# Annual Evaluation Report for Rural Physics Teacher Resource Agents

## Covering Period from June 2003 to May 2004

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# Introduction

This report summarizes the activities and findings of Horizon Research, Inc. (HRI) in its external evaluation of AAPT's Rural Physics Teacher Resource Agents (PTRA) project since June 2003. During this period, from June 2003 to May 2004, HRI has:

- Administered pre- and post-institute questionnaires to all 72 PTRAs attending the 2003 summer institute;
- Observed a portion of the PTRA institute in Madison;
- Interviewed a random sample of 10 current PTRAs who attended the PTRA institute;
- Interviewed all 11 PTRAs who led the 2003 rural institutes;
- Interviewed all 11 Rural Regional Coordinators;
- Administered a questionnaire to all teachers who attended the rural institutes facilitated by PTRAs;
- Developed and administered (in a pre-test/post-test design) a kinematics and dynamics content assessment to outreach participants attending rural institutes focused on those topics;
- Observed a sample of the rural institutes and follow-up sessions;
- Administered a follow-up questionnaire for participants in the 2002 rural institutes that did not participate in the 2003 rural institutes;
- Interviewed a sample of 10 rural institute outreach participants; and
- Developed a student assessment focusing on kinematics and dynamics and administered it in a pilot study of the impact of the AAPT/PTRA rural program on students of outreach participants.

This report is divided into five 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 2003 PTRA institute, including PTRAs' perceptions of the quality of the institute, their vision of effective professional development, and the impact of the institute on their preparedness to lead rural institutes. The third section reports data collected on the rural institutes held during the summer of 2003. These data include a description of the eleven rural institutes and the teachers attending them, as well as feedback from the PTRAs leading these institutes and the Rural Regional Coordinators. This section also reports the results of a study of the impact of the project on the content knowledge of outreach participants. The fourth section describes a pilot study of the impact of the AAPT/PTRA rural program on student achievement in kinematics and dynamics. The final section summarizes the report 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 program 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 a week-long PTRA institute, the PTRAs are trained to present workshops on a wide variety of topics. Most institute workshops are six-hours in length and focus on familiarizing the PTRAs with the classroom activities in the workshop manual. The institute also provides multiple 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 and skills needed to effectively lead the rural institutes for second tier participants (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 workshops are intended to give the rural participants an opportunity to revisit concepts and skills from the rural 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. The rural institutes also give rural teachers, who are often the only science teacher in their school, an opportunity to network with other science teachers. At the 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 and focuses 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 centers?

2. To what extent does the PTRA institute prepare PTRAs with the physics and pedagogical content knowledge needed to present outreach workshops?

3. To what extent does the PTRA institute 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 centers, 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 it is too early in the project to answer these questions fully, data collected during the project's second year provide some insight into the project's progress in reaching its goals.

# 2003 PTRA Institute

As noted above, the goal of the PTRA summer 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.

The PTRA 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 which focus on various physics topics, technological tools (e.g., graphing calculators), and/or teaching strategies. The majority of these workshops are six-hours long, though a few are three-hours in length. These workshops are developed by selected PTRAs, members of the project leadership, and/or other interested and knowledgeable members of the physics education community. The workshops provide opportunities for the PTRAs to experience a sample of the classroom activities included in the workshop manual, and a forum to discuss physics content, classroom practices, and issues of leadership.

In July of 2003, the project gathered 72 PTRAs in Madison, WI for the institute. For the first time in many years, no new PTRAs were invited to the institute. The project offered 13 workshops during the 2003 PTRA institute, covering topics such as kinematics, dynamics, waves, laboratory interfacing devices, and physlets (computer simulations). This section of the report focuses on the quality and impact of the summer institute using data collected from the pre- and post-institute questionnaires, evaluator observations, and interviews with PTRAs.

**The PTRAs**

The pre-institute questionnaire, administered by mail (though the PTRAs had the option of completing it on the Internet), gathered a variety of data from the PTRAs, including demographic characteristics and information on their learning needs as professional development providers. Sixty-five PTRAs responded to the pre-institute questionnaire, a response rate of 90 percent. Table 1 shows the demographic characteristics of the responding PTRAs. A majority (63

percent) of the 2003 PTRAs were male; nearly all were Caucasian. About half teach in suburban schools, about one-third teach in rural schools, and the remaining teach in urban schools. Eighty-three percent taught physics and/or physical science during the 2002–03 academic year and two-thirds have over 20 years of teaching experience. The majority of attendees became PTRAs prior to 1997.

**Table 1**
**Demographic Data for PTRAs Attending the 2003 Summer Institute**

| | Percent of Respondents (N= 65) |
|---|---|
| **Physics/physical science in Previous Year Teaching Assignment** | 83 |
| **Gender** | |
| Male | 63 |
| Female | 37 |
| **Race/Ethnicity** | |
| White | 95 |
| African-American | 2 |
| Asian or Pacific Islander | 2 |
| Hispanic | 0 |
| Other | 2 |
| **Location of School** | |
| Suburban | 52 |
| Urban | 16 |
| Rural | 32 |
| **Year Originally Became a PTRA** | |
| 1985–1988 | 29 |
| 1992–1996 | 40 |
| 1997–2002 | 32 |
| **Membership in Professional Organizations** | |
| AAPT | 95 |
| NSTA | 66 |
| **Years of Physics/Physical Science Teaching Experience** | |
| 0–5 Years | 6 |
| 6–10 Years | 5 |
| 11–15 Years | 2 |
| 16–20 Years | 19 |
| 21–25 Years | 19 |
| 26–30 Years | 22 |
| 31–35 Years | 16 |
| 36 or More Years | 13 |

## PTRAs' Views about Effective Professional Development

One of the key issues in preparing a large group of professional development providers such as the PTRAs is creating a shared vision of effective teaching and effective professional development. The lack of a shared vision would make it difficult, if not impossible, for the project (and the PTRAs themselves) to identify the knowledge and skills the PTRAs need to further develop. In an effort to ascertain the extent to which PTRAs share a common vision of effective professional development, the PTRAs were asked on the pre-institute questionnaire to list the key features of effective professional development. Twenty-eight of the 47 respondents to this question indicated that effective professional development must be relevant and applicable to participants' classroom practice. In most cases, the PTRAs defined relevant as providing

teachers with activities they could use in their classroom and giving them experience with technology. Ten PTRAs indicated that professional development should be "fun and motivating"; eight said that it was important for the professional development to provide opportunities for participants to learn physics content. Only three PTRAs mentioned providing teachers opportunities to discuss/reflect upon classroom practice or how students learn. Typical responses to this question were:

> *Keep people interested. Material must be relevant. Provide materials that are user-friendly.*
>
> *Providing participants with materials which can be implemented right away with ease. Providing time for participants to share their experiences and knowledge.*
>
> *1. Relevant material coverage that is devoid of ego/elitist presentations. 2. Presentation of "tried & true" material. 3. Professional development material must be fun to learn about—not like a faculty meeting.*
>
> *Most important, learning physics content. Learning new activities for physics instruction. Gaining experiences with new technologies.*

It will be important for the project to consider the extent to which the PTRAs' vision of effective professional development aligns with the leadership's vision. As the PTRAs pointed out, professional development should provide experiences that are relevant to participants in a positive environment. Using classroom activities as the basis of PTRA professional development typically suits these two requirements. However, it is not clear whether the project leadership views the classroom activities as the means to an end, or the end itself. It appears that the PTRAs, as a whole, lean more towards seeing the activities as the latter. If the project intends the former, it may need to make a more concerted effort at building a vision of effective professional development among the PTRAs.

**The Quality and Impacts of the PTRA Institute**

Prior to the summer institute, PTRAs were asked what they expected to gain from the upcoming PTRA summer institute. The most common response, given by 18 of the 51 PTRAs responding to this question, was to network and continue to build friendships. Learning teaching strategies to use in their own classrooms and increasing their skills as a professional development providers were each mentioned by 14 PTRAs. Twelve PTRAs indicated that they hoped to increase their knowledge of physics content. In the words of two PTRAs:

> *I expect to meet with old and new friends to develop new skills in pedagogy and content knowledge. I expect to get encouraged to keep teaching.*
>
> *[I expect] additional training [in] physical science/physics related topics that would help me become a better science teacher and a more effective PTRA workshop leader.*

In a similar vein, the pre-institute questionnaire asked PTRAs about the extent to which each of a number of activities would enhance their abilities as professional development providers. After the institute, PTRAs were asked to what extent these activities occurred. As can be seen in Table 2, nearly all of the responding PTRAs indicated that learning new activities for physics instruction would enhance their abilities as professional development providers. Over three-quarters of the respondents thought that gaining experience with new technologies, learning strategies for helping other teachers, learning strategies for helping students learn physics, and learning effective strategies of staff development would make them better professional development providers. Half thought that learning physics content would make them more effective professional development providers. It is interesting to note that a large majority of PTRAs hold the view that learning new physics activities for classroom instruction and gaining experience with new technologies would enhance their skills as professional development providers. These data are consistent with data presented above regarding the PTRAs' vision of effective professional development.

**Table 2**
**PTRAs' Expectations and Outcomes Regarding the Summer Institute**

| | Percent of Respondents (N = 54) | |
|---|---|---|
| | **Would help them be a more effective professional development provider†** | **Occurred during the summer institute to a great extent†** |
| Learn new activities for physics instruction | 93 | 96 |
| Learn strategies for helping students learn physics | 78 | 92 |
| Learn strategies for helping other teachers become better physics teachers | 80 | 88 |
| Gain experience with new technologies for physics instruction | 87 | 80 |
| Learn about the principles of effective staff development, including working with adult learners | 78 | 63 |
| Learn physics content | 50 | 50 |

† 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."

Based on responses to the post-institute questionnaire,[1] administered by mail two weeks after the institute (again with the option of completing it on the Internet), it is clear that the PTRAs believed the institute provided ample opportunities for learning new physics activities (96 percent), learning strategies for helping students learn physics (92 percent), learning strategies for helping other teachers become better physics teachers (88 percent), and gaining experience with new technologies (80 percent). Far fewer PTRAs indicated having ample opportunities for learning strategies for working with adult learners and learning physics content (63 and 50 percent, respectively). (It is not surprising that learning new content was not a major outcome, as many of the PTRAs are well-versed in physics.)

[1] Fifty-seven PTRAs returned the post-institute questionnaire, a response rate of 79 percent. HRI was able to match the pre- and post-responses of 54 PTRAs.

These data are consistent with HRI's observations at the summer institute. In the sessions HRI observed, the majority of the time was spent having the PTRAs work through classroom activities as if they were students. If the project's vision for PTRA-provided professional development is the same as the vision held by the PTRAs (i.e., focused mainly on giving outreach participants activities to use in their classroom), the data above are very positive. If the project's vision also encompasses having the PTRAs help outreach participants become reflective practitioners, the summer institute may need more of a balance between providing the PTRAs with additional classroom activities and providing them with the opportunity to learn and practice the skills needed to carry out the broader vision successfully.

Overall, the summer institute appears to have been well-received by the PTRAs. When asked on the post-institute questionnaire what aspects of the summer institute were particularly good, 28 of the 52 PTRAs responding to this open-ended question mentioned the quality of the workshops, either the quality of the instruction or the activities they received. Twenty-eight PTRAs also mentioned their appreciation of the host campus and its staff. Seventeen pointed to the opportunity to network with other physics teachers. Three examples of PTRAs' comments are:

> *This was probably the best institute. It was run very well and all of the workshops I attended were very, very helpful.*
>
> *All workshops attended. Time to interact and exchange ideas with excellent physics teachers. Great food and facilities.*
>
> *Some of the presentations. Time to read some of the manuals. A chance to discuss physics and its teaching with other participants.*

Responses to a question asking the PTRAs to describe the single greatest impact of the institute yielded similar findings. The most common response, given by 18 of the 56 PTRAs answering this question, was that the institute afforded them the opportunity to share ideas with other physics teachers. Thirteen PTRAs mentioned receiving activities to use in their classroom and/or in workshops, and 12 highlighted exposure to new technology. In the words of two PTRAs:

> *I always benefit from talking to other physics teachers. I get to hear how other people handle situations, and I always pick up new ideas for teaching.*
>
> *It was a lot of fun. It's great to be able to share ideas as a physics teacher and also as a PTRA; it allows us to better serve our students and our teacher-students.*

These sentiments were echoed in the interviews HRI conducted with 10 PTRAs after the summer institute. When asked about the most useful aspects of the summer institute, all interviewees mentioned specific workshops that they enjoyed and found beneficial to their teaching. As two PTRAs stated:

*I got a lot of good information that I can use in my classroom and I know I can share with other teachers…new labs to use in class. Just different ways to kind of introduce the topics to the students.*

*The physlets were a new idea. That was kind of interesting. I am hoping I can expand on that and include it in my course at home. And I am hoping I can share that with other teachers. Some of the other stuff is things that have been around for a while, like Newton's Laws, and this is like a new way of looking at a lot of that stuff.*

Nine of the 10 interviewed PTRAs also mentioned networking and the sharing of ideas with other teachers as a highlight of the summer institute. As one PTRA said:

*Every year, the best part of it [the PTRA institute] is the conversation we hold with the other teachers. It's one of those things that fuels you and keeps you current and grounded.*

It is worth noting that across their responses to the questions on the impact and most useful aspects of the summer institute, the PTRAs tend to speak about themselves as teachers rather than as professional development providers. This result is another indication that the project may need to reconsider how much emphasis the summer institute places on classroom activities, as opposed to focusing on the PTRAs' role as professional development providers.

The post-institute questionnaire asked PTRAs for suggestions for improving the summer institute and the AAPT/PTRA Rural project as a whole. As was the case last year, there was no single issue mentioned by a significant portion of the respondents, an indication of the PTRAs' overall satisfaction with the institute. Similar to last year, the most common suggestion, mentioned only by 3 of the 43 PTRAs answering this question, was that they would like the institute to have a greater emphasis on workshop pedagogy. As one of these three PTRAs wrote:

*I'd like some time spent specifically on pedagogy and science teaching strategies, maybe not even in a workshop, but perhaps a panel discussion. It just needs more time.*

As mentioned above, the main vehicles for the preparation of the PTRAs are the institute workshops. The project offered 12 workshops during the 2003 PTRA institute, plus a three-hour leadership session which reviewed project policies and procedures. Table 3 shows the title, duration, and percentage of PTRAs taking each workshop (based upon the 57 responses to the post-institute questionnaire). Of these 12 workshops, 10 are intended to be given as outreach workshops.[2] Most PTRAs participated in 6 workshops during the institute, 4 six-hour workshops and 2 three-hour workshops. The workshop taken by the greatest number of PTRAs was *Energy*. Having a large number of PTRAs trained in the *Energy* workshop should benefit the project as that is one of the core topics covered in the 2nd year of the rural institutes' three-year sequence.

[2] The *PhysTEC Mentoring* workshop explored ways in which the PTRA program could collaborate with AAPT's PhysTEC project; and the *Assessing Teacher Learning* workshop introduced using student work as a professional development strategy that also provides the workshop leader with formative feedback on whether participants are "getting it."

**Table 3**
**Participation Data for Workshops Offered during the 2003 PTRA Institute**

| | Duration (Hours) | Percent of PTRAs Taking Workshop in 2003 (N = 57) |
|---|---|---|
| Energy | 6 | 77 |
| Assessing Teacher Learning | 3 | 57 |
| Waves | 6 | 56 |
| Make and Takes | 3 | 56 |
| Physlets | 6 | 50 |
| Demonstrations | 6 | 47 |
| Kinematics | 6 | 44 |
| Newton's Second Law | 6 | 35 |
| Interfacing (Vernier) | 6 | 26 |
| PhysTEC Mentoring | 6 | 22 |
| Interfacing (Pasco) | 6 | 18 |
| TI-83 Graphing Calculator | 3 | 17 |

The post-institute questionnaire asked the PTRAs why they selected the workshops in which they participated. Of the 55 PTRAs who responded to this open-ended question, 17 PTRAs indicated that they chose their workshops to enhance their ability to offer them to outreach participants. In the words of two PTRAs:

> *These workshops were integral to the rural PTRA programs which I wanted to prepare myself to participate in.*

> *I always enjoy the "Make and Take." I have something to show my students the first day of class and something to make in my workshops. I picked "Energy" because it will be one of the topics for the rural workshops. Demonstrations are something that all teachers can use more of.*

Fifteen PTRAs responded that they chose their workshops because they were the only ones they had never taken before, a testament to the number of years many PTRAs have been involved in the project. Eleven PTRAs selected workshops based upon personal interest in the topic. Ten PTRAs indicated that they did not get their druthers in terms of which workshops they would attend; rather they were assigned to workshops by the project leadership. These viewpoints are captured in the following responses:

> *I chose "Physlets," "PASCO interfacing," and "Make and Take" because these were the workshops I could immediately use in my classroom. "Kinematics" and "Waves" were assigned to me.*

*I selected them because I never had them in previous years. One that I had [this year], "Make and Take," I did not sign up for.*

The post-institute questionnaire asked the PTRAs to rate the quality of instruction of each workshop in which they participated. As can be seen in Table 4, many of the workshops were rated quite highly for their quality of instruction, including *Kinematics*, *Make and Takes*, and *TI-83 Graphing Calculator*. Only one workshop, *Waves,* had fewer than half of the participating PTRAs rate the instruction as excellent. The lower ratings for the *Waves* workshop are most likely due to the disorganization and lack of focus that plagued the workshop during the first of the two occasions it was offered.

**Table 4**
**PTRAs Rating Workshop Instruction as Excellent[†]**

| | N[§] | Percent of PTRAs |
|---|---|---|
| Kinematics | 23 | 100 |
| Make and Takes | 27 | 100 |
| TI-83 Graphing Calculator | 8 | 100 |
| Demonstrations | 24 | 96 |
| Physlets | 25 | 96 |
| Newton's Second Law | 19 | 95 |
| Interfacing (Vernier) | 14 | 93 |
| Interfacing (Pasco) | 9 | 89 |
| Assessing Teacher Learning | 31 | 77 |
| Energy | 40 | 70 |
| PhysTEC Mentoring | 10 | 60 |
| Waves | 30 | 43 |

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

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

By matching 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 provide these workshops to outreach participants. Participants in 6 of the 10 workshops intended to be given as outreach workshops had significantly greater gains in their perceptions of preparedness to lead that workshop than did non-participants (see Table 5). These six workshops were: *Demonstrations*, *Energy*, *Interfacing (Pasco)*, *Newton's Second Law*, *Physlets*, and *Waves*.

**Table 5**
**PTRAs Feeling Well Prepared to Present Each of the Following Workshops, by Workshop Participation[†]**

| | Percent of PTRAs | | |
|---|---|---|---|
| | N[§] | Pre | Post |
| **Demonstrations*** | | | |
| Participants | 23 | 91 | 100 |
| Non-Participants | 24 | 88 | 79 |
| **Energy*** | | | |
| Participants | 37 | 73 | 92 |
| Non-Participants | 11 | 82 | 73 |
| **Interfacing (Pasco)*** | | | |
| Participants | 9 | 22 | 33 |
| Non-Participants | 39 | 38 | 41 |
| **Interfacing (Vernier)** | | | |
| Participants | 12 | 58 | 83 |
| Non-Participants | 39 | 56 | 69 |
| **Kinematics** | | | |
| Participants | 21 | 71 | 100 |
| Non-Participants | 30 | 93 | 100 |
| **Make and Takes** | | | |
| Participants | 28 | 75 | 93 |
| Non-Participants | 22 | 77 | 77 |
| **Newton's Second Law*** | | | |
| Participants | 17 | 71 | 100 |
| Non-Participants | 34 | 82 | 91 |
| **Physlets*** | | | |
| Participants | 24 | 4 | 63 |
| Non-Participants | 22 | 5 | 0 |
| **TI-83 Graphing Calculator** | | | |
| Participants | 8 | 25 | 63 |
| Non-Participants | 42 | 45 | 50 |
| **Waves*** | | | |
| Participants | 25 | 80 | 96 |
| Non-Participants | 22 | 86 | 59 |

[†] 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 greater than non-participants' change (Logistic Regression, $p < 0.05$).

When PTRAs did not feel well prepared to offer a workshop after participating in it during the institute, the post-institute questionnaire asked them to explain why the session did not better prepare them. Eighteen of the 30 PTRAs responding to this question indicated that six hours was not enough time to feel confident in their abilities to present the workshop, and that they needed more experience with the topic and/or the workshop materials. Many of these responses specifically referred to wanting more hands-on experience with technology that was new to them and/or they did not have access to at their schools. As one PTRA wrote:

*Physlets was a great program (workshop), only I need more time to acquaint myself with the computer program before I "give" a workshop on it. We don't use the PASCO program at my school, so it will take longer to learn how to help others use it.*

The second most common response, given by seven PTRAs, was that the workshop presentation was poor and that they did not want to replicate what they had experienced. As two PTRAs wrote:

*The [workshop title] workshop has the potential to be a great workshop. I felt that there was too much time spent on data analysis. There are also better pedagogical techniques to present some of the content.*

*[Workshop title] had many activities, but no coherent theme. A few good activities would have been better than trying to do a zillion that were less effective.*

The PTRAs were also asked how well prepared they felt to work with other teachers on a number of goals. As can be seen in Table 6, 98 percent of the responding PTRAs indicated that they felt well prepared (a 4 or 5 on a five-point scale) to develop outreach participants' knowledge of core physics concepts; 96 percent indicated that they felt well prepared to help outreach participants understand when and why to use a specific activity and understand student thinking and/or common misconceptions. A large majority of PTRAs also indicated that they felt prepared to help outreach participants examine their own teaching practices (91 percent), develop effective questioning strategies (91 percent), or help outreach participants examine student work and informally assess students for understanding (86 percent each). Nearly all PTRAs feel at least somewhat prepared in each of these areas.

**Table 6**
**PTRAs' Feelings of Preparedness to Help Outreach Participants in Various Aspects of Teaching**

| | Percent of Respondents (N = 57) | | | | | |
|---|---|---|---|---|---|---|
| | Not Adequately | | Somewhat | | Very Well | |
| | 1 | 2 | 3 | 4 | 5 | 4 + 5 |
| Develop understanding of important physics concepts | 0 | 0 | 2 | 42 | 56 | 98 |
| Understand when and why to use a particular activity within their science curriculum | 0 | 0 | 4 | 42 | 54 | 96 |
| Understand student thinking and/or common misconceptions | 0 | 0 | 4 | 46 | 51 | 96 |
| Examine pedagogy/teaching strategies and when/why to use them | 0 | 0 | 9 | 49 | 42 | 91 |
| Develop questioning strategies that effective elicit student understanding | 0 | 0 | 9 | 56 | 35 | 91 |
| Informally assess student learning | 0 | 0 | 14 | 46 | 40 | 86 |
| Learn how to examine student work in order to assess student thinking and reflect on classroom practice | 0 | 2 | 12 | 58 | 28 | 86 |
| Identify/develop lessons aligned to learning goals and state and national standards | 0 | 0 | 19 | 39 | 42 | 81 |
| Formally assess student learning | 0 | 0 | 21 | 51 | 28 | 79 |

These data indicate that the PTRAs perceive themselves to be well prepared to accomplish a large number of goals in their outreach workshops. However, in observations of rural institutes and follow-up sessions over the past two years, as well as other PTRA workshop in previous years, HRI rarely witnessed PTRAs going beyond sharing activities. When PTRAs did do more than share activities, the focus tended to be on developing participants' content knowledge. It may be that the PTRAs do not think the other kinds of activities are important to include. Or perhaps the PTRAs, despite their responses on the questionnaire, are not prepared to conduct professional development that addresses those goals.

Finally, a series of items on both the pre- and post-institute questionnaires asked PTRAs about their feelings of preparedness to lead a variety of professional development activities. As can be seen in Table 7, a significantly greater percentage of PTRAs perceive themselves to be well prepared to lead an extended length workshop around one or two core topics after the institute than before the institute. This finding is encouraging given the project's goal of providing extended professional development rather than one-shot experiences. There were no significant gains in the PTRAs' feelings of preparedness to do five of the six activities, though this result may be due to the relatively high initial responses as well as the fact that the summer institute did not explicitly focus on these skills.

**Table 7**
**PTRAs' Feelings of Preparedness to Provide Various Forms of Professional Development**[†]

| | Percent of Respondents (N=54) | | |
|---|---|---|---|
| | **Pre** | **Post** | **Difference** |
| Lead a two -to five-day outreach institute focusing on one or two core physics topics (e.g., kinematics) | 78 | 93 | 15* |
| Conduct a demonstration lesson in an outreach participant's classroom | 85 | 94 | 9 |
| Lead a six-hour outreach workshop | 91 | 98 | 7 |
| Plan workshop activities that meet the needs of teachers with a wide range of backgrounds | 83 | 89 | 6 |
| Provide on-going support to outreach participants via electronic media (email, listservs, on-line forums, etc.) | 77 | 83 | 6 |
| Coach an outreach participant (i.e., observe and provide feedback on a lesson) | 83 | 85 | 2 |

† 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."

* Indicates a significant increase in PTRAs' feelings of preparedness (1-tailed McNemar test, $p < 0.05$).

Responses to the post-institute questionnaire appear to indicate that the summer institute is engaging the PTRAs as learners of physics content and as teachers experiencing new classroom activities, but not as professional development providers. These findings are consistent with HRI's observations of the summer institute and interviews with a random sample of PTRAs. Although the 2003 summer institute may have created the possibility for PTRAs to develop the skills needed to provide effective professional development that moves beyond sharing activities,

HRI's interviews with PTRAs and observations of the institute indicate that structured opportunities that would facilitate this learning were not very common. When asked during interviews to consider all the aspects of the summer institute and to describe what the institute focused on the most, 6 of the 10 interviewees indicated that the workshops had a strong emphasis on doing the activities in the manuals. In the words of two PTRAs:

> *Activities, activities, activities. They spent their time giving us activities; that's what we go for.*

> *They try to deliver new information; they try to explain how we are supposed to actually give workshops. Mostly we get lots of activities to use in the workshops and with our own kids.*

Only two of the interviewees mentioned without prompting that the summer institute focused on working with adult learners. However, when these two interviewees were asked to provide specific examples of ways the institute focused on working with adult learners, they were unable to provide concrete examples:

> *I know we talked about it, in [one workshop] I know he said it, but I can't think of any specifics.*

> *I can't think of one really.*

When asked directly whether the workshops focused on increasing their preparedness as professional development providers, 9 of the 10 interviewees replied in the affirmative. These PTRAs indicated that the workshops modeled effective strategies, but in general did not explicitly discuss different strategies for working with teachers. As one PTRA said when asked about leadership strategies:

> *The workshop I was at gave me good ideas on how to run a workshop to show teachers how to do the activities. I liked the way they modeled their workshop. Techniques, however, were not explicitly discussed.*

Two PTRAs did provide examples of leadership strategies they learned at the summer institute, though these examples were very general in nature. One "strategy" was the need to "go slower." The other was "don't assume because they are teachers that they know the material." None of the interviewees could describe a professional development approach other than going through the activities as if the participants were students.

That the PTRAs reported on the post-institute questionnaire that the summer institute included a focus on increasing their skills as professional development providers is positive. However, the interview data indicate that if such as focus was present, it did not leave much of an impression, or have much of an impact, on the PTRAs.

**Implications**

Looking across the data on the summer institute and its impacts on the PTRAs, a couple of themes emerge. It is clear that the PTRAs value the program and enjoy the summer institute, including the opportunity to network and gain experience with classroom activities and new technologies. However, it also appears that many PTRAs have difficulty switching from their role as teacher to that of trainer of teachers. A large number of responses to open-ended items asked on the post-institute questionnaire and during interviews indicate that the PTRAs view the summer institute primarily as a means to improve their own classroom practice.

A number of factors may be contributing to this phenomenon. First, the PTRAs' vision of professional development is largely centered on sharing classroom activities. Second, this vision is reinforced by the summer institute itself, where workshops typically focus on providing the PTRAs with classroom activities (or familiarizing them with new technologies that can be used in the classroom). Third, the culture of the summer institute is much more of teachers getting together to "talk shop," and less of professional development providers getting together to improve their abilities to help rural institute participants become more effective teachers of physics/physical science. Fourth, participants in outreach workshops love getting activities that they can use in their classroom (even if they do not know how to use them appropriately), and the feedback of these participants provides positive reinforcement to the PTRAs.

In order to help the PTRAs mature as professional development providers, the project may start with establishing a common vision of effective professional development. Creating a shared vision should help the project along a number of fronts. First, once a vision is in place, it should be easier to decide what knowledge and skills the PTRAs need to enact the vision. Second, a shared vision should help the PTRAs reflect on their own skills as professional development providers, giving them an opportunity to take stock of which knowledge and skills they have already mastered and which they need to develop further. Third, once the set of knowledge and skills has been identified, and the needs of the PTRAs assessed, the project should be able to provide structured learning and practice opportunities for the PTRAs in the areas of most need.

# 2003 Rural Institutes

As noted earlier, the main goals of the AAPT/PTRA Rural project focus on improving the teaching and learning of physics/physical science in rural classrooms via the Rural Regional Centers. The project's model is for each center to host a four- or five-day summer institute, and two day-long 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 proven 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 Center operates in conjunction with 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. The coordinator

makes it possible for the PTRAs to focus their energies on designing and implementing the professional development.

This section of the report describes the quality and impacts of the 2003 rural institutes. Data for this section of the report come from project records of participant attendance, a questionnaire administered to all rural institute participants, HRI's observations of portions of two rural institutes and a follow-up session, interviews with a sample of outreach participants from, a follow-up questionnaire administered to Year One participants not returning for Year Two, interviews with all Rural Regional Coordinators, and interviews with the PTRAs leading each rural institute.

**Participation in the Rural Institutes**

The AAPT/PTRA Rural project operated 11 rural regional centers during its second year, 3 of which were continuations of "prototype" institutes created to test the logistics of this model prior to NSF funding. Table 8 shows the number of outreach participants attending each of the rural summer institutes and follow-up sessions.[3] Overall, 251 rural teachers attended the four institutes. Fewer teachers attended the follow-up sessions held during the school year. The difficulty in getting teachers to attend the follow-up sessions, possibly due to scheduling conflicts during the school year, has implications for the project's ability to reach its goal of providing teachers with 36 hours of professional development per year. Table 8 also shows that nearly two-thirds of the outreach participants reached the goal of receiving 36 hours of professional development during the project's second year, a much higher proportion than in the project's first year.

**Table 8**
**Outreach Participants Attending each Session,**
**by Rural Regional Center**

| | Number of Outreach Participants | | | |
|---|---|---|---|---|
| | **Rural Institute** | **Follow-Up #1** | **Follow-Up #2** | **At Least 36 Hours of PD** |
| Brigham Young University | 11 | 11 | 11 | 11 |
| Central Pennsylvania | 22 | 13 | — | 12 |
| Coastal Carolina University† | 38 | 14 | — | 5 |
| Emporia State University | 15 | 13 | 13 | 13 |
| Illinois State University† | 17 | — | — | 9 |
| James Madison University | 20 | 14 | 15 | 14 |
| Montana State University | 11 | — | — | 0 |
| South Dakota State University† | 23 | 17 | 16 | 19 |
| Ohio State University | 24 | 7 | 14 | 18 |
| Texas A&M University | 32 | — | — | 31 |
| Texas Tech University | 38 | 33 | 23 | 32 |
| **Total** | **251** | **122** | **92** | **164** |

† "Prototype" center

[3] Participation data come from AAPT/PTRA Rural project records and are current as of April 12, 2004.

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 from the past three years, it is possible to examine the project's progress towards reaching this goal. As can be seen in Table 9, relatively few rural institute participants attended a Rural Regional Center for more than one year. Of the 96 individuals who have participated in a center founded in 2001, 15 have attended for two years and 10 have attended for all three years. At the one center established in 2002, 8 of the 34 participants have attended for both years, a rate of return similar to that for the centers started in 2001.

**Table 9**
**Retention Rates for Rural Regional Centers, by Inaugural Year of the Center**

| | Number of Outreach Participants | | |
|---|---|---|---|
| | Inaugural Year of Rural Regional Center | | |
| | 2001† | 2002 | 2003 |
| 1 Rural Institute Attended | 71 | 26 | 153 |
| 2 Rural Institutes Attended | 15 | 8 | — |
| 3 Rural Institutes Attended | 10 | — | — |
| **Total** | **96** | **34** | **153** |

† "Prototype" centers

In the fall of 2003, HRI sent a follow-up questionnaire to all Year One participants that did not return for a Year Two institute. In addition to gathering information on project impacts, the questionnaire contained a series of items designed to ascertain why these participants did not attend an institute in Year Two. Despite repeated mailings and the offering of a financial incentive, only 17 of the 40 participants returned a completed questionnaire (a response rate of 43 percent). Although the data from this questionnaire are presented below since they may provide the project with some insight into why participants are not returning for multiple years, the data should be interpreted with caution as the low response rate increases the likelihood of the results not being representative of the target population.

As can be seen in Table 10, finding the time to attend a rural institute was the most common barrier to attendance, mentioned by 14 respondents, either because of conflicts with other commitments or because of the extended nature of the institute. Nine respondents indicated that the topic(s) covered at the institute was a factor in their decision not to participate again. Technology and quality issues were each mentioned only by two respondents.

**Table 10**
**Year One Outreach Participants' Indicating Each of the Following Factors Was Important† in Their Decision Not to Attend a Year Two Rural Institute**

| | Number of Respondents |
|---|---|
| **Time Issues** | **14** |
| The dates of the institute conflicted with other commitments | 13 |
| I could not commit to attending for all five days | 8 |
| **Topic Issues** | **9** |
| I don't teach the topic(s) covered at this year's institute | 6 |
| The content of the previous institute was too advanced | 4 |
| I am not teaching physics/physical science | 4 |
| This year's topic(s) did not interest me | 3 |
| The activities and materials from the previous institute were too high level for me to use in my classroom | 3 |
| The content of the previous institute was too low level | 2 |
| The activities and materials from the previous institute were too low level for me to use in my classroom | 2 |
| **Technology Issues** | **2** |
| There was not enough emphasis on technology in the previous institute | 2 |
| There was too great an emphasis on technology in the previous institute | 0 |
| **Quality Issues** | **2** |
| Last year's institute was not well implemented (e.g., poor presenters, disorganized) | 2 |
| There were not enough interactions with other participants last year | 1 |

† Includes those who rated the item a 2 or 3 on a three-point scale from 1 "Not important" to 3 "Very important."

## The Outreach Participants

A teacher 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 11, the project drew teachers with a wide range of prior teaching experience. About half of the outreach participants were female and nearly all were white. Eighty-eight percent taught high school during the 2002–03 academic year. Seventy percent of the participants were responsible for teaching physics, and about half taught physical science. Given the project's target audience of rural teachers, it is not surprising that over two-thirds of the outreach participants taught other science subjects and 1 in 4 taught non-science classes.

**Table 11**
**Demographic Data for Outreach Participants**

| | Percent of Participants |
|---|---|
| **Gender** | |
| Male | 52 |
| Female | 48 |
| **Race**† | |
| White | 94 |
| Black or African-American | 3 |
| Hispanic or Latino | 1 |
| Asian | 1 |
| American Indian or Alaskan Native | 1 |
| Native Hawaiian or Other Pacific Islander | 0 |
| **Grade Level Taught**† | |
| High School | 88 |
| Middle School | 16 |
| Elementary School | 1 |
| Not a Classroom Teacher | 2 |
| **Prior Teaching Experience** | |
| 0–2 Years | 13 |
| 3–5 Years | 11 |
| 6–10 Years | 23 |
| 11–20 Years | 35 |
| 21 or More Years | 19 |
| **Teaching Assignment Includes**† | |
| Physics | 70 |
| Physical Science | 54 |
| Other Science | 69 |
| Non-Science | 26 |

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

Table 12 shows the number of semesters of college coursework completed by the outreach participants. Fifty percent of the outreach participants have taken eight or more college semesters of physics/physical science while 32 percent have taken three or fewer semesters. These data indicate that the rural institute participants were quite varied in terms of their physics content background.

**Table 12**
**Outreach Participants' College Coursework**

| | Percent of Participants | | | |
|---|---|---|---|---|
| | **0 Semesters** | **1–3 Semesters** | **4–7 Semesters** | **8 or More Semesters** |
| Life Science/Biology | 9 | 19 | 14 | 57 |
| Chemistry | 4 | 23 | 23 | 50 |
| Physics/Physical Science | 4 | 26 | 21 | 50 |
| Mathematics | 1 | 23 | 31 | 44 |
| Earth/Space Science | 20 | 38 | 18 | 24 |
| Engineering/Technology | 44 | 29 | 16 | 11 |

The baseline questionnaire also asked the outreach participants about their opinions, feelings of preparedness, and frequency of use of various teaching practices. These items have been administered to large samples of teachers in previous research, and based on the results of factor analysis, combined into a number of composite variables to reduce the unreliability associated with single survey items. (Definitions of the composite variables, descriptions of how they were created, and reliability information are included in Appendix A.) Each composite has a minimum possible score of 0 and a maximum possible score of 100. A score of 0 would indicate that a participant selected the lowest response option for each item in the composite, whereas a score of 100 would indicate that a participant selected the highest response option for each item.

The composites fall into two groups. The first set deals with teachers' attitudes and preparedness and the second focuses on their classroom practices. By linking data across years, HRI is able to examine changes in these composite scores for participants completing the questionnaire on multiple occasions. Table 13 shows composite scores for participants with two data points: baseline (measured prior to the 2003 rural institutes) and after one year of participation (measured prior to the 2004 rural institutes).[4]

There are a number of interesting findings in these data. First, participants have higher perceptions of their physics preparedness after one year of participation, an indication that the project is being successful at improving participants' content knowledge. (Further evidence of the project's impact on participants' content knowledge is presented later in this report.) Second, participants report a significant increase in their frequency of use of classroom practices that foster an investigative culture (e.g., having students work in cooperative groups, requiring students to supply evidence to support their claims). None of the other composites exhibited a statistically significant change.

**Table 13**
**Outreach Participants' Composite Scores**

| | | Baseline | | After One Year | |
|---|---|---|---|---|---|
| | N | Mean | Standard Deviation | Mean | Standard Deviation |
| Attitudes Toward *Standards*-Based Teaching | 39 | 80.94 | 13.00 | 77.01 | 13.24 |
| Pedagogical Preparedness | 33 | 63.13 | 14.30 | 66.22 | 17.09 |
| Physics Preparedness | 39 | 60.90 | 17.28 | 66.67* | 17.83 |
| Traditional Teaching Practices | 24 | 70.83 | 13.25 | 70.31 | 9.26 |
| Investigative Teaching Practices | 27 | 32.99 | 11.67 | 35.19 | 10.60 |
| Investigative Classroom Culture | 27 | 65.05 | 17.10 | 72.11* | 16.05 |

* Year Two score significantly greater than Year One score, 1-tailed repeated measures t-test, $p < 0.05$.

[4] Composite scores are computed only for those participants with multiple time points and responses to all items associated with a composite. In addition, data for the teaching practice composites are presented only for those participants whose teaching assignment did not change from one year to the next.

As the number of rural centers increases, the number of participants submitting questionnaires at multiple time points should increase considerably, allowing for a broader look at the impact of the project.

**Teacher Impact Study**[5]

In addition to the outreach participant questionnaire, a content assessment focusing on kinematics and dynamics was administered at the beginning and again at the end of each of the seven rural institutes focusing on these topics. Table 14 shows descriptive statistics for the assessment, overall and separately for the kinematics and dynamics sub-scales.

**Table 14**
**Descriptive Statistics for the Teacher Assessment**

| | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|
| **Pre-Test** | | | | |
| Overall | 26.47 | 97.06 | 69.08 | 17.58 |
| Kinematics | 23.53 | 100.00 | 73.57 | 18.80 |
| Dynamics | 5.88 | 100.00 | 64.59 | 21.09 |
| **Post-Test** | | | | |
| Overall | 32.35 | 100.00 | 73.84* | 15.12 |
| Kinematics | 23.53 | 100.00 | 77.92* | 16.75 |
| Dynamics | 29.41 | 100.00 | 69.76* | 17.63 |

* Post-test scores significantly higher than pre-test score, repeated measures analysis of covariance, $p < 0.05$.

A repeated measures analysis of covariance model was used to statistically test changes in teachers' assessment scores. Teacher gender and grade-level taught were also included in the analysis to examine if the performance was consistent across different types of participants. The major findings from the study were:

1. Teachers' scores were significantly higher on the post-test than on the pre-test;
2. Changes in teachers' scores did not vary by gender;
3. Elementary/middle school teachers had significantly greater gains on the overall assessment and kinematics sub-scale, but not on the dynamics sub-scale, than did high school teachers (due in part to the fact that elementary/middle school teachers had much greater room for growth).

The results of this study provide additional evidence of the project's impact on outreach participants' content knowledge.

[5] For a full description of the study and results see: Banilower, E.R., Results of the 2003 AAPT/PTRA Teacher Impact Study. Horizon Research, Inc., Chapel Hill, NC, December 2003.

**Outreach Participant Interviews**

In the fall of 2003, HRI conducted telephone interviews with a random sample of 10 outreach participants to gather their feedback on the program.[6] When asked why they decided to participate, participants mentioned improving their understanding of physics and getting activities to use in the classroom, each noted by five participants. As two participants said:

> *I was teaching physics and felt it would be a good opportunity to improve on what I was doing. I wanted to try to do more activities, to get through to the kids with the concepts, and make them easier to understand and teach.*

> *I have a special, broad-field degree, but my major is in biology and chemistry. I wanted more physics because I don't feel comfortable teaching it.*

HRI also asked the interviewees to what extent the stipend and availability of graduate or continuing education credits affected their decision to participate. Four of the 10 interviewees cited the availability of credit as a reason for attending. In addition, six of the participants indicated that the stipend did motivate them to attend. In the words of two participants:

> *It [the stipend] was an incentive. It is a three-hour trip for me…*

> *I took three credit hours. That was a large factor in my decision to sign up for it.*

Overall, the interviewees had positive comments about the institute. When asked what aspects of the institute were particularly good or effective, participants cited a number of features. Eight of the 10 interviewees mentioned the classroom activities, either receiving activities they could use in their classroom (5 participants) or having the opportunity to work through the activities in the workshop (3 participants). The quality of the instructors and the opportunity to learn physics were also mentioned by the interviewees. As three participants said:

> *When you have seven preps a day, you need labs that are easy and ready, you can't be developing them from scratch. A lot of the stuff they demo'd I'll never use, it's way out of my money limit. But some of the activities I can use "as-is" with my students.*

> *Being able to do the labs and demonstrations was beneficial, instead of reading out of a book and trying to figure it out on my own. It was nice to see it take place and to discuss problems and how to fix them.*

> *The presenters were accomplished physics teachers, they were not professors, but out in the field and we felt comfortable with them and the materials. And they didn't make you feel uncomfortable if you didn't know about it [the topic].*

When asked what aspects of the rural institute could have been better, the only issue that was mentioned by more than one participant was the emphasis on using technology to teach physics.

[6] The interview sample was randomly drawn from a list of participants provided by the project; at the time of the interviews, the project was unable to provide the names of participants from the Central Pennsylvania Rural Regional Center.

Four of the interviewees thought that the institutes focused too much on technology. For example:

> *The materials presented were out of budget for a lot of people…the equipment was unrealistic. They need to show more ideas that didn't rely on expensive gear.*

> *They could have included more low-tech options. I don't think many of the schools here have CBLs for the students or probes. It wouldn't hurt to walk through the whole lab, math and all, so you have it all worked out when you want to use it in the classroom. We didn't get to do that because we had to spend time making sure everyone could use the technology that we will never use again anyway.*

The interviewees were also asked to what extent the institute focused on deepening their content knowledge, familiarizing them with the activities, preparing them to integrate the activities into their curriculum, and deepening their understanding of common student misconceptions/how students learn physics. All 10 participants indicated that becoming familiar with the activities was a major objective of the institute; 9 of the 10 said it was the primary objective. As one participant said:

> *We were given three-ring binders with more labs than you could ever imagine, and they picked out ones that they thought crossed the grade levels.*

Eight of the interviewees indicated that the institute also focused on helping them integrate the activities into their curriculum. However, the examples participants gave dealt with materials management (e.g., substituting equipment), rather than what students should experience prior to or after a particular activity or when/why to use one activity over another. Eight of the interviewees also thought that deepening their content knowledge was a major goal of the institute; the two who did not see content as a major focus indicated that familiarizing them with technology was the primary objective of the institute.

When asked if deepening their understanding of common student misconceptions/how students learn physics was a goal of the institute, eight participants responded that it was, but 5 of the 8 indicated that it was only dealt with a little. None of the 8 could give a specific example, suggesting that this aspect was not dealt with in a manner that highlighted its importance. As one participant said, "I think they did talk about misconceptions, but I can't think of any right now."

The interviewees were also asked what they got out of the institute. Activities to use in the classroom was most commonly mentioned (eight participants). Learning teaching strategies and how to use technology were each mentioned by three participants. Deeper content knowledge, the opportunity to network, and earning continuing education credits were each mentioned by one participant. Two representative comments were:

> *I got mostly labs that I could use. I wanted to buy a physics curriculum with labs, but my school could not afford it.*

*Taking those labs back with me. Having labs to do, to explain several concepts and to have several labs to choose from.*

All 10 interviewees indicated that they have already incorporated elements of the rural institute into their classroom teaching, in each case including using some of the activities they received. None of the participants described using a new teaching strategy.

**Lead PTRAs' Reflections on the Rural Institutes**

HRI interviewed each of the lead PTRAs from each of the 11 rural institutes. The interview dealt with a three main areas: (1) how the PTRAs planned for their institute; (2) their thoughts on the implementation of the institute; and (3) the follow-up workshops.

***Institute Planning***

The lead PTRAs were asked to describe the goals for their rural institute. The most common objective, mentioned by 9 of the 11 lead PTRAs, was increasing the participants' understanding of basic physics topics. Providing participants with classroom activities was mentioned by seven lead PTRAs, and exposing participants to technology was a goal of five lead PTRAs. Not surprisingly, these goals are consistent with the community of PTRAs' vision of professional development.

Helping participants explore student understanding of concepts, network, and write grants were also mentioned as institute goals. As one would expect of a week-long institute, most lead PTRAs had multiple goals:

*We were hoping they would be more empowered to have students do labs and use more open-ended exploring and move away from cookbook labs. We also wanted to give them more tools to do things like contests where students might be challenged in a game setting. Content-wise, we wanted them to have a basic understanding of [topic].*

*What we really wanted them to have was a better understanding of the concepts, [and] to obtain information about technology, even if money for technology isn't there. Also, we wanted them to learn some inquiry activities to incorporate into their classroom. We wanted them to understand that effective teaching could involve things other than drill and lecture—Good lessons involve students in the lesson.*

It is interesting to note that although the PTRAs had many objectives for their institutes other than providing participants with activities, it was the activities that most of the participants focused on in their interviews. It may be that the balance of objectives in the institutes was tilted so heavily towards familiarizing participants with the activities, that the other objectives were pushed too far into the background for the participants to focus on.

This hypothesis is supported by HRI's observations at a sample of the rural institutes. During the observations, HRI noted that the majority of the time was spent on doing activities, with limited discussion of why a teacher would select a particular activity, what common misconceptions students (and many teachers) have regarding the concepts, or where in the instructional sequence an activity would be most effective. Further, while the workshop leaders

may have modeled effective pedagogy, there was little explicit discussion of the strategies being used or alternative ones that the participants might consider utilizing. Without a deliberate involvement of participants in a discussion of these issues, the importance of these ideas can easily be lost in the flurry of activities.

When asked what resources they used to plan their institute, all 11 lead PTRAs indicated that they drew heavily on the PTRA workshop manuals. Four lead PTRAs indicated they supplemented those with activities from other workshops they have attended or from published materials. Specific activities were chosen because they focused on the concepts central to the topic of the institute.

The lead PTRAs were also asked whether the number of PTRAs working at the institute was sufficient. Nine of the 11 lead PTRAs indicated that they did not have enough PTRAs helping at their institute, primarily due to the extensive needs of many participants, particularly when it came to using technology. As two lead PTRAs said:

> *We firmly believe you could not do it with less than four leaders. With a lot of technology and a lot of participants with no knowledge of technology, you need at least one leader and two helpers. Plus, so many of them, their skills were so low that we had participants we had to constantly go check-in on. We had one [participant] who had no idea what she was doing at all. She was the worst, but there were many like her. At that kind of level of ability and knowledge, you need a sufficient number [of PTRAs] there not to lose them.*
>
> *I think they [the project leadership] are foolish if they think two people can do it. If we're going to have technology as a strand, and that's something they want to pursue, you need to make sure that there are enough bodies there to help them so that (1) you don't get so frustrated and burned out because you're running around like a chicken with your head cut off; and (2) they're all in the same boat.*

Of the two lead PTRAs who indicated that they had adequate staff, one had four PTRAs to draw upon, the other only had 16 participants and indicated that two PTRAs were enough for a group that small. (The average number of participants at the rural institutes was 23; the maximum number was 38.)

***Institute Implementation***

Nine of the 11 lead PTRAs indicated that the participants attending their institute were a mix of middle school and high school teachers; two institutes served only high school teachers. According to the lead PTRAs, participants varied widely in terms of their backgrounds, with some participants having physics degrees and others having no science training at all. For six of the lead PTRAs, the participants' backgrounds matched their expectations; four lead PTRAs were surprised by the overall low level of physics preparedness of their participants.

Even though the majority of lead PTRAs expected their participants to have little or no physics background, 8 of the 11 had planned to do too much in the institutes, and adjusted the workshop by lowering the pace and covering fewer activities.

Four lead PTRAs attempted to deal with the diverse needs of their audience by assigning participants to groups based upon their proficiency level, placing a participant with a strong background in the same group as a participant with a weak background. In some instances, the lead PTRAs thought that this strategy was successful; in other instances it did not work as well as hoped. As one lead PTRA said:

> *We worked it in to have the physics people help some of the beginning people, to engage and to help out. For the most part it worked, a couple of times the personality was irritating to the other person.*

Given that most of the institutes needed to adjust their pace, it is not surprising that all of the institutes covered only a portion of what they had originally planned. Still, 8 of the 11 lead PTRAs indicated that they managed to cover most of their original agenda, while three cut over half of their original agenda. Typically, the lead PTRAs cut out extension activities or those that required complicated equipment or technology. Three of the eight lead PTRAs that had to cut their agenda allowed the participants to choose which topics to cover and which to cut.

Overall, the lead PTRAs thought their institutes were successful. Five lead PTRAs indicated that they though participants had developed a better understanding of important physics concepts. Five lead PTRAs indicated that the participants left with an "arsenal" of classroom activities. Creating a professional community among the participants was a success mentioned by four lead PTRAs. Nine of the 11 lead PTRAs felt that they had accomplished their goals for the institute. The other two lead PTRAs indicated that they had more work to do in helping participants improve their teaching skills. As one lead PTRA whose institute focused heavily on technology said:

> *You know, for the technology part, I don't think we had that much of an impact quite frankly. When we did the follow-up [workshop], we talked with the people there and we asked them what things worked for them and what things didn't. I think our impact was more in giving them better backgrounds rather than giving them new things to use. The simple things we gave them, they liked, they used, but the more complex things of the technology, I don't think that translated to the classroom very well at all. It was just, logically, they just don't have that sort of equipment. So I think our real advancement there, if any, was giving them a better background and giving them some simple things to use. So how effective were we? I think they enjoyed what they got. I think they learned a bit. The transfer to the classroom was less effective.*

When asked how the institute could be improved upon, lead PTRAs raised a wide array of issues. Four of the lead PTRAs mentioned the need to improve logistical issues, ranging from having software properly installed on computers prior to the start of the institute to making sure participants receive their stipends in a timely manner. Three lead PTRAs indicated that their institute would benefit from covering less material, but in greater depth. Two mentioned cutting back on the amount of technology utilized.

Similarly, when asked what they would do differently next year, 4 of the 11 lead PTRAs indicated that they would slow down the pace. As one lead PTRA said:

*Now I know the pace that is required. I know which activities need more work as far as instruction notes…Now, I'm not going to be so concerned if I don't get to dynamics, or even through dynamics, if that's what it takes to slow it down and bring it to their level.*

Three lead PTRAs indicated that they would begin their planning earlier, and spend more time on the planning process. Having additional PTRAs available to assist with the institute and de-emphasizing the technology were each mentioned by one lead PTRA.

***The Follow-up Workshops***

The interviews also asked the lead PTRAs about the school-year follow-up sessions. At the time of the interviews, only 10 of the 11 institutes had held follow-up workshops. Each of these 10 used time during the follow-up workshop to revisit the content from the summer sessions, either by doing additional activities or showing participants how to do previously covered activities with technology. Seven of the 10 sites built time into the follow-up workshops to allow teachers to share their experiences in implementing what they had learned from the summer sessions, in three of these cases having participants look at student work related to the topic; one site moved on to new content.

When asked what aspects of the follow-up workshops went well, four lead PTRAs touted the time given for teachers to reflect on their classroom practice. In the words of one lead PTRA:

*Sharing ideas of what worked well and frustrations of administrative aspects in school…The sharing was fantastic, the best part.*

In terms of improving the follow-up workshops, the most common response centered on figuring out how to get more participants to attend. The lead PTRAs described a range of obstacles participants face in returning for the follow-up workshops, including scheduling issues, finding a substitute teacher, travel and hotel costs, and the burden of traveling a large distance, in some cases five hours each way, for a six-hour workshop. As three lead PTRAs said:

*Well we obviously have to figure out the timing of it. I've already told you that. I'm still torn between the one day and the two days. I don't know what the answer to that is so, yes, that's going to have to be improved upon. I kind of wish they could just help us financially to pay hotel rooms and work with them longer than six hours. That's a very short time to address issues when they've had to drive for five hours to get there.*

*It would be really nice if the follow-up sessions didn't require them to miss school to get here. The distances are so great that the people that are doing the follow-up…You know you have to find somebody who's going to come in and cover your class and you have to find stuff that they can do during the day so that it's not a total wash. Yet they can't travel 400 miles on a Friday and be able to do something all day Saturday and turn around and go back on Sunday.*

*The only thing that would have made things better were if more people could have come. The timing was hard to get a time when everyone could come, so only 8 showed up. I don't know how to fix that.*

Given the value of having the follow-up workshops, the project should continue to support institute teams in exploring ways to "make it work." The project's decision to allow some rural centers to offer a single two-day follow-up workshop rather than two one-day follow-up workshops, although not optimal from the perspective of "spaced learning," is a positive example of allowing rural institute leaders to find solutions that solve the problems at their sites while still providing the amount of professional development expected at each rural center.

**Rural Regional Coordinator Interviews**

In addition to interviewing a sample of rural institute participants and all lead PTRAs, HRI conducted telephone interviews with the 11 Rural Regional Coordinators (RRC). The interviews asked the RRCs for their thoughts on how the rural institute went overall as well as on specific aspects for which they were responsible (e.g., recruiting participants).

All 11 RRCs were extremely positive about the rural institutes. When asked for specific aspects that went well, five mentioned the hands-on activities offered at the institute. A typical comment was:

*The teachers appreciated the make and take, the activities in particular—the fact that they got to build things and take that with them for the classroom.*

Three RRCs indicated that the opportunity for participants to network and the camaraderie of the participants were a highlight of the institutes. The quality of the content and of the presenters were each mentioned by two RRCs as strengths of the institutes. As one RRC said when asked to describe a strength of the institute:

*The fact that it is 24 hour experience. They stayed together in the dormitory, ate together in the cafeteria, worked together all day in the institute, and the staff members stayed there with them right there in the dorm and ate with them and so forth. And I think one of the things that was common to all of the participants, they are, by definition of being rural teachers, they are isolated and the fact that they had other people with similar challenges and interests. That they are able to spend that much time [other rural teachers] with ended up being even more beneficial than the instruction itself that took place.*

In addition to pointing out the strengths of the rural institutes, the RRCs also had thoughts on ways the institutes could be improved, though most of the issues were raised by RRCs at first year sites. Five of the 11 RRCs indicated that they would like to improve their planning for the institute by "getting more things done ahead of time," and four RRCs would like to improve upon the recruitment process, changing the way they advertise or finding ways to make it less time consuming.

The recruitment process was one of the foci of the interviews. When asked how they went about recruiting participants, all 11 RRCs indicated that they had used a variety of methods, including mailings to schools. Eight RRCs also advertised on local science teacher association websites and listservs; five distributed information at local science teacher conferences.

When asked what strategies were most promising, four RRCs highlighted the importance of sending mailings to specific teachers, not just to the school. As one RRC said:

> *It was important that we sent it to actual names. Another program found in the past that if they just sent it to the science teacher without a name, then it just went straight to the principal and sat on a desk and never got where it needed to be.*

Meeting potential participants face-to-face, asking teachers to recommend other teachers, and utilizing multiple strategies were each mentioned by at least one RRC. On the other hand, three RRCs specifically said that attending local conferences to advertise had not been very effective, and wasn't a particularly good use of their time. Overall, it seems that recruitment is highly dependent upon local contexts, and what works in one location may not be effective in another. Still, RRCs would probably benefit from sharing strategies for recruitment.

Only eight of the RRCs indicated that they that were knowledgeable about the follow-up workshops, and all of these thought that they went very well. Four indicated that the follow-up sessions were successful at helping teachers network and build morale within the group. As one RRC reported:

> *I think one of the greatest side benefits was the network building, and this way they all got together again and can informally share war stories.*

Three RRCs indicated that having time for teachers to share their successes and failures was a strength of the follow-up session. As two RRCs said:

> *I think it all went well, but the sharing part went surprisingly well. I was worried that it wouldn't go well. I thought it would be deadly dull, but it was very interactive.*

> *Just the opportunity to talk to people about the things that worked and didn't work. The fact that they had been together for a week and had emailed each other. There was a comfort and security level that was there.*

When asked about what could be improved upon, the only issue mentioned by more than one RRC was increasing the number of participants attending the follow-up workshops (three of the RRCs reported struggling with this issue). To some degree, the RRCs are not sure what they can do to improve attendance. As one RRC said:

> *I think that it is something that the whole program struggles with in the sense that, how do you get people to consider coming to the follow-up sessions as part of their responsibility? I am not sure how to address that.*

The RRCs were asked about the support provided to them by the project leadership. Overall, the RRCs think the project has been supportive, particularly in clarifying procedural issues and roles (mentioned by six RRCs) and in providing suggestions for recruiting participant s (mentioned by two RRCs). One RRC was very thankful for the leadership's role in selecting PTRAs for the institute. As two RRCs said:

> *The suggestions have been good ones. They have also given us samples of letters to send out to recruit, so we've modified those and made them specific to [site].*

> *The biggest thing they do for us is send out three really competent teachers [PTRAs]. If those teachers had been less prepared then it would have been a really ineffective program. It's all about those teachers and their preparation that determines the success or failure of it, and in this case, all of them were top flight.*

Although they thought that the leadership has been generally supportive, five of the RRCs indicated that the project could have been timelier in providing that support. As one RRC described the situation:

> *Supportive, yes, but sometimes, and this might just be a function of everyone being busy, it takes a while for information to come back. Like you'll ask a question or have a problem…it seems like things take a lot of time.*

Five RRCs also indicated that the project could improve by better documenting and clarifying the role of the RRC and the various processes involved in running a rural center. Three such comments were:

> *We need clearer statements on those monetary issues. If five of us [at our site] misunderstand it all in the same way, it seems like there must be something in the information that we got that was misleading or just not clear.*

> *They could have been more helpful in the beginning with providing guidance about how to interface with the grant to getting people reimbursed for travel and lodging and meals and materials and things like that.*

> *[They need to] identify a clearer point of contact for various things about management questions*

Although the project has made great strides in describing and clarifying the various responsibilities of the RRCs, as evidenced by the numerous documents on the PTRA web-site, it appears that there is more work to be done in this area. Having clear and standard procedures is even more important as the project grows and operates an increasing number of rural centers.

**Implications**

Three main themes emerge from the rural institute data. The first theme centers on recruiting and retaining outreach participants. A number of the RRCs expressed frustration at the level of effort required on their part and the difficulty of filling the available slots at their center. Further,

although the project has had much more success this year in getting outreach participants to attend the school-year follow-up sessions than last year, both the RRCs and the lead PTRAs expressed a desire to figure out how to get even more outreach participants to return for the follow-up sessions. Thus, the project may want to foster opportunities for the RRCs and lead PTRAs to share ideas on these issues, perhaps starting and facilitating a listserv discussion by asking each RRC and lead PTRA to share a strategy that has worked well and a strategy that has not worked well.

In a similar vein, the first two cohorts of rural centers have not been very successful at retaining participants across years. When asked why they did not return for another year, survey respondents were most likely to indicate that they could not commit to the scheduled dates. The second most common reason was that the topic of the institute did not meet their needs. The project may be able to reduce attrition by better communicating the sequence of topics and dates of each rural institute at the very beginning of a participant's involvement with a rural center.

The second theme deals with tailoring the rural institutes to the needs of the local teachers. The project is providing professional development to teachers with a wide range of backgrounds and needs. Nearly all of the lead PTRAs indicated that once their rural institute began, they needed to make major adjustments, including slowing the pace substantially, spending more time discussing the physics concepts, and showing participants low-tech alternatives to some of the presented activities. The project may want to explore ways of gathering information from the rural institute participants, perhaps on the rural institute application form, regarding their comfort level with physics topics and the level and types of technology available to them at their schools. These pieces of information may help the PTRAs plan more appropriately for their rural institutes.

Although many of the rural institutes have a focus on developing participants' knowledge of core physics topics, in addition to providing them with activities to use in their classrooms, the project may need to incorporate other professional development goals into the institutes to maximize its impact on physics/physical science teaching and learning. These goals might include developing participants' questioning skills, knowledge of common misconceptions, and ability to informally assess student understanding. Both lead PTRAs and RRCs commented on the value of giving participants time during the follow-up workshops to reflect on attempts to integrate what they learned into their classroom. The project may want to consider integrating similar opportunities into the week-long rural institutes as a way of helping outreach participants develop into reflective practitioners. If the project chooses to follow this path, it will be important to provide the PTRAs with opportunities to develop and practice the skills necessary to be successful at leading this type of professional development.

The third theme focuses on the need to continue efforts to clarify and document the roles and responsibilities of the various personnel involved in making the project work. A number of RRCs indicated that the project documentation was not always as clear as it needed to be, and that at times there were lengthy delays in the project's responses to their requests for information and/or clarification. Although the project has made great strides in codifying its policies and operation procedures, it is clear that additional effort in this area is required, particularly as the project increases the number of rural centers in operation.

# Pilot Student Impact Study

In the summer of 2003, HRI and the AAPT/PTRA Rural project leadership developed a pilot study for investigating the impact of the AAPT/PTRA Rural project on student achievement. It was decided that the study would focus on kinematics and dynamics as those were the topics being covered at 7 of the 11 rural institutes operating that summer (the other 4 rural institutes had covered these topics to varying extents in previous years). The project recruited 44 teachers to participate in the study, representing 6 of these 7 rural institutes. The study utilized a pre-test/post-test single group design (no comparison group was available), with the extent of teacher use of PTRA activities in their teaching being the main independent variable of interest.

Although 44 teachers volunteered to participate in the study, HRI received complete data from only 24 teachers, including 1,053 students in 70 classes. Although the six rural institutes were represented in the final data set, the number of teachers per institute varied widely; one institute had 10 teachers and two institutes each had only one teacher. Because of the small number of teachers participating, as well as the unequal representation of rural institutes, the results of this pilot study should be interpreted with caution as the data may not be representative of the project as a whole.

The assessment utilized in this study was developed jointly by HRI and the AAPT/PTRA leadership, and included some items from previously developed assessments such as Jim Minstrell's *Diagnoser* and Ron Thornton and David Sokoloff's *Force-Motion Concept Evaluation*. The assessment contained 41 items, with 23 items focusing on kinematics concepts and 18 items focusing on dynamics concepts. (A copy of the assessment is included in Appendix B.) Percent correct scores were computed for the test as whole and separately for the kinematics and dynamics items. As can be seen in Table 15, students scored higher on the post-test than they did on the pre-test. On both administrations, students also performed better on the kinematics items than on the dynamics items. Item statistics for each item on the assessment are shown in Appendix C.

**Table 15**
**Descriptive Statistics for Student Assessment**

| | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|
| **Pre-Test** | | | | |
| Overall | 14.63 | 87.80 | 46.12 | 12.19 |
| Kinematics | 13.04 | 100.00 | 54.43 | 16.29 |
| Dynamics | 0.00 | 83.33 | 35.50 | 12.27 |
| **Post-Test** | | | | |
| Overall | 17.07 | 100.00 | 57.30 | 15.73 |
| Kinematics | 21.74 | 100.00 | 63.52 | 16.98 |
| Dynamics | 0.00 | 100.00 | 49.34 | 18.76 |

The main research question of this pilot study was whether students of teachers basing a greater amount of their kinematics and dynamics instruction on the PTRA activities performed better than students of teachers utilizing fewer PTRA activities. Because of the nested nature of the data (students grouped in classes, multiple classes taught by the same teacher), hierarchical modeling (multilevel regression) was used to analyze the data. Statistical techniques that do not account for potential shared variance within groups in nested data structures can lead to incorrect estimates of the relationship between independent factors and the outcome. Hierarchical modeling is an appropriate technique for apportioning and predicting variance within and across groups in a nested data structure.[7]

Separate regression analyses were conducted for each score: the overall test score, and the kinematics and dynamics sub-scale scores. The outcome variable of each regression was the respective post-test scale score. Student level control variables included the matching pre-test scale score, gender, race/ethnicity (collapsed into two categories: White/Asian and non-Asian minority), and grade level ($9^{th}$/$10^{th}$ grade were combined due to the small number of $10^{th}$ grade students). At the classroom level, control variables included number of students enrolled in the class, total minutes of instruction on kinematics and dynamics and class type. At the teacher level, the control variables were type of schedule and teacher experience level.

The main independent variable of interest, proportion of instruction based upon PTRA activities, was included at the class level since teachers utilized different numbers of activities in different classes. Table 16 provides descriptive statistics on the categorical variables in the analyses; Table 17 provides descriptive statistics on the continuous variables included in the analyses.

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

**Table 16**
**Descriptive Data for Categorical Variables**

| | Percent |
|---|---|
| **Student Level** | **(N = 1053)** |
| Gender | |
| Male | 51 |
| Female | 49 |
| Race/Ethnicity | |
| White/Asian | 89 |
| Non-Asian minority | 11 |
| Grade | |
| $9^{th}/10^{th}$ | 27 |
| $11^{th}$ | 43 |
| $12^{th}$ | 30 |
| **Class Level** | **(N = 70)** |
| Class Type | |
| Physical science | 19 |
| $1^{st}$ year physics | 69 |
| $2^{nd}$ year/AP physics | 13 |
| **Teacher Level** | **(N = 24)** |
| Teaching Experience | |
| 0–5 years | 18 |
| 6–10 years | 18 |
| 11 or more years | 64 |
| Schedule Type | |
| Block | 33 |
| Traditional | 67 |

**Table 17**
**Descriptive Data for Continuous Variables**

| | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|
| **Class Level (N = 70)** | | | | |
| Number of Students | 3.00 | 28.00 | 16.49 | 5.73 |
| Minutes of Instruction on Kinematics and Dynamics | 495.00 | 4680.00 | 2365.23 | 915.09 |
| Percent of Instruction Based on PTRA Activities | 8.00 | 82.00 | 24.14 | 15.51 |

The regression coefficients and standard errors for each analysis are shown in Table 18. The percentage of instruction based on PTRA activities, the main independent variable of interest in these analyses (highlighted), was not a significant predictor of student post-test scores in any of the three models after controlling for pre-test scores and the other variables. In other words, greater use of PTRA activities did not lead to higher scores on the assessment. Although the results of this study need to be interpreted with great care due to the limitations mentioned above, these findings lend additional weight to the argument that providing teachers with activities is not sufficient to improve physics teaching and learning.

**Table 18**
**Regression Results**

| | Regression Coefficient (standard error) | | |
|---|---|---|---|
| | **Overall** | **Kinematics** | **Dynamics** |
| **Student Level** | | | |
| Intercept | 56.98 | 63.36 | 49.04 |
| | (1.07) | (1.11) | (1.48) |
| Pre-test score | 0.66*** | 0.60*** | 0.28*** |
| | (0.03) | (0.03) | (0.04) |
| Female | -4.35*** | -4.54*** | -5.50*** |
| | (0.66) | (0.74) | (0.91) |
| Non-Asian minority | -3.32** | -2.12 | -5.72*** |
| | (1.12) | (1.26) | (1.56) |
| Grade Level (compared to 9th/10th grader) | | | |
| 11th grader | -2.05 | -0.95 | -4.13 |
| | (1.87) | (2.09) | (2.62) |
| 12th grader | -4.22* | -3.23 | -6.29* |
| | (1.99) | (2.22) | (2.78) |
| **Class Level** | | | |
| Number of students | 0.06 | 0.07 | 0.20 |
| | (0.12) | (0.12) | (0.19) |
| Course Type (compared to 1st year physics) | | | |
| Physical science | -9.78** | -11.77*** | -10.92** |
| | (2.81) | (2.88) | (4.09) |
| 2nd year/AP physics | 3.24 | 4.74* | 5.39 |
| | (2.08) | (2.10) | (3.07) |
| Minutes of instruction (in 10's of minutes) | 0.01 | 0.01 | 0.02 |
| | (0.02) | (0.02) | (0.02) |
| Percent of instruction based on PTRA activities | 0.00 | 0.08 | -0.10 |
| | (0.09) | (0.09) | (0.13) |
| **Teacher Level** | | | |
| Teacher Experience (compared to 6–10 years) | | | |
| 0–5 years | 1.91 | 2.04 | 4.52 |
| | (3.87) | (4.00) | (5.38) |
| 11 or more years | 6.12 | 3.17 | 13.12** |
| | (3.10) | (3.20) | (4.29) |
| Block schedule | -0.23 | 0.95 | -3.27 |
| | (2.30) | (2.39) | (3.18) |

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

There are a number of other interesting findings from these analyses, including that minutes of instruction was not a significant predictor of student scores. Female students tended to score about five points lower on each scale than did male students. Non-Asian minority students scored lower than white/Asian students on the dynamics scale, but not on the kinematics scale. Additional analyses indicated that these patterns were the same across classes, regardless of the amount of instruction or how much of it was based on PTRA activities.

Not surprisingly, students in physical science classes score about 10 points lower than students in 1st year physics classes; students in 2nd year/AP physics classes scored about 5 points higher on

the kinematics scale than students in 1st year physics classes, but did not perform significantly better on the dynamics scale. Finally, students of teachers with 11 or more years experience scored 13 points higher on the dynamics scale than students of teachers with 6–10 years of experience.

**Implications**

Although this pilot study was quite small in scope, several lessons can be culled from the experience and the data. First, if a credible study of the project's impact on students is to be conducted, a much larger and more representative sample of rural institute participants will need to be involved. In addition, the project may want to consider offering teachers an incentive to participate to help reduce the attrition rate. The project's plan to recruit teachers for the study during the rural institute, rather than after the teachers have returned to their homes, is a move that should yield positive results.

Second, a credible study will require the inclusion of a comparison group. It may be possible to use rural institutes in their first year (focusing on kinematics and dynamics) as a comparison group for rural institutes in their second year (focusing on impulse, momentum, and energy), and vice-versa. If this strategy does not work out, the project may want to consider randomly assigning new rural institutes to different topics so that they may serve as comparison groups for each other.

Finally, even though the pilot study was extremely small in size, and not very representative of all of the rural institutes, the results are worth some consideration. That students of teachers devoting a higher proportion of their instruction to PTRA activities did not perform any better than students of teachers devoting a lower proportion of their instruction to these activities, raises questions about the wisdom of the project focusing so heavily on providing rural participants with activities.

# Summary and Recommendations

In its second year of operation, the AAPT/PTRA Rural project can be credited for a number of accomplishments. The project successfully established an additional seven Rural Regional Centers and generated considerable enthusiasm among the PTRAs for the rural center model. The project has made great progress in systematizing and documenting roles, responsibilities and procedures, which should make the job of PTRAs, RRCs, and the project leadership easier. The project has also greatly increased the proportion of outreach participants attending the follow-up workshops. In addition, data from the teacher impact study indicate that the project has had a positive impact on participants' physics content knowledge.

On the other hand, there may be an inordinate focus on classroom activities at both levels of the project: the PTRA institute and the rural institutes, so much so that it appears that the activities have become the goal themselves rather than the means of helping outreach participants develop into highly-effective teachers of physics/physical science. Although the PTRAs are becoming adept at using the classroom activities to teach outreach participants core physics topics, much as if the outreach participants were students in the PTRAs' classes, other aspects of

physics/physical science teaching critical to effective practice have not yet been integrated into PTRA-provided professional development. In the spirit of a critical friend, HRI offers the following recommendations to the project.

- **The project's success depends upon the PTRAs. Thus, providing PTRAs with a vision of effective professional development, as well as the knowledge and skills to implement that vision, is critical.**

  In actuality, the project needs to consider three parallel levels of vision. The first vision, at the classroom level, is that of effective teaching and learning. The project leadership, the PTRAs, and the outreach participants need to develop a shared understanding of what effective physics/physical science instruction looks like. Without such a vision of teaching and learning, professional development cannot be focused on helping teachers work towards that goal. The set of knowledge and skills needed by teachers to achieve this vision becomes the objectives for professional development (i.e., the rural institutes). In addition, having a vision of effective teaching and learning provides teachers a "gold standard" for reflecting upon their practice.

  The second level of vision is at the rural institute level. The project leadership and the PTRAs need to have a common vision of effective professional development in addition to a vision of effective classroom practice. This vision of professional development would allow the project leadership and the PTRAs to determine what skills and knowledge are needed by the PTRAs to help teachers move towards the vision of effective classroom practice. This vision of effective professional development would provide the PTRAs with a gold standard for reflecting upon their practice as professional development providers.

  The third level is at the PTRA program level. In order to prepare the PTRAs to provide high-quality professional development, the project leadership and the designers and implementers of the PTRA institute need to share a vision of how best to prepare the PTRAs for their role as professional development providers. The skills and knowledge needed by the PTRAs to provide effective professional development to outreach participants should be the focus of the PTRA institute.

  Developing these three levels of vision is not an easy or quick task, however, it will be essential if the project is to maximize its impact on physics/physical science teaching and learning. To help in the process, the project may want to initiate a conversation with the PTRAs about effective classroom practice, perhaps using video of classroom instruction, or role-plays, providing examples and non-examples of effective teaching as a basis for the discussion.

  Likewise, once a vision of classroom practice is established, the project can then move onto developing a shared vision of effective professional development among the PTRAs. Again, video can be a powerful means for fostering such a discussion. Thus, the project leadership may want to ask PTRAs to video some of their outreach workshops, or perhaps video their own workshops to make the prospect less threatening to the PTRAs, as grist for this

conversation. With images of professional development, the leadership could foster an honest but critical discussion about professional development.

This process would also have a number of side benefits. First, it would shift the emphasis of the PTRA institute from classroom activities to professional development. Second, it would help the PTRAs see themselves as professional development providers rather than classroom teachers. It would also provide the PTRAs with the means to reflect upon their own practice as professional development providers, analyzing their areas of strength and weakness.

- **The project should consider including a greater focus on the findings of the physics education community in its workshop manuals and summer institute.**

  Given that physics, more so than any other subject, has a large body of research about misconceptions and effective teaching practices, the AAPT/PTRA Rural project is perfectly positioned to help bridge the gap between the physics education research community and the classroom teacher. Having this information built into the workshop manuals would make it easier, and thus more likely, for the PTRAs to include relevant pieces in their outreach workshops, helping them become effective professional development providers and move beyond the role of sharers of activities.

- **The project should consider ways to boost attendance at the rural institute follow-up sessions as well as the retention rate from one year to the next.**

  Offering consistently high-quality professional development is important to sustaining participation, but additional measures may be needed as well. It will be important to make sure the participants are told the dates and times of the follow-up sessions when they are signing up for an institute. In addition, the project's recruitment literature could stress the importance of attending these sessions. Similarly, providing participants with information regarding future years' institutes further in advance may help increase retention across years. Finally, creating opportunities for lead PTRAs and RRCs to share their successes and failures in regards to recruitment and retention would provide them with an expanded repertoire of strategies to draw upon.

# 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, HRI used factor analysis to identify survey questions that could be combined into "composites."[1] Each composite represents an important construct related to science teaching.

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. By doing this, 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 9-item composite where each item is on a scale of 0–4 would have a denominator of 0.36.

| **Attitudes Towards *Standards*-Based Teaching** | **Item** |
|---|---|
| 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)** | **.77** |

[1] See "Technical Report: Analysis of the Psychometric Structure of the LSC Surveys" (12/07/98) by David B. Flora and A.T. Panter, L.L. Thurstone Psychometric Lab, University of North Carolina at Chapel Hill, NC for a detailed description of the factor analysis process.

| Pedagogical Preparedness | Item |
|---|---|
| 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)** | **.91** |

| Physics Content Preparedness | Item |
|---|---|
| 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)** | **.84** |

| Traditional Teaching Practices | Item |
|---|---|
| Assign science/mathematics homework. | Q13m |
| Answer textbook/worksheet questions | Q14g |
| Practice routine computations/algorithms. | |
| 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)** | **.71** |

| **Investigative Teaching Practices** | **Item** |
|---|---|
| Make formal presentations to the class. | Q13d |
| Engage in hands-on science activities. | Q13e |
| 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)** | **.80** |

| **Investigative Culture** | **Item** |
|---|---|
| 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)** | **.80** |