnicity** | |
| White | 100 |
| Asian or Pacific Islander | 0 |
| American Indian or Alaskan Native | 0 |
| African-American | 0 |
| Hispanic | 0 |
| Other | 0 |
| **Location of School** | |
| Suburban | 50 |
| Rural | 35 |
| Urban | 15 |
| **Year Originally Became a PTRA** | |
| 1985–1988 | 29 |
| 1992–1996 | 29 |
| 1997–2001 | 29 |
| 2002–2005 | 14 |
| **Membership in Professional Organizations** | |
| AAPT | 95 |
| NSTA | 55 |
| **Years of Physics/Physical Science Teaching Experience** | |
| 0–5 Years | 3 |
| 6–10 Years | 7 |
| 11–15 Years | 5 |
| 16–20 Years | 12 |
| 21 or More Years | 72 |

## The Quality and Impacts of the PTRA Institute

### *PTRAs' Needs and Expectations*

Knowing what participants' needs and expectations are for a professional development experience can provide valuable insight into their perceptions of the quality of that experience. The pre-institute questionnaire asked PTRAs the extent to which additional training in a number of areas would help them become more effective professional development providers. About half of the PTRAs indicated a need for at least a moderate amount of additional training in the research on how people learn, principles of effective professional development, and common misconceptions/student thinking in physics. (See Table 2.) Relatively few PTRAs indicated a moderate or greater need for additional training in physics content (20 percent) or activities for physics instruction (30 percent).

**Table 2**
**PTRAs' Perceived Needs for Additional Leadership Training**

| | Percent of Responding PTRAs (N = 60) | | |
|---|---|---|---|
| | **No additional training** | **A little additional training** | **Moderate amount to a lot of additional training** |
| The research on how people learn | 9 | 41 | 50 |
| The research on the principles of effective professional development | 5 | 47 | 48 |
| The research on common misconceptions/student thinking in physics | 2 | 51 | 47 |
| Strategies for implementing the principles of effective professional development in workshops for other teachers | 5 | 53 | 42 |
| Technologies for physics instruction | 5 | 54 | 41 |
| Activities for physics instruction | 3 | 67 | 30 |
| Physics content | 15 | 65 | 20 |

PTRAs' responses to an open-ended item on the questionnaire regarding what they hoped to gain from the Leadership Institute provided further insight into their perceived needs for leadership training. The most common response, given by 55 of the 58 PTRAs answering this question, was becoming familiar with new activities and/or learning new strategies. Of these 55 respondents, 29 specifically mentioned activities/strategies to use in leading workshops, 3 mentioned activities/strategies for use in their classrooms, 15 referred to both workshop and classroom use, and 8 were nonspecific. Learning physics content and networking with their colleagues were also mentioned by quite a few PTRAs (15 and 14, respectively). Taken as a whole, these data indicate that many PTRAs entered the institute focusing on what would benefit them both as a workshop leader and as a teacher. As two PTRAs described their goals:

> *I hope to gain added information about physics and physics teaching. I would also like to gain information on how to plan and conduct a PTRA workshop. I am also looking forward to the networking with physics teachers and exchange of ideas and information.* (New PTRA)
>
> *I want to improve and enhance my understanding of common misconceptions and learn effective methods to overcome these problems. I want to learn and develop new activities to bring a better understanding of physics concepts to my students and workshop participants.* (Veteran PTRA)

***PTRAs' Experiences at the AAPT/PTRA Leadership Institute***

The main vehicle for preparing the PTRAs as professional development providers is the institute workshops. The project offered seven workshops during the 2005 PTRA Institute, plus a leadership session. The post-institute questionnaire asked the PTRAs a number of questions about the institute, including which workshops they participated in and the quality of those workshops. Fifty-seven PTRAs returned the post-institute questionnaire, a response rate of 78 percent.

Table 3 shows the title, duration, and percentage of PTRAs taking each workshop. The workshops taken by the greatest number of PTRAs were *Ranking Tasks/TIPERs* ("Tasks Inspired by Physics Education Research") and *Inquiry*, with 86 and 84 percent participation, respectively.

**Table 3**
**Participation Data for Workshops Offered during the 2005 PTRA Institute**

| | Duration (Hours) | Percent of Responding PTRAs (N = 57) |
|---|---|---|
| Ranking Tasks/TIPERs | 6 | 86 |
| Inquiry | 6 | 84 |
| Make and Take | 3 | 70 |
| Leadership | 3 | 67 |
| | | |
| Graphical Analysis | 6 | 56 |
| CASTLE | 12 | 52 |
| Geometric Optics | 6 | 52 |
| Physlets | 6 | 52 |

The PTRAs clearly found the workshops worthwhile; a majority of PTRAs rated the quality of instruction in each workshop as high in quality. (See Table 4.) Over 90 percent of responding PTRAs rated *Ranking Tasks/TIPERs, CASTLE*, and *Make and Take* highly.

**Table 4**
**PTRAs Rating Workshop Instruction as High Quality†**

| | N‡ | Percent of Responding PTRAs |
|---|---|---|
| Ranking Tasks/TIPERs | 46 | 98 |
| CASTLE | 28 | 96 |
| Make and Take | 37 | 92 |
| Physlets | 27 | 89 |
| | | |
| Inquiry | 46 | 87 |
| Graphical Analysis | 28 | 86 |
| Leadership | 34 | 74 |
| Geometric Optics | 28 | 68 |

† Includes those who rated the workshop a 4 or 5 on a five-point scale from 1 "poor" to 5 "excellent."

‡ By design, not all PTRAs participated in each workshop; the total number responding for each workshop is included in the table.

The PTRAs were also asked about the extent to which the institute focused on various goals related to their preparation as professional development providers. Because the project has been working to increase its focus on preparing PTRAs as professional development providers, rather than just as classroom teachers, Table 5 shows responses to this set of questions from both the 2005 and 2004 institutes. The data indicate that the project has been successful in shifting the emphasis of the institute; significantly more PTRAs in 2005 than in 2004 reported learning about the research on how people learn, the research on common misconceptions in physics, research on the principles of effective professional development, and strategies for implementing those principles into workshops (with effect sizes[1] ranging from 0.33 to 0.72).

**Table 5**
**PTRAs' Indicating that each of the**
**Following Occurred to a Large Extent† at the Summer Institute, by Year**

| | Percent of Responding PTRAs | | Effect Size |
|---|---|---|---|
| | 2004 (N = 56) | 2005 (N = 57) | |
| Learned about the research on how people learn* | 25 | 60 | 0.72 |
| Learned about the research on common misconceptions in physics* | 39 | 65 | 0.53 |
| Learned about the research on the principles of effective professional development * | 33 | 53 | 0.41 |
| Learned strategies for implementing the principles of effective professional development into workshops for other teachers* | 54 | 70 | 0.33 |
| Gained activities for physics instruction | 86 | 89 | — |
| Gained experience with technologies for physics instruction | 68 | 64 | — |
| Learned physics content | 53 | 61 | — |

† Includes those who rated the item 4 or 5 on a five-point scale from 1 "not at all" to 5 "to a great extent."

* Percentage of 2005 respondents indicating the occurrence of the topic to a large extent is significantly different than the percent of 2004 respondents (two-tailed z-test, $p < 0.05$).

As can also be seen in Table 5, nearly all PTRAs indicated that the institute focused heavily on activities for physics instruction. However, the PTRAs appear to have gotten the message that the activities in the institute were meant to help them as professional development providers. On an open-ended item on the post-institute questionnaire, the PTRAs were asked to explain what they had gained as a result of their participation in the summer institute that would help them in their role as professional development providers. Twenty-nine of the 42 PTRAs responding to this item indicated they had gained activities and strategies. Of these 29 PTRAs, 18 specifically mentioned gaining activities/strategies for leading workshops, nine mentioned learning activities/strategies in general and, 2 mentioned learning activities/strategies for teaching students. Examples of PTRAs' responses include:

> *I feel I've gained many more strategies for helping other teachers not only teach physics and physical science more effectively but also to help them learn physics content themselves.* (Veteran PTRA)

[1] Effect sizes of about 0.20 are typically considered small, 0.50 medium, and 0.80 large. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates.

> *I developed further understanding in the use of inquiry learning in my own workshops. I obtained additional materials to assist in preparing other teachers to become more effective.* (Veteran PTRA)

Other responses to the open response item included the opportunity to network with other PTRAs and increased confidence/enthusiasm, noted by 5 and 4 PTRAs, respectively.

***Impacts of the PTRA Institute***

By comparing responses from the pre- and post-institute questionnaires, HRI is able to examine the impact of the institute on the PTRAs' perceptions of their preparedness to lead outreach participant workshops.[2] The questionnaires probed two aspects of the PTRAs' preparedness to apply what they learned in the Leadership Institute to their outreach workshops. The first aspect was their preparedness to deepen outreach participants' understanding of the physics content related to the workshop. The second was their preparedness to train outreach participants to implement the activities/instructional strategies from the workshop in their own classrooms.

As can be seen in Table 6, for each of the seven workshops the change in preparedness to deepen teachers' understanding of related physics content was greater for PTRAs participating in a workshop than non-participants. Particularly large gains were seen for *CASTLE*, *Inquiry*, and *Ranking Tasks/TIPERS*. For example, prior to the institute, 29 percent of PTRAs felt well prepared to deepen teachers understanding of the physics content related to *Ranking Tasks/TIPERS*. After the institute, 89 percent of the PTRAs attending that workshop, compared to 14 percent of the PTRAs not attending that workshop, felt well prepared to deepen teachers' understanding of related content.

Although PTRAs participating in the *Physlets* workshop had larger gains in preparedness than non-participants, nearly half of the participating PTRAs did not feel well prepared after the workshop. This result may be due to the nature of the *Physlets* workshop, which centers on computer simulations related to a wide variety of physics topics. The relatively high preparedness of non-participants in *CASTLE* and *Graphical Analysis*, both before and after the institute, is likely due to many of the PTRAs attending these workshops in previous years and maintaining their feelings of preparedness.

[2] HRI was able to match the pre- and post-questionnaire responses of 52 PTRAs; some PTRAs submitted one, but not both questionnaires.

**Table 6**
**PTRAs Feeling Well Prepared† to Deepen Teachers' Understanding of Related Physics Content, by Workshop Participation**

| | Percent of Responding PTRAs | | |
|---|---|---|---|
| | N‡ | Pre | Post |
| **CASTLE (Electricity)*** | | | |
| Participants | 26 | 23 | 96 |
| Non-Participants | 24 | 75 | 75 |
| **Geometric Optics *** | | | |
| Participants | 23 | 35 | 65 |
| Non-Participants | 21 | 29 | 38 |
| **Graphical Analysis*** | | | |
| Participants | 24 | 63 | 96 |
| Non-Participants | 22 | 77 | 77 |
| **Inquiry*** | | | |
| Participants | 41 | 32 | 88 |
| Non-Participants | 6 | 33 | 17 |
| **Make and Take*** | | | |
| Participants | 35 | 57 | 89 |
| Non-Participants | 11 | 55 | 36 |
| **Physlets*** | | | |
| Participants | 25 | 20 | 56 |
| Non-Participants | 19 | 37 | 42 |
| **Ranking Tasks/TIPERS*** | | | |
| Participants | 45 | 29 | 89 |
| Non-Participants | 7 | 29 | 14 |

† Includes those who rated the item a 4 or 5 on a five-point scale from 1 "not adequately prepared" to 5 "very well prepared."

‡ By design, not all PTRAs participated in each workshop; the total number responding for each workshop to both the pre- and post-institute questionnaires is included in the table.

* The change in participants' perceptions of preparedness is statistically different than non-participants' change (Ordinal Regression, $p < 0.05$).

When PTRAs did not feel well prepared to apply what they learned in a workshop to deepen teachers' understanding of related physics content, the post-institute questionnaire asked them to explain why the session did not better prepare them. The most common response, given by 12 of the 26 PTRAs replying to this question, was that they needed more time to become familiar with the workshop. Of these 12, 10 specifically mentioned needing more experience with the activities and strategies presented in the workshop. As two PTRAs wrote:

> *This was my first AAPT[/PTRA] meeting and was the first time I saw the AAPT[/PTRA] material. We could not cover all the material in the handouts. I will just need time to look over the material and do some of the experiments myself. I wouldn't feel comfortable unless I had done them myself.* (New PTRA)

> *Basically my sense of preparedness is because I have not yet applied what I have learned. I am sure that once I apply the Salt Lake City workshop program I will be secure in success.* (Veteran PTRA)

HRI also compared the PTRAs' preparedness before and after the institute to train teachers to implement the activities/instructional strategies from the workshop in their own classrooms.

PTRAs participating in each of the seven workshops had significantly greater increases in their perceptions of preparedness to help teachers use the resources from a workshop in their instruction than non-participants. (See Table 7.) As was the case with deepening teachers' content knowledge, PTRAs in the *CASTLE*, *Inquiry Tasks*, and *Ranking Tasks/TIPERS* workshops had particularly large changes relative to non-participants.

**Table 7**
**PTRAs Feeling Well Prepared[†] to Train Teachers to Use the Resources in their Classroom Instruction, by Workshop Participation**

| | Percent of Responding PTRAs | | |
|---|---|---|---|
| | **N[‡]** | **Pre** | **Post** |
| **CASTLE (Electricity)*** | | | |
| Participants | 27 | 15 | 96 |
| Non-Participants | 23 | 70 | 74 |
| **Geometric Optics *** | | | |
| Participants | 25 | 40 | 80 |
| Non-Participants | 21 | 24 | 43 |
| **Graphical Analysis*** | | | |
| Participants | 24 | 58 | 88 |
| Non-Participants | 20 | 75 | 75 |
| **Inquiry*** | | | |
| Participants | 41 | 24 | 85 |
| Non-Participants | 5 | 20 | 20 |
| **Make and Take*** | | | |
| Participants | 32 | 53 | 78 |
| Non-Participants | 10 | 40 | 30 |
| **Physlets*** | | | |
| Participants | 24 | 13 | 63 |
| Non-Participants | 18 | 39 | 39 |
| **Ranking Tasks/TIPERS*** | | | |
| Participants | 44 | 27 | 95 |
| Non-Participants | 6 | 17 | 0 |

† Includes those who rated the item a 4 or 5 on a five-point scale from 1 "not adequately prepared" to 5 "very well prepared."

‡ By design, not all PTRAs participated in each workshop; the total number responding for each workshop to both the pre- and post-institute questionnaires is included in the table.

* The change in participants' perceptions of preparedness is statistically different than non-participants' change (Ordinal Regression, $p < 0.05$).

Again, the most common reason PTRAs did not feel well prepared to help teachers implement resources in their classroom instruction, given by 16 of the 26 respondents, was that they needed more time to become familiar with the workshop. Eleven of these 16 specifically mentioned needing more experience with the activities and strategies presented in the workshop. As two PTRAs wrote:

> *I need to read the manual to feel comfortable with the ideas.* (Veteran PTRA)
>
> *I want to use these in my own classes for a while before I encourage others to do the same.* (Veteran PTRA)

The PTRAs were also asked a series of questions on the pre- and post-institute questionnaires regarding their preparedness to lead professional development. These items were combined into a composite variable to reduce the unreliability associated with individual survey items. (Definitions of the composite variable, a description of how it was created, and reliability information are included in Appendix A.) The composite has a minimum possible score of 0 and a maximum possible score of 100. A score of 0 would indicate that a PTRA selected the lowest response option for each item in the composite, whereas a score of 100 would indicate that a PTRA selected the highest response option for each item.

The composite measures PTRAs' feelings of preparedness to do a number of activities in their workshops, such as helping other teachers (1) develop an understanding of physics concepts, (2) examine science teaching strategies, and (3) develop questioning strategies to elicit student understanding. By linking PTRAs' responses from the pre- and the post-institute questionnaires, HRI is able to examine changes in this composite score. As can be seen in Table 8, PTRAs' perceptions of their preparedness to provide professional development increased significantly after participating in the summer institute. The effect size for the change is very large, 1.01 standard deviations.

**Table 8**
**Composite: PTRAs' Perceptions of their Preparedness to Provide Professional Development**

| (N = 52) | Mean | Standard Deviation |
|---|---|---|
| Pre | 68.16 | 15.43 |
| Post* | 80.82 | 12.96 |

* Post-questionnaire composite score significantly greater than pre-questionnaire composite score (one-tailed dependent samples t-test, $p < 0.05$).

On both the pre- and post-institute questionnaire, PTRAs were asked the extent to which they needed leadership training in each of a number of areas. It was hypothesized that participation in the AAPT/PTRA Leadership Institute would result in a decreased need for additional training. As can be seen in Table 9, after attending the institute, there appears to be a downward trend in the percent of PTRAs perceiving a need for additional training in several areas, although the differences were not statistically significant. It is also noteworthy that roughly 2 out of 5 PTRAs indicated a substantial need for additional training in how people learn, technologies for physics instruction, common misconceptions/student thinking in physics, and research on and strategies to implement the principles of effective professional development. This finding indicates that the project may need to take additional steps to adequately prepare all PTRAs for their role as professional development providers.

**Table 9**
**PTRAs Indicating a Substantial Need† for Additional Leadership Training**

| | Percent of Responding PTRAs (N = 51) | | |
|---|---|---|---|
| | **Pre‡** | **Post** | **Difference§** |
| The research on how people learn | 48 | 38 | -10 |
| Technologies for physics instruction | 45 | 40 | -5 |
| Activities for physics instruction | 30 | 26 | -4 |
| The research on the principles of effective professional development | 47 | 45 | -2 |
| The research on common misconceptions/student thinking in physics | 44 | 42 | -2 |
| Strategies for implementing the principles of effective professional development in workshops for other teachers | 43 | 43 | 0 |
| Physics content | 18 | 18 | 0 |

† Includes those who rated the item 3 or 4 on a four-point scale from 1 "I don't need any additional training" to 5 "I could use a lot of additional training."

‡ The pre-institute percents shown here are different than those shown in Table 2 as this table includes responses from only those PTRAs that completed both a pre- and post-institute questionnaire.

§ Post-institute responses are not significantly different than pre-institute responses (Wilcoxin Signed Ranks Test, $p \geq 0.05$).

Data from PTRAs' responses to an open-ended item on the post-institute questionnaire that asked what additional training would be helpful in preparing them for their role as a professional development provider also indicate that PTRAs would like more training in many of these areas. The most common request was for more activities and strategies, given by 27 of the 42 PTRAs responding to this question; 12 of these respondents specifically mentioned wanting activities/strategies to use in leading a workshop. Additionally, 8 of the 42 respondents requested more information on how students learn physics/common misconceptions, 5 asked for more physics content knowledge, 4 asked for information on physics education research in general, and 4 asked for more time to interact with their peers at the institute. Examples of comments made by PTRAs include:

> *I feel inadequately prepared to help other teachers understand how people learn and common misconceptions students have in physics.* (Veteran PTRA)
>
> *I can always use help with using activities and strategies for professional development.* (Veteran PTRA)

As a final indicator of the impact of the institute, PTRAs were asked in what ways the outreach workshops they lead will be different as a result of attending the summer institute in Salt Lake City. The most common response to this open-ended item, given by 26 of the 49 respondents, was that they would change the pedagogy used in their workshops; half of these specifically mentioned adding or increasing the focus on inquiry in their workshops. The second most common response to this open-ended item, given by 18 respondents, was that the PTRAs would add more activities to their workshops. It was not clear from the responses if they intended to increase the number of activities they use in a workshop or replace some of the activities with new ones. Thus, the project may want to reemphasize to the PTRAs that new activities are meant to diversify, not overload, the workshops. Thirteen PTRAs mentioned adding ranking tasks/TIPERs in particular. Examples of PTRAs responses include:

*I will add inquiry and ranking task ideas in any workshop I give.* (Veteran PTRA)

*I will emphasize more methods of teaching and try to model them.* (Veteran PTRA)

*More inquiry activities with discussion of value. Already do this but more emphasis on process.* (Veteran PTRA)

*Greater emphasis on misconceptions and processes of thinking when developing concepts.* (Veteran PTRA)

# 2005 Rural Institutes

The main goal of the AAPT/PTRA Rural Project is to improve the teaching and learning of physics/physical science in rural classrooms via the AAPT/PTRA Rural Regional sites. The project's model is for each site to host a 30-hour summer institute and two, six-hour follow-up sessions during the school year. The summer institute is intended to focus on a small number of physics topics and provide outreach participants the opportunity for in-depth study of both the physics content and teaching strategies. The two follow-up sessions are intended to give outreach participants an opportunity to revisit the topic and reflect upon their attempts to incorporate what they learned into their classroom teaching.

Each Rural Regional Site is hosted by a local university and has a designated Rural Regional Coordinator, typically a member of the university's physics department. The coordinator's responsibilities include recruiting outreach participants, arranging facilities and equipment for the institutes, and managing all of the necessary paperwork. This arrangement makes it possible for the PTRAs to focus their energies on designing and implementing the professional development.

This section of the report examines teacher participation in, and the impacts of, the rural institutes. Data come from project records of participant attendance; a questionnaire administered to all rural institute participants; a content assessment administered to outreach teachers attending institutes focusing on kinematics and dynamics; interviews with a sample of outreach participants; and a student impact study.

## Participation in the Rural Institutes

The AAPT/PTRA Rural Project operated 34 rural regional sites[3] during its fourth year. Three of the sites were continuations of "prototype" institutes created to test the logistics of this model prior to NSF funding, 1 site was initiated in the project's first year, 7 in the second year, 14 in the third year, and 9 in the fourth year of NSF funding. Table 10 shows the number of outreach

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[3] The Colorado School of Mines hosted two institutes in 2005 and is counted twice.

participants attending each of the rural institute summer and follow-up sessions.[4] A total of 680 teachers attended the Rural Regional Site summer institutes; 55 percent of these teachers attended a follow-up session during the school year.[5] Fifty-four percent of the outreach participants reached the project's goal of 36 hours of professional development during a year.

[4] Participation data come from AAPT/PTRA Rural project records and are current as of March 30, 2006.

[5] Additionally, seven teachers attended follow-up sessions without having attended a summer institute.

**Table 10**
**Outreach Participants Attendance, by Rural Regional Site**

| Rural Regional Site | Number of Outreach Participants | | | |
|---|---|---|---|---|
| | Summer Institute and Follow-Up Session† | Summer Institute Only | Follow-Up Session Only† | At Least 36 Hours of Professional Development this Year |
| Auburn University | 0 | 9 | 0 | 0 |
| Bismarck State College | 35 | 14 | 1 | 35 |
| Brigham Young University | 12 | 3 | 1 | 10 |
| Central Pennsylvania | 10 | 6 | 0 | 10 |
| Coastal Carolina University | 0 | 18 | 0 | 0 |
| Colby College | 13 | 6 | 0 | 12 |
| Colgate University | 16 | 10 | 1 | 16 |
| Colorado School of Mines (Kinematics and Dynamics) | 6 | 16 | 0 | 6 |
| Colorado School of Mines (Momentum and Energy) | 5 | 9 | 1 | 5 |
| Eastern Kentucky University | 19 | 9 | 0 | 17 |
| Emporia State University | 9 | 7 | 2 | 8 |
| Frostburg State University | 7 | 4 | 0 | 6 |
| Georgia College and State University | 18 | 6 | 0 | 18 |
| Gonzaga University | 0 | 13 | 0 | 0 |
| Higher Education Consortium of Central California | 17 | 8 | 1 | 17 |
| Idaho State University | 28 | 17 | 1 | 28 |
| Illinois State University | 0 | 19 | 0 | 0 |
| James Madison University | 13 | 5 | 0 | 13 |
| Lee College | 14 | 7 | 1 | 14 |
| Mississippi State University | 0 | 9 | 0 | 0 |
| Montana State University | 11 | 7 | 0 | 11 |
| Ohio State University | 0 | 16 | 0 | 0 |
| Saginaw Valley State University | 23 | 3 | 0 | 23 |
| Santa Fe Community College | 7 | 0 | 0 | 7 |
| Sewanee: University of the South | 17 | 4 | 0 | 17 |
| South Dakota State University | 14 | 8 | 0 | 13 |
| State University of New York – Fredonia | 0 | 29 | 0 | 0 |
| Texas A&M University | 0 | 26 | 0 | 0 |
| Texas Tech University | | | | |
| University of Arkansas | 10 | 8 | 0 | 18 |
| University of Dallas | 8 | 2 | 1 | 7 |
| University of Pittsburg – Bradford | 9 | 9 | 0 | 9 |
| University of Wisconsin – River Falls | 13 | 3 | 1 | 11 |
| Youngstown State University | 11 | 4 | 0 | 11 |
| **Total Number‡** | **374** | **322** | **13** | **367** |

† The duration of follow-up sessions ranged from 2 to 12 hours; the median duration was 6 hours.

‡ Twenty-two outreach participants attended professional development at more than one rural regional site; these individuals are represented in the counts for each site attended. Thus, the totals slightly overestimate the number of individual teachers participating in the project.

Interviews with a sample of nine outreach participants[6] shed some light on the reasons why teachers do and do not attend follow-up workshops. Six of the 9 interviewees had attended a follow-up session during the school year, a somewhat higher rate than the 54 percent of summer institute attendees that attended a follow-up workshop. Of these 6, 3 stated that they attended the follow-ups because it was a requirement of the project. The other three attended because they found the summer institute to be highly worthwhile. As one outreach participant said:

> *[I attended] because of the effectiveness and degree to which the main courses were good for me. I got a lot out of the summer sessions, and I wanted more.*

Of the 3 participants who did not attend a follow-up session, 2 stated that the meetings were too far from their homes and inconvenient to attend; 1 said that a family function conflicted with the meeting.

The results of the interviews are consistent with data collected in previous years. Finding a meeting time that works for all participants at a rural site has been challenging. Similarly, the fact that some participants are located hundreds of miles from the rural site makes travel for a one-day workshop difficult. However, as some sites have higher rates of participation in the follow-up sessions, the project may want to create a mechanism for site leaders to share strategies they have found effective for boosting attendance.

In addition to the goal of providing at least 36 hours of professional development to participants per year, the project has the larger goal of providing at least 108 hours of professional development over the course of three years. By combining participant data provided by the project from the past several years, it is possible to examine the project's progress towards reaching this goal. As can be seen in Table 11, 144 of the 418 outreach participants in sites that have existed for at least three years have attended rural institutes for at least three years. The data also show that the project has made major improvements in retaining outreach participants; 50 percent of participants in sites inaugurated in 2003 have attended for three years, compared to 15 percent in sites started in 2001 and 24 percent in sites started in 2002.

[6] HRI attempted to interview 10 randomly selected outreach participants. Only 5 participants from the original sample of 10 agreed to be interviewed. HRI contacted another 10 participants, which yielded 4 additional interviews. The 9 interviewees represent eight different rural sites. Two of the participants had attended an institute for the first time in 2005; 7 had also participated in previous years.

**Table 11**
**Retention Rates for Outreach Participants, by Inaugural Year of the Site**

| | Inaugural Year of Rural Regional Site | | | | | Total |
|---|---|---|---|---|---|---|
| | 2001† | 2002 | 2003 | 2004 | 2005 | |
| ***Number*** **of Participants Attending** | | | | | | |
| 1 Rural Institute | 82 | 27 | 56 | 190 | 137 | **492** |
| 2 Rural Institutes | 45 | 12 | 52 | 208 | — | **317** |
| 3 Rural Institutes | 21 | 12 | 109 | — | — | **142** |
| 4 Rural Institutes | 2 | 0 | — | — | — | **2** |
| **Total** | **150** | **51** | **217** | **398** | **137** | **953** |
| ***Percent*** **Attending for at Least Three Years** | **15** | **24** | **50** | — | — | — |

† "Prototype" sites

## The Outreach Participants

A questionnaire administered at the beginning of each rural institute collected a variety of information on the outreach participants. Since the questionnaires were administered on-site at the beginning of each institute, a 100 percent response rate was achieved. As can be seen in Table 12, about half of the outreach participants were female and nearly all were white. Eighty-three percent taught high school during the 2004–05 academic year. Sixty-three percent taught physics, and 60 percent taught physical science (88 percent taught physics and/or physical science). Given the project's target audience of rural teachers, it is not unexpected that 75 percent of the outreach participants taught other science subjects, and more than 1 in 4 taught non-science classes.

Table 13 shows the number of semesters of college coursework completed by the outreach participants. Forty-five percent of the outreach participants have taken eight or more college semesters of physics/physical science; nearly one-third have taken three or fewer semesters. Outreach participants were also asked to identify those disciplines in which they are certified to teach at the secondary level. As can be seen in Table 14, 77 percent are certified to teach physics/physical science. It is important to note that several participants did not answer the questionnaire items regarding college coursework and certification to teach. If participants skipped items for which they did not have coursework/certification, these data would overestimate participants' qualifications.

**Table 12**
**Demographic Data for Outreach Participants**

| | Percent of Outreach Participants (N = 659) |
|---|---|
| **Gender** | |
| Male | 49 |
| Female | 51 |
| **Race**† | |
| White | 95 |
| Black or African-American | 3 |
| American Indian or Alaskan Native | 1 |
| Asian | 1 |
| Hispanic or Latino | 1 |
| Native Hawaiian or Other Pacific Islander | 0 |
| **Grade Level Taught**† | |
| High School | 83 |
| Middle School | 24 |
| Elementary School | 2 |
| Not a Classroom Teacher | 4 |
| **Prior Teaching Experience** | |
| 0–2 Years | 14 |
| 3–5 Years | 16 |
| 6–10 Years | 22 |
| 11–20 Years | 31 |
| 21 or More Years | 17 |
| **Teaching Assignment Includes**† | |
| Physics | 63 |
| Physical Science | 60 |
| Other Science | 75 |
| Non-Science | 29 |

† Percents may add to more than 100 as participants could select more than one category.

**Table 13**
**Outreach Participants' College Coursework**

| | | Percent of Outreach Participants | | | |
|---|---|---|---|---|---|
| | N | 0 Semesters | 1–3 Semesters | 4–7 Semesters | 8 or More Semesters |
| Life Science/Biology | 602 | 9 | 26 | 14 | 51 |
| Chemistry | 616 | 7 | 21 | 24 | 48 |
| Physics/Physical Science | 635 | 6 | 25 | 25 | 45 |
| Mathematics | 607 | 2 | 25 | 31 | 42 |
| Earth/Space Science | 589 | 21 | 40 | 19 | 21 |
| Engineering/Technology | 548 | 39 | 34 | 12 | 15 |

**Table 14**
**Outreach Participants Certified to Teach Each of the Following Subjects**

| | N | Percent of Outreach Participants |
|---|---|---|
| Physics/Physical Science | 610 | 77 |
| Chemistry | 589 | 70 |
| Life Science/Biology | 586 | 61 |
| Earth/Space Science | 563 | 49 |
| Mathematics | 564 | 31 |
| Engineering/Technology | 507 | 7 |

## Impacts of the Rural Institutes

The Outreach Participant Questionnaire asked teachers about their attitudes, beliefs, and classroom practices. These items were combined into six composite variables (Appendix A contains complete composite definitions and scale reliabilities):

1. Attitudes toward standards-based teaching;
2. Perceptions of pedagogical preparedness;
3. Perceptions of physics content preparedness;
4. Use of traditional teaching practices;
5. Use of investigative teaching practices; and
6. Use of practices that foster and investigative classroom culture.

By linking data across years, HRI is able to examine changes in these composite scores for participants completing the questionnaire on multiple occasions. Because of the increasing number of rural outreach participants that have been in the project for multiple years, HRI was able to compare participants' scores on the composite variables after varying lengths of participation. Table 15 shows the number of questionnaires submitted by 1,113 outreach participants who have completed at least one questionnaire since the project's inception.

**Table 15**
**Number of Questionnaires Completed by Outreach Participants**

| | Percent of Outreach Participants (N = 1,113) |
|---|---|
| 1 questionnaire | 59 |
| 2 questionnaires | 30 |
| 3 questionnaires | 12 |

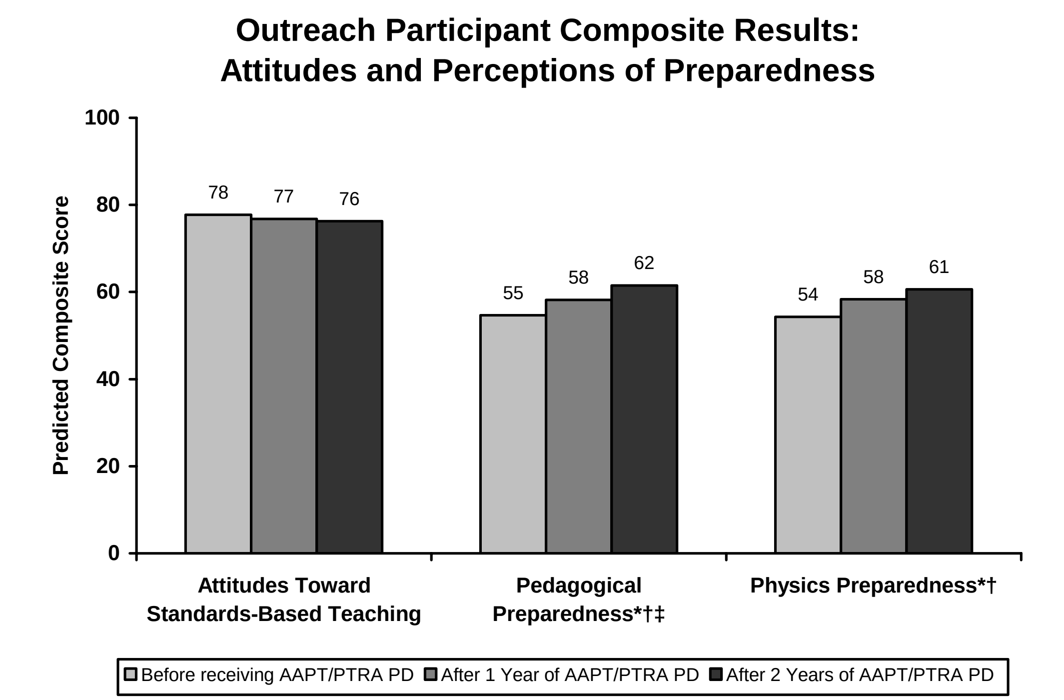
These longitudinal data have a nested structure, with time points nested within individual participants, who are nested within rural institutes. Statistical techniques that do not account for potential grouping effects (e.g., participants in one rural institute all had the same workshop experience, while participants in another rural institute all shared a somewhat different workshop experience) in nested data structures can lead to incorrect estimates of the relationship between independent factors and the outcome. Hierarchical regression modeling[7] is an appropriate technique for analyzing nested data and was used to examine trends in participants' composite scores. The analysis of these data also controlled for participant demographics (gender, grade range taught) and institute size.

Figure 1 shows the predicted composite scores (i.e., scores adjusted for the control variables) relating to the attitudes and perceptions of preparedness across the three data time points from

[7] Bryk, A.S. & Raudenbush, S.W. (1992). *Hierarchical linear models: Applications and data analysis methods.* Newbury Park, CA: Sage Publications.

the 901 participants included in these analyses.[8] These analyses show that participants' perceptions of their pedagogical preparedness were significantly higher after one year of AAPT/PTRA professional development, with another significant increase after a second year of AAPT/PTRA professional development. These yearly increases correspond to effect sizes[9] of 0.22 and 0.20 standard deviations, respectively, with a total effect size of 0.42 standard deviations for two years of professional development.

Participant scores on the perceptions of physics content preparedness composite were significantly higher after one year of professional development (an effect size of 0.21 standard deviations), but did not increase significantly after a second year of professional development. There were no significant changes in participants' attitudes towards standards-based teaching. This outcome is not surprising as participants' attitudes were high at the outset of their involvement in the project.




* Composite score after 1 year of PD is significantly higher than composite score before receiving PD (HLM, $p < 0.05$).
† Composite score after 2 years of PD is significantly higher than composite score before receiving PD (HLM, $p < 0.05$).
‡ Composite score after 2 years of PD is significantly higher than composite score after 1 year of PD (HLM, $p < 0.05$).

***Figure 1***

HRI also examined whether participation in AAPT/PTRA professional development had different impacts depending on teachers' gender and grade-level taught. Females had slightly higher scores on the attitudes composite (i.e., more positive attitudes toward standards-based teaching) than did males; elementary/middle school teachers tended to have higher scores than

[8] Some participants submitted incomplete questionnaires, which were dropped from the analyses.

high school teachers. These differences did not change based upon the amount of AAPT/PTRA professional development teachers received.

Although there were no differences in scores on the perceptions of pedagogical preparedness composite by teacher gender or grade-level taught, there were differences on the perceptions of content preparedness composite. On average, male teachers tended to have greater feelings of content preparedness than female teachers. However, this difference between male and female teachers decreased after participation in AAPT/PTRA professional development. (See Figure 2.) There was also a difference on this outcome between elementary/middle school teachers and high school teachers; this gap did not change over time.

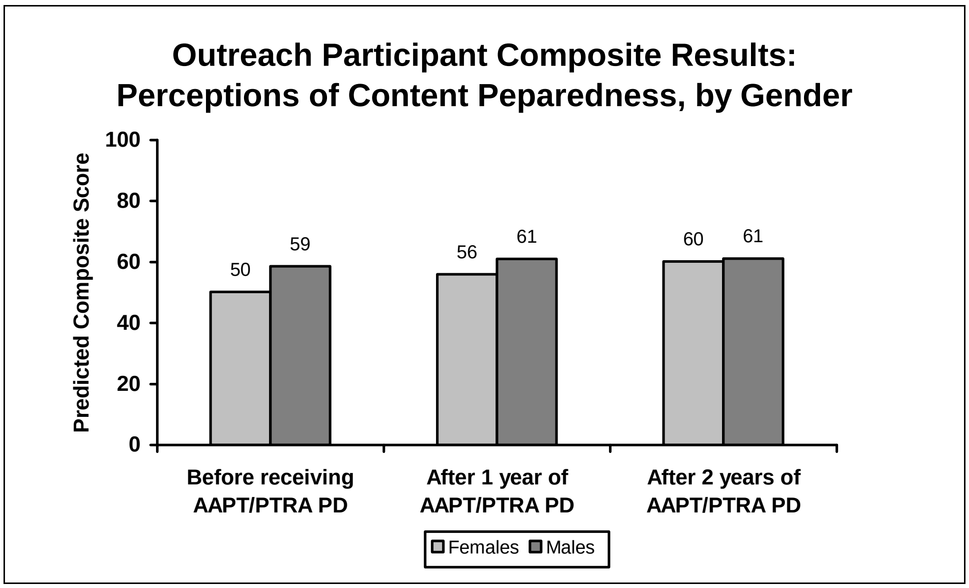



***Figure 2***

Results from a teacher content knowledge impact study provide additional evidence that the AAPT/PTRA rural project is having a positive impact on participants' physics content knowledge. A 28-item assessment focusing on ideas in force and motion was administered to all teachers attending a summer rural institute, once at the beginning of the institute and again at the end of the institute. Items for the assessment came from the NSF-supported ATLAST project (EHR-0335328) and were selected by the AAPT/PTRA rural project PIs as aligning with the goals of the rural institutes focusing on kinematics and dynamics. The assessment consisted of three types of items, all of which were set in an instructional context, measuring teachers':

- Knowledge of physics content;
- Ability to use physics content knowledge to diagnose student thinking; and
- Ability to use physics content knowledge to make instructional decisions.

The study found that the AAPT/PTRA rural institutes have had a positive impact on teachers' physics content knowledge. (See Table 16.) Teachers scored about 6.5 percentage points higher on the post-test than on the pre-test (an effect size of 0.60 standard deviations), getting approximately 2 more out of the 28 items correct on the post-test than on the pre-test. The study also found that these impacts occurred regardless of teacher gender; the same size increase was detected for male and female participants.

**Table 16**
**Teacher Assessment Results**

| (N = 192) | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|
| Pre-test | 17.86 | 96.43 | 58.48 | 20.02 |
| Post-test* | 21.43 | 100.00 | 64.99 | 20.87 |

* Post-test scores significantly higher than pre-test scores (one-tailed dependent samples t-test, $p < 0.05$).

Interviews with outreach participants support the findings from the questionnaire and the teacher assessment. Six of the 9 interviewed teachers indicated that the project had increased their physics content knowledge (with four spontaneously mentioning it when asked about impacts in general). As two outreach participants said:

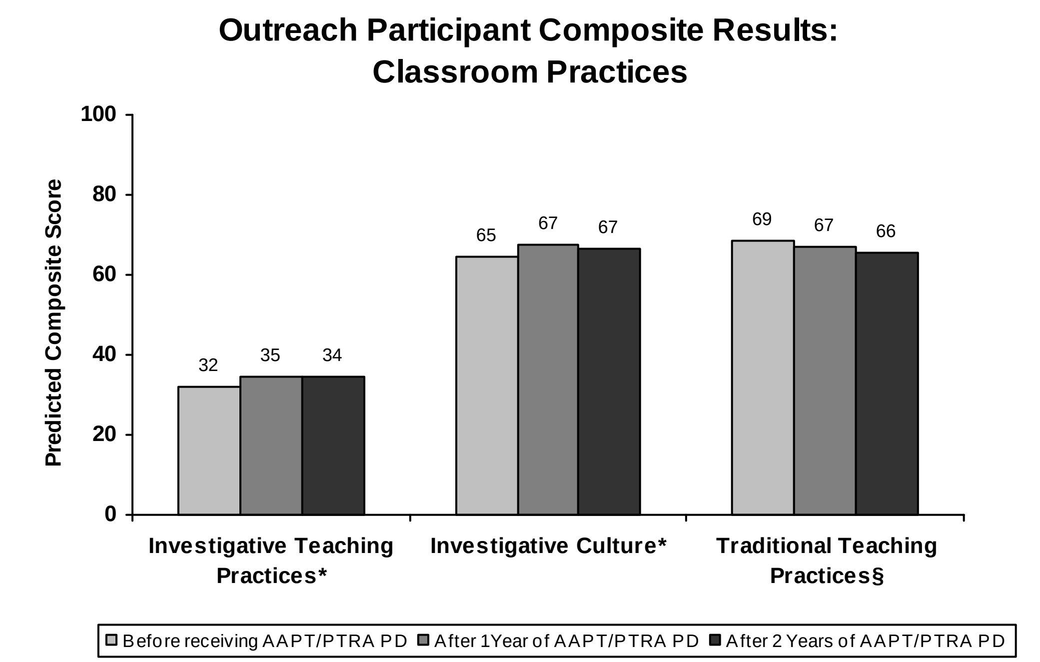
> *I felt confident going in, but it clarified some things and brought out some misconceptions that I had.*
>
> *The workshop has increased it [physics content knowledge]. With the kinematics, I got in there and was kind of lost on the formulas. It has really helped me get back into that mindset of using those things and relating to them. In particular, really dealing with the motion, in general, and using Newton's laws and applying them to everyday things. I found out there were some things I was teaching wrong; it was the right idea, but I was giving the wrong example. It cleared up some misunderstandings, I had so I could clear it up for the students…the vast quantity of material and activities we went through helped me.*

Two teachers also stated that PTRA professional development had an impact on their understanding of student learning by teaching them about common student misconceptions. As these two teachers stated:

> *We talked especially about what misconceptions students might have and how I can prevent those in the students.*
>
> *They handed out a sheet to us and gave us a text called* Five Easy Lessons *on physics, and those had misconceptions in it that the general public and students had on physics, and that was the biggest [impact]. Being able to see those and clarify them before I teach the students was good.*

The AAPT/PTRA rural project also appears to be having an impact on how physics is being taught. The outreach participant questionnaire asked teachers to describe their teaching in the first physics/physical science class of the day during the past school year. (If they did not teach physics/physical science, they were asked to describe their teaching in the first science class of the day.) Three composite variables were created from these questions to describe teaching practices. HRI compared scores on these composites across the three time points for the 746 participants who responded for the same type of class in all years in which they submitted data. These composite scores are shown in Figure 3.

Participants' report of their frequency of use of investigative teaching practices increased significantly after one year of AAPT/PTRA professional development (an effect size of 0.21 standard deviations). Scores on the investigative culture composite also increased significantly after one year of AAPT/PTRA professional development (an effect size of 0.19 standard deviations). In addition, participants' use of traditional teaching practices was significantly lower after two years of professional development than prior to participation (an effect size of -0.21 standard deviations). In addition to providing evidence of the project's impact, these data also support the project's decision to work with participants for three years.




* Composite score after 1 year of PD is significantly higher than composite score before receiving PD (HLM, $p < 0.05$).
§ Composite score after 2 years of PD is significantly lower than composite score before receiving PD (HLM, $p < 0.05$).

***Figure 3***

Participants' teaching practices composite scores were also tested for differences by gender and grade range. Elementary/middle school teachers tended to have higher scores on the investigative teaching practices composite, and lower scores on the traditional teaching practices composite, than high school teachers. Female teachers tended to have slightly higher scores on the investigative culture composite than male teachers. Although there was no difference overall between males and females on the traditional teaching practices composite, female teachers' scores decreased significantly over time while male teachers' scores stayed relatively constant. (See Figure 4.)

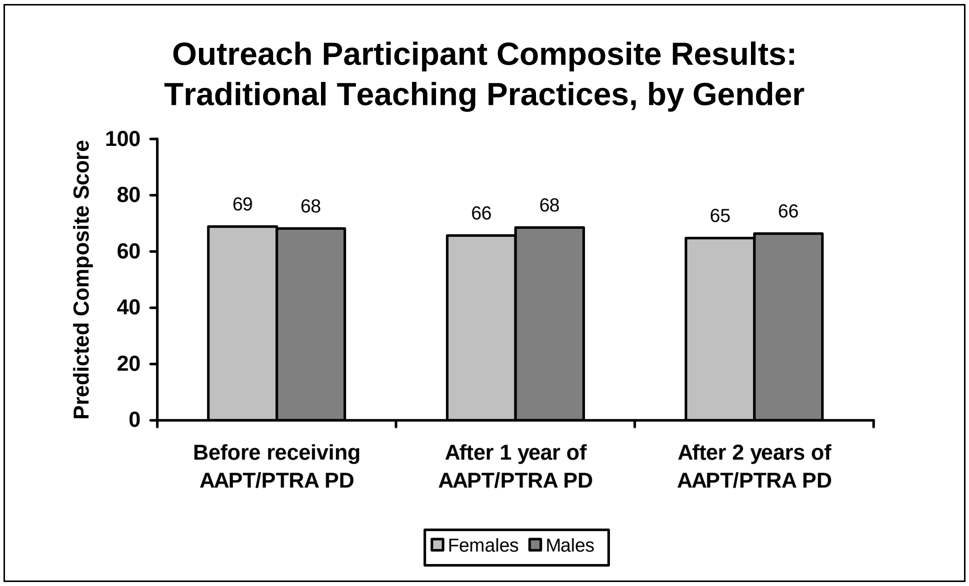



***Figure 4***

Interviews with the outreach participants provide further evidence of the project's impact on participants' teaching. All nine interviewees indicated that the AAPT/PTRA professional development had an impact on their physics/physical science teaching, specifically mentioning implementing activities and labs from the workshops into their teaching. As two participants said:

> *It has had a big impact on my teaching. I have been able to take the labs, like the ones on mechanics and momentum, and it helps me explain it all better to the students. They like it too.*

> *I spend a lot more time with labs and less with lecture.*

The interviewees also described how the changes in their teaching have led to improved student learning. All nine participants indicated that their use of AAPT/PTRA materials in their classrooms had benefited their students. Eight mentioned that their students enjoyed science more by doing all the activities provided by PTRA. Two teachers stated that the students' enjoyment in class increased their confidence in doing physics; another two indicated that their students are learning more as a result of the project. In the words of the outreach participants:

> *The hands-on activities have made it more enjoyable for them. Their enjoyment is transmitted into more willingness to participate and make an attempt to learn.*

> *My students like science more. I think because I'm more comfortable with the subject matter that I can explain it better to [my students]. And the activities give me more to*

*show them as I teach. They can actually see the principle at work and not just talk about it. I had fewer labs relating to physics than other aspects I teach, but now in doing [PTRA], I have more activities and it gives them a different perspective on science. Maybe when they get to high school, they won't be so worried about taking physics.*

*Projectile motion is difficult for students to understand. PTRA has a model to do that. By being able to have students see the half projectile and break it down in the steps in this particular problem, helped them understand the projectiles before going through the full projectile. And I used their discrepant events hand outs. They have a series of tasks that students had to evaluate, ranking tasks. Those are really great because students can assess themselves to see "do I really understand this or not" and is a really valuable tool for me to use.*

*My kids had a better knowledge of how electricity works, the majority are kids that don't understanding anything about how things wire up. This program [CASTLE] has taught this group of kids much more than any previous year's group. They do better on my tests, and I think they'll do better on the state test.*

In an attempt to more systematically investigate the impact of the AAPT/PTRA rural project on student achievement, HRI and the AAPT/PTRA rural project leadership developed a study for investigating the impact of the project on student achievement in kinematics, dynamics, momentum, and energy.[10] The study utilized a pre-test/post-test design, with teachers from the kinematics and dynamics institute serving as a comparison group for teachers from the momentum and energy institute (and vice versa). The 50-item assessment utilized in this study was developed by the AAPT/PTRA Rural Project leadership with assistance from HRI.

Although 90 teachers initially agreed to participate in the study, only 49 returned usable data. Some teachers dropped out of the study; others provided only portions of the data needed. Although HRI anticipated some drop-outs during the planning of the study, more teachers withdrew than was expected. Thus, the statistical power of the study was much lower than predicted (i.e., the probability of detecting a significant difference among the groups was smaller than hoped for).

Of the 49 teachers that returned complete data, 27 had participated in a 2004 kinematics and dynamics institute, 16 had participated in a 2004 energy and momentum institute and a 2003 kinematics and dynamics institute, and 6 had participated in only a 2004 momentum and energy institute. These 49 teachers administered the assessment to 105 classes, and 1,589 students completed both a pre- and post-test.

Student achievement was examined on two outcomes. The first outcome was performance on kinematics and dynamics items; the second outcome was performance on momentum and energy items. Teachers were classified into one of three categories: (1) participation in a kinematics and dynamics institute only, (2) participation in a momentum and energy institute only, or (3)

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[10] Full results of this study can be found in Banilower, E. R. & Fulp, S. L. (2005). Results of the 2004–05 AAPT/PTRA Rural Project Student Impact Study. Chapel Hill, NC: Horizon Research, Inc.

participation in both institutes. The analyses controlled for pre-test scores, student gender, student race/ethnicity (categorized as white/Asian or non-Asian minority), amount of instruction on the topic, class level (basic, college prep, or advanced), and class size.

For the momentum and energy outcome, HRI found no significant differences among students by whether or not their teacher participated in an AAPT/PTRA rural institute on momentum and energy (regardless of whether the teacher also participated in a kinematics and dynamics institute). HRI also found no differences among students on the kinematics and dynamics outcome by whether or not their teacher participated in an AAPT/PTRA rural institute on kinematics and dynamics. Table 17 shows the post-test means for students in each group (note: means are adjusted for student demographics and pre-test scores and represent the "typical" student across all of the teachers' classes).

**Table 17**
**Average Student Post-Test Scores,**
**by Teacher Participation in AAPT/PTRA Rural Institute**

| | AAPT/PTRA Rural Institutes Attended† | | |
|---|---|---|---|
| | 2004 Kinematics and Dynamics Institute Only | 2004 Momentum and Energy Institute and 2003 Kinematics and Dynamics Institute | 2004 Momentum and Energy Institute Only |
| Momentum and Energy Score | 48.19 | 47.83 | 43.72 |
| Kinematics and Dynamics Score | 52.42 | 52.62 | 51.06 |

† No significant differences were found in student post-test scores (controlling for pre-test scores and demographics) among the three groups (HLM, $p \geq 0.05$).

Surprisingly, for both outcomes, the amount of instructional time devoted to the topic was not related to student scores. These results could be interpreted in a number of ways. One interpretation could be that the assessment items are not well aligned with teachers' objectives for their courses. Another interpretation could be that the items are aligned, but not sensitive to instruction (in other words, the items may not be very good for the purpose of this study). A third interpretation could be that only a little instruction is needed to improve student performance in these areas, and that there are diminishing returns for further instruction. Alternatively, it could be that the teachers' instruction was just not very effective (the average kinematics and dynamics pre-test score was about 43, the post was about 53; the average momentum and energy pre-test score was about 41, the post was about 48).

In regard to the overall study findings, a number of interpretations are plausible. First, because of the smaller than expected number of teachers participating, the probability of the study finding a significant difference, if one really existed, was rather modest. A second possibility is that even though the assessment was aligned with the AAPT/PTRA Institute topics, it was not well aligned with teachers' instructional goals. Another possible explanation is that although the institutes are having a positive impact on teachers' understanding of the content (as evidenced by the teacher impact study), the institutes are having less of an impact on teachers' understanding of student learning (the common misconceptions, why people have them, and how to confront the misconceptions) and/or their ability to provide high quality instruction. A fourth interpretation could be that teachers need more time to practice what they learned in the institute before positive impacts in student achievement can be observed.

## Summary and Recommendations

The AAPT/PTRA rural project has continued to make progress. In its fourth year, the project successfully established an additional nine Rural Regional Sites, and provided professional development to roughly 700 teachers in the 34 rural summer institutes and follow-up sessions. The majority of rural institute participants reached the project's goal of 36 hours of professional development during the year. In addition, the project has greatly increased the rate at which participants return for additional years of training (50 percent of participants in sites inaugurated in 2003 compared to 15 and 24 percent for sites started in 2001 and 2002, respectively).

The professional development provided at the rural sites appears to be having a positive impact. Outreach participants have higher perceptions of pedagogical preparedness and their reported frequency of use of investigative teaching practices has increased. Data from questionnaires, interviews, and a teacher content assessment also indicate that the project has had a positive impact on participants' physics content knowledge.

The key to the project's success is preparing the PTRAs to provide high-quality professional development in outreach workshops. One of the strengths of the project is that most, if not all, PTRAs have strong physics backgrounds and a great deal of experience teaching physics prior to joining the project. However, leading professional development requires skills above and beyond those required to be successful in the classroom.

Data collected about the AAPT/PTRA Leadership Institute indicate that the project has had an impact in this area. PTRAs reported gaining activities and instructional strategies at the Leadership Institute that they can use both in their own classrooms and in their outreach workshops. PTRAs also reported a positive impact on their preparedness to implement professional development (e.g., their preparedness to help outreach teachers develop questioning strategies to elicit student understanding).

Another strength of the project is the collection of instructional resources that has been amassed in the creation of the AAPT/PTRA manuals. These manuals are the foundation of the outreach workshops, and the outreach participants highly value receiving the activities in them. However, even the best activities won't improve student learning if they are not implemented properly. In evaluating a wide array of professional development programs and observing a great deal of classroom instruction, HRI has found that teachers often need support to effectively implement new instructional materials. It is in this area that HRI offers the following recommendations to the project.

- **The project should consider systematically providing additional pedagogical content knowledge information with each of the AAPT/PTRA manual activities intended for use in the rural institutes.**

In addition to being familiar with the mechanics of implementing an activity in the classroom, teachers should know several things to maximize the effectiveness of an instructional activity, including:

- The specific learning goal(s) addressed by the activity;
- Where in the instructional sequence the activity should be placed (i.e., what instruction students should have prior to and after experiencing the activity);
- The conceptions/misconceptions students are likely to have prior to experiencing the activity, as well as which misconceptions the activity confronts;
- Likely student responses to the activity (both correct and incorrect); and
- How to wrap-up the activity to increase the likelihood that student sense-making occurs.

Without this type of information, outreach participants may implement an activity without having a clear idea of how the activity adds to the conceptual storyline of a unit, resulting in "activity for activity's sake" (i.e., doing hands-on, but not minds-on). Currently, many AAPT/PTRA manuals do not include this type of information with the activities. Although some PTRAs may integrate these aspects into their workshops, systematically building this information into the AAPT/PTRA manuals would increase the likelihood that all PTRAs do so. Given the large number of manuals and activities, the project might consider setting aside time at the AAPT/PTRA Leadership Institute for such a task, splitting the most commonly used activities up among small groups of PTRAs and having them add the needed information.

In addition, the project should consider providing PTRAs with a template cover sheet for activities that would include areas for the above information to be completed during the outreach workshop. Providing the PTRAs with such a template would emphasize the need for them to address these areas in their outreach workshops, and would provide a mechanism for the outreach participants to record this important information.

- **The project should continue to work on developing the PTRAs' abilities to facilitate high-quality professional development.**

Just like students need opportunities to practice and receive feedback on the skills they are expected to master, the PTRAs need opportunities to practice and receive feedback on their professional development facilitation skills. Providing the PTRAs with these opportunities may require decreasing the Institute's focus on familiarizing PTRAs with classroom activities and increasing the focus on practicing and receiving feedback on leadership skills (e.g., leading discussions, informally assessing participants' understanding, helping outreach participants examine student work/focus on questioning strategies). These changes may require the project leadership to increase their work with the AAPT/PTRA Leadership Institute workshop leaders, helping them incorporate what is known from physics education research and the research on effective professional development.

# Appendix A
# Analysis and Reporting of Questionnaire Data

To facilitate the reporting of large amounts of survey data, and because individual questionnaire items are potentially unreliable, groups of survey questions that measure similar ideas can be combined into "composites." Each composite represents an important construct related to science teaching or professional development. Cronbach's Coefficient Alpha is a measure of the reliability of a composite (i.e., the extent to which the items appear to be measuring the same construct). A Cronbach's Alpha of 0.6 is considered acceptable, 0.7 fair, 0.8 good, and 0.9 excellent.

Each composite is calculated by summing the responses to the items associated with that composite and then dividing by the total points possible. In order for the composites to be on a 100-point scale, the lowest response option on each scale was set to 0 and the others were adjusted accordingly; so for instance, an item with a scale ranging from 1 to 5 was re-coded to have a scale of 0 to 4. As a result, someone who marks the lowest point on every item in a composite receives a composite score of 0 rather than some positive number. It also assures that 50 is the true mid-point. The denominator for each composite is determined by computing the maximum possible sum of responses for a series of items and dividing by 100; e.g., a nine-item composite where each item is on a scale of 0–4 would have a denominator of 0.36.

## PTRA Pre- and Post-Institute Questionnaire Composite Definitions

**Table A-1**
**Preparedness to Provide Professional Development**

| Questionnaire Composite | Pre | Post |
|---|---|---|
| Develop their own understanding of important physics concepts | Q12ap | Q8ap |
| Understand student thinking and/or common misconceptions related to important physics concepts | Q12bp | Q8bp |
| Examine science pedagogy/teaching strategies (e.g., white boarding, pair share) and when/why to use them | Q12cp | Q8cp |
| Understand when and why to use a particular activity within their science curriculum | Q12dp | Q8dp |
| Learn how to examine student work in order to assess student thinking and reflect on classroom practice | Q12ep | Q8ep |
| Identify/develop lessons aligned to learning goals and state and national standards | Q12fp | Q8fp |
| Develop effective questioning strategies to elicit student understanding | Q12gp | Q8gp |
| Informally assess student learning | Q12hp | Q8hp |
| Formally assess student learning | Q12ip | Q8ip |
| | | |
| **Number of Items in Construct** | **9** | **9** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.90** | **0.89** |

# Outreach Participant Questionnaire Composite Definitions

**Table A-2**
**Attitudes Toward *Standards*-Based Teaching**

| **Questionnaire Composite** | |
|---|---|
| Provide concrete experience before abstract concepts. | Q8ai |
| Develop students' conceptual understanding of science. | Q8bi |
| Make connections between science and other disciplines. | Q8di |
| Have students work in cooperative learning groups. | Q8ei |
| Have students participate in appropriate hands-on activities. | Q8fi |
| Engage students in inquiry-oriented activities. | Q8gi |
| Use computers. | Q8ji |
| Engage students in applications of science in a variety of contexts. | Q8ki |
| Use portfolios. | Q8mi |
| Use informal questioning to assess student understanding. | Q8ni |
| | |
| **Number of Items in Construct** | **10** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.73** |

**Table A-3**
**Pedagogical Preparedness**

| **Questionnaire Composite** | |
|---|---|
| Provide concrete experience before abstract concepts. | Q8ap |
| Develop students' conceptual understanding of science. | Q8bp |
| Take students' prior understanding into account when planning curriculum and instruction. | Q8cp |
| Make connections between science and other discipline. | Q8dp |
| Have students work in cooperative learning groups. | Q8ep |
| Have students participate in appropriate hands-on activities. | Q8fp |
| Engage students in inquiry-oriented activities. | Q8gp |
| Engage students in applications of science in a variety of contexts. | Q8kp |
| Use performance-based assessment. | Q8lp |
| Use portfolios. | Q8mp |
| Use informal questioning to assess student understanding. | Q8np |
| Lead a class of students using investigative strategies. | Q9a |
| Manage a class of students engaged in hands-on/project-based work. | Q9b |
| Help students take responsibility for their own learning. | Q9c |
| Recognize and respond to student diversity. | Q9d |
| Encourage students' interest in science. | Q9e |
| Use strategies that specifically encourage participation of females and minorities in science. | Q9f |
| Involve parents in the science education of their students. | Q9g |
| | |
| **Number of Items in Construct** | **18** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.91** |

## Table A-4
## Physics Content Preparedness (Version A)

| **Questionnaire Composite** | |
|---|---|
| Forces and motion | Q10a1 |
| Energy | Q10a2 |
| Light and sound | Q10a3 |
| Electricity and magnetism | Q10a4 |
| Modern physics (e.g., special relativity) | Q10a5 |
| Formulating hypotheses, drawing conclusions, making generalizations | Q10b1 |
| Experimental design | Q10b2 |
| Describing, graphing, and interpreting data | Q10b3 |
| | |
| **Number of Items in Construct** | **8** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.85** |

## Table A-5
## Physics Content Preparedness (Version B)

| **Questionnaire Composite** | |
|---|---|
| Kinematics (i.e., Motion) | Q10a1 |
| Forces (i.e., gravitational, normal, friction, tension) | Q10a2 |
| Newton's Laws | Q10a3 |
| Linear Momentum | Q10a4 |
| Energy (i.e., Thermodynamics) | Q10a5 |
| Energy as a Societal Issue | Q10a6 |
| Static Electricity | Q10a7 |
| Direct Current Circuits | Q10a8 |
| Formulating hypotheses, drawing conclusions, making generalizations | Q10b1 |
| Experimental design | Q10b2 |
| Describing, graphing, and interpreting data | Q10b3 |
| | |
| **Number of Items in Construct** | **11** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.91** |

## Table A-6
## Traditional Teaching Practices

| **Questionnaire Composite** | |
|---|---|
| Assign science/mathematics homework. | Q13m |
| Answer textbook/worksheet questions | Q14g |
| Review homework/worksheet assignments. | Q14h |
| Take short-answer tests (e.g., multiple choice, true/false, fill-in-the-blank). | Q14y |
| | |
| **Number of Items in Construct** | **4** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.65** |

## Table A-7
## Investigative Teaching Practices

| Questionnaire Composite | |
|---|---|
| Make formal presentations to the class. | Q14d |
| Engage in hands-on science activities. | Q14k |
| Design or implement their own investigation. | Q14m |
| Work on models or simulations. | Q14o |
| Work on extended science investigations or projects (a week or more in duration). | Q14p |
| Participate in field work. | Q14q |
| Write reflections in a notebook or journal. | Q14s |
| Work on portfolios. | Q14x |
| | |
| **Number of Items in Construct** | **8** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.76** |

## Table A-8
## Investigative Classroom Culture

| Questionnaire Composite | |
|---|---|
| Arrange seating to facilitate student discussion. | Q13d |
| Use open-ended questions. | Q13e |
| Require students to supply evidence to support their claims. | Q13f |
| Encourage students to explain concepts to one another. | Q13g |
| Encourage students to consider alternative explanations. | Q13h |
| Participate in discussions with the teacher to further science understanding. | Q14b |
| Work in cooperative learning groups. | Q14c |
| Share ideas or solve problems with each other in small groups. | Q14j |
| | |
| **Number of Items in Construct** | **8** |
| **Reliability (Cronbach's Coefficient Alpha)** | **0.77** |

# Appendix B

## PTRA Pre-Institute Questionnaire

## PTRA Post-Institute Questionnaire

## Rural Institute Participant Questionnaire (Version A)

## Rural Institute Participant Questionnaire (Version B)