# Evaluation of Mitchell Institute Physics Enhancement Program (MIPEP) Summer Institute

## August 2013

Education Research Center
at Texas A&M University

TEXAS A&M UNIVERSITY

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Prepared by:
Education Research Center at Texas A&M University

## Credits

### Education Research Center at Texas A&M University

The Education Research Center (ERC) at Texas A&M University (TAMU) studies major issues in education reform and school governance in order to improve policy and decision-making in P-16 education.

For additional information about ERC at TAMU research and evaluation, please contact:

Education Research Center
at Texas A&M University
112 Harrington Tower
4232 TAMU
College Station, Texas 77843-4232
erc.cehd.tamu.edu

### Contributing Authors

Education Research Center
at Texas A&M University:

Jacqueline R. Stillisano
Sandra Metoyer
Danielle B. Brown

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## EXECUTIVE SUMMARY

The Mitchell Institute Physics Enhancement Program (MIPEP) Summer Institute was envisioned and designed by Dr. Bhaskar Dutta, Texas A&M physics professor and interim director of the George P. and Cynthia Woods Mitchell Institute for Fundamental Physics and Astronomy, and Paula Hiltibidal, an Education Service Center Region 15 master teacher and high school science specialist in the Early Independent School District, in collaboration with Dr. Alexey Belyanin and Dr. Tatiana Erukhimova, faculty in the Texas A&M University Department of Physics and Astronomy. The Institute was purposed to (a) positively impact physics teaching and learning, (b) increase participants' physics content knowledge, (c) assist participants to develop and use research-based instructional strategies, (d) provide laboratory-based learning experiences, and (d) encourage collaboration among physics educators.

The present evaluation examined the impact of the MIPEP 2013 Summer Institute, including increasing participants' knowledge of, and confidence in teaching, physics concepts. The evaluation was a mixed-methods study and included pre- and post-assessments of participants' content knowledge, pre-and post-perceptional surveys, post-session topic surveys, observations of lab-based experiences, and final reflections.

### Key Findings

The MIPEP 2013 Summer Institute was found to include the following strengths:

- The 2013 Summer Institute was successful in increasing participants' physics content knowledge
- The 2013 Summer Institute was successful in increasing participants' confidence in teaching physics to their students
- The 2013 Summer Institute was successful in increasing participants' confidence in implementing research-based instructional strategies in their individual classrooms

### Key Recommendations

The primary recommendations include the following:

- Follow each physics topic with a window of time for practice, followed by a window of time for exploration of teaching strategies specific to the topic. Repeat for each physics topic taught.
- Prior to each new physics topic, offer a math review session that introduces the mathematical skills needed for the topic.
- Create permanent study groups on the first day of the Institute.
- Provide follow-up and support to participants as they implement the new teaching strategies and content knowledge in their classrooms.

In conclusion, the MIPEP 2013 Summer Institute appears poised to have a major impact on physics instruction in Texas. Findings indicate that overall, participants had positive opinions of their experience, perceiving that their physics content knowledge had increased, as well as their understanding of instructional strategies for effectively teaching high school physics courses.

# CHAPTER 1: Introduction

In this country there is a significant need for greater numbers of highly qualified physics teachers in high school classrooms. Nationally, less than 50% of high school physics teachers have the equivalent of a physics or physics education major, and only 11% have a minor in the subject (Sabella, Van Ouzor, Passehl, & Weisenburger, 2012). In Texas, specifically, many high school physics teachers have completed no more than 6 credit hours of college-level physics courses (Dutta, 2012).

The Mitchell Institute Physics Enhancement Program (MIPEP) Summer Institute was initiated to address the need for more qualified physics teachers in Texas. Underwritten by the Cynthia and George Mitchell Foundation and using funds provided through the Texas A&M Foundation, the MIPEP Summer Institute is purposed to establish an outreach effort to improve Texas high school students' mathematics and science performance by providing exemplary professional learning opportunities for physics teachers across the state. More than a dozen faculty from the Texas A&M Department of Physics and Astronomy volunteer their time to offer an intensive 2-week immersion in key physics content and instructional skills to MIPEP Summer Institute participants.

The Education Research Center at Texas A&M University (ERC at TAMU) was commissioned by MIPEP in April 2013 to conduct an external evaluation of the MIPEP 2013 Summer Institute. This report describes the findings from the MIPEP evaluation, which addressed research questions related to the following five project objectives:

1. Positively impact physics teaching and learning in Texas
2. Increase participating teachers' understanding of physics concepts
3. Assist participating teachers to develop and use research-based strategies that engage and provide differentiated instruction for their physics students
4. Provide rigorous laboratory-based learning experiences for participants
5. Facilitate collaboration of physics educators in Texas

## Program History

The Mitchell Institute Physics Enhancement Program (MIPEP) Summer Institute was envisioned and designed by Dr. Bhaskar Dutta, Texas A&M physics professor and interim director of the George P. and Cynthia Woods Mitchell Institute for Fundamental Physics and Astronomy, and Paula Hiltibidal, an Education Service Center Region 15 master teacher and high school science specialist in the Early Independent School District, in collaboration with Dr. Alexey Belyanin and Dr. Tatiana Erukhimova, faculty in the Texas A&M University Department of Physics and Astronomy. Janie Head, physics teacher at Foster High School in Lamar Consolidated Independent School District and Ph.D. candidate in Curriculum and Instruction at Texas A&M University, provides key content and pedagogical input. In addition, more than a dozen faculty from the Department of Physics and Astronomy volunteer their time to teach key physics concepts during the 2-week institute.

The purpose of the MIPEP Summer Institute is to improve Texas high school students' mathematics and science performance by providing rigorous, sophomore-level physics education (physics 201 and 202) to high school physics teachers across the state of Texas. Applicants for the program are required to meet two criteria: (a) they must be current high school physics teachers, and (b) they may not have completed more than four physics course while in college.

The curriculum of the Summer Institute focuses on fundamental physics concepts and subjects such as mechanics, electricity, and magnetism. Instruction is provided at the Cook's Branch Conservatory in Montgomery County. In addition, two days of laboratory-based work is provided at the Texas A&M campus in active research labs.

The MIPEP Summer Institute is underwritten by the Cynthia and George Mitchell Foundation with funds provided through the Texas A&M Foundation. Participants in the program receive a certificate, as well as Continuing Profession Education credits (CPUs). Additionally, each participant receives a stipend and travel support, as well as lodging and meals provided at the Cook's Branch Conservatory.

The first MIPEP Summer Institute occurred in June 2012. Participants included 15 teacher-students from 13 different school districts. The second MIPEP Summer Institute took place in June 2013. Participants for this institute included 18 teacher-students from 18 high schools in 18 different districts and nine Education Service Center regional areas across Texas.

## Organization of the Report

The primary purpose of this report is to address the evaluation questions related to the Mitchell Institute Physics Enhancement Program (MIPEP) 2013 Summer Institute. The report is organized into five chapters. Chapter 1 provides the history and background information for MIPEP, Chapter 2 presents the MIPEP program components, Chapter 3 describes the research methods used in the current evaluation, and Chapter 4 addresses the results of the evaluation. Finally, Chapter 5 offers a summary and conclusions.

# CHAPTER 2: Description of Key Program Components

The Mitchell Institute Physics Enhancement Program (MIPEP) was envisioned as a Texas A&M University Department of Physics and Astronomy outreach effort to improve Texas high school students' mathematics and science performance by providing rigorous, college sophomore-level physics education to high school physics teachers across the state of Texas through intensive, 2-week summer institutes. The Education Research Center at Texas A&M University (ERC at TAMU) was commissioned by MIPEP in April 2013 to conduct an external evaluation of the 2013 MIPEP Summer Institute.

## MIPEP Summer Institute Objectives

The MIPEP Summer Institute was established with the following five objectives:

Objective 1: Positively impact physics teaching and learning in Texas.

Objective 2: Increase the participating teachers' understanding of physics concepts.

Objective 3: Assist participating teachers to develop and use researched-based strategies that engage and provide differentiated instruction for all of their physics students.

Objective 4: Provide authentic laboratory-based learning experiences.

Objective 5: Facilitate and encourage collaboration of physics educators in Texas.

## Program Inputs

The MIPEP 2013 Summer Institute represents an outreach effort and goal of the Department of Physics and Astronomy in the College of Science at Texas A&M University, continuing the department's history of commitment to improve preK-12 science teaching and learning in Texas schools by providing exemplary professional learning opportunities for teachers.

Dr. Bhaskar Dutta, Dr. Alexey Belyanin, and Dr. Tatiana Erukhimova, faculty members from the Department of Physics and Astronomy, facilitate the MIPEP Summer Institute and teach different sessions. Additional organization, planning, and teaching expertise are provided by Paula Hiltibidal, an Education Service Center Region 15 master teacher and high school science specialist in the Early Independent School District, and Janie Head, a physics teacher at Foster High School in Lamar Consolidated Independent School district and Ph.D. candidate in Curriculum and Instruction in the Department of Teaching, Learning, and Culture at Texas A&M University.

The MIPEP 2013 Summer Institute was underwritten by the Cynthia and George Mitchell Foundation, with funds provided by the Texas A&M University Foundation. The George P. and Cynthia Woods Mitchell Institute for Fundamental Physics and Astronomy hosts the Summer Institute, providing classroom facilities, meals, and accommodations for participants at the Cook's Branch Conservatory, a 5000+ acre spread in Montgomery County. In addition, participants receive a stipend and reimbursement for travel expenses.

More than a dozen faculty members from Texas A&M University's Department of Physics and Astronomy volunteer their time to teach key physics content during the MIPEP Summer Institute. Additionally, laboratory facilities at the Department of Physics and Astronomy on the Texas A&M campus are provided for lab-based sessions and hands-on training participants can embed in their own curricula.

## Program Outputs

At the time of this evaluation report, the MIPEP 2013 Summer Institute had concluded. Stakeholders served by the program were comprised of the teacher-students who attended and participated in the 2013 Summer Institute.

The MIPEP 2013 Summer Institute provided an intensive 2-week physics experience for 18 physics teachers in Texas. Table 2.1 provides demographic information regarding the participants.

Table 2.1
*MIPEP Participant Demographics*

| Characteristics | *n* |
|---|---|
| **Sex** | |
| Female | 11 |
| Male | 7 |
| **Ethnicity** | |
| White, not of Hispanic descent | 14 |
| Asian/Pacific Islander | 2 |
| Latino(a) | 1 |
| American Indian/Alaskan Native | 1 |
| **Number of college physics courses completed** | |
| One | 1 |
| Two | 10 |
| Three | 5 |
| Four | 2 |

*Source.* MIPEP Perceptions Pre-Survey.

Participants in the 2013 MIPEP Summer Institute originated from across the state of Texas, with physics teachers from 18 high schools in 18 different districts and nine Education Service Centers regions participating. Table 2.2 illustrates the geographic distribution of the 2013 Summer Institute participants.

**Table 2.2**
*Geographic Distribution of MIPEP 2013 Participants*

| Service Center Regional Area | Number Participating |
|---|---|
| ESC Region II | 4 |
| ESC Region IV | 1 |
| ESC Region VI | 1 |
| ESC Region VII | 4 |
| ESC Region VIII | 1 |
| ESC Region XI | 2 |
| ESC Region XIII | 2 |
| ESC Region XV | 2 |

*Source.* MIPEP 2013 Participant spreadsheet.

## CHAPTER 3: Evaluation Methods

### Evaluation Questions

The evaluation of the MIPEP 2013 Summer Institute was guided by questions related to five objectives: (a) positively impact physics teaching and learning in Texas, (b) increase participating teachers' understanding of physics concepts, (c) assist participating teachers to develop and use research-based instructional strategies, (d) provide rigorous laboratory-based learning experiences, and (e) encourage and facilitate collaboration of physics educators in Texas. Table 3.1 provides the specific evaluation questions related to each of the five objectives.

Table 3.1
*Evaluation Questions for MIPEP 2013 Summer Institute Evaluation*

| |
|---|
| Objective 1: Positively Impact Physics Teaching and Learning in Texas |
| Q1.1. To what extent do teachers perceive that participation in the 2013 MIPEP Summer Institute will positively benefit their physics instruction?<br>Q1.2. What are potential barriers to implementation of the content learned at the 2013 MIPEP Summer Institute, as identified by participants? |
| Objective 2: Increase Participating Teachers' Understanding of Physics Concepts |
| Q2.1. To what extent did participant's knowledge of the concepts presented at the 2013 Summer Institute increase as a result of their participation in MIPEP?<br>Q2.2. To what extent did participants' confidence in their ability to teach physics concepts increase as a result of their participation in MIPEP?<br>Q2.3. What aspects of the content instruction did participants identify as most effective in increasing their knowledge base? |
| Objective 3: Assist Participating Teachers to Develop and Use Research-Based Instructional Strategies |
| Q3.1. What types of research-based instructional strategies were presented at the 2013 MIPEP Summer Institute?<br>Q3.2. What aspects of the instructional strategies training did participants identify as most effective in increasing their knowledge base?<br>Q3.3. What are potential barriers to implementation of research-based instructional strategies, as identified by participants in the 2013 MIPEP Summer Institute? |
| Objective 4: Provide Laboratory-Based Learning Experiences |
| Q4.1. What types of laboratory experiences were provided at the 2013 MIPEP Summer Institute?<br>Q4.2. Do participants feel confident in their understanding of physics concepts as a result of their 2013 MIPEP Summer Institute laboratory experiences?<br>Q4.3. Do participants feel confident in their ability to teach physics concepts as a result of their 2013 MIPEP Summer Institute laboratory experiences? |

| | |
|---|---|
| Q4.4. What are potential barriers to implementation of the 2013 MIPEP Summer Institute laboratory experiences in participants' own classrooms, as identified by participants? | |
| Objective 5: Encourage and Facilitate Collaboration of Physics Educators in Texas | |
| Q5.1. To what extent do participants intend to share the information gained through the 2013 MIPEP Summer Institute with colleagues on their individual campuses? | |

*Source*. 2013 MIPEP Summer Institute Evaluation Plan.

## Participants

Participants for this evaluation study included members of the MIPEP Planning/Facilitation Team, MIPEP presenters (TAMU physics professors and physics master teachers), and 2013 Summer Institute attendees.

## Data Sources and Collection

The evaluation team employed a mixed-methods research design for this study. Quantitative and qualitative data were collected from the following sources: classroom observations of the laboratory-based sessions held on the Texas A&M University campus and secondary data obtained from the MIPEP 2013 Summer Institute facilitators, including results from pre- and post-perception surveys, pre- and post-content knowledge surveys, topic sessions post-surveys, daily reflection surveys, and final reflections survey.

### Observation Data

Researchers from the Education Research Center at Texas A&M conducted observations of laboratory-based sessions held in the Department of Physics and Astronomy on the Texas A&M University campus on June 14 and 21. The research team adapted the *MIPEP Lab-Based Sessions Observation Protocol (L-BSOP)* from observation instruments used in other, similar evaluations of teacher professional development programs. The instrument was used to examine the extent to which particular instructional processes or strategies were used or demonstrated during a particular session and specifically allowed researchers to collect data revealing the extent to which certain elements of (a) instructional orientation; (b) instructor/facilitator practices; (c) preparation; (d) presentation skills/style; and (e) environment, materials, and resources were observed or demonstrated. In addition to completing the *MIPEP Lab-Based Sessions Observation Protocol*, observers took careful field notes that were examined and included as part of the analysis.

**Survey/Assessment Data**

MIPEP Summer Institute facilitators administered several surveys and assessments. Data collected from these instruments were shared with the ERC evaluation team and used in the evaluation. First, the *MIPEP Pre-Content Assessment* and the *MIPEP Post-Content Assessment,* consisting of questions designed to examine change in participants' understanding of 19 of the 20 physics concepts taught, were administered to participants. (The *capacitors* concept was not included in the content assessments.)

The *MIPEP Pre-Content Assessment* was administered to participants on the first day of the 2013 Summer Institute. The *MIPEP Post-Content Assessment*, consisting of the same questions as those included in the *MIPEP Pre-Content Assessment*, was administered to participants at the end of the final day of the 2013 Summer Institute. Both instruments were administered as paper-and-pencil instruments and consisted of questions designed to examine changes in participants' physics content knowledge.

The *MIPEP Pre-Perceptions Survey* was administered to participants on the first day of the 2013 Summer Institute, and the *MIPEP Post-Perceptions Survey* was administered on the final day of the Summer Institute. Both surveys were administered as paper-and-pencil instruments and consisted of questions designed to measure participants' perceptions of their need for professional development in specific instructional strategies, as well as their confidence in their abilities to use certain specific strategies in physics instruction, their confidence in their abilities to teach certain physics concepts, and their confidence in their abilities to guide and develop student learning in specific domains of science processing. Data from these two surveys were analyzed and examined to measure changes in participants' perceptions in these areas. In addition to closed-ended, quantitative questions, the *MIPEP Post-Perceptions Survey* contained two open-ended questions purposed to collect qualitative data regarding participants' perceptions of the most effective laboratory experiences in the 2013 Summer Institute, as well as of possible barriers participants might face in implementing the labs in their individual classrooms.

The *MIPEP Topic Sessions Post Survey*, consisting of 13 questions, was administered to participants subsequent to each topic session. (More than one topic session was addressed on most days of the 2013 Summer Institute.) Questions on this instrument were designed to measure participants' perceptions regarding pedagogical strategies employed by topic session presenters, value of materials and information provided regarding each specific physics topic, participants' confidence in teaching a specific topic, and participants' perceived knowledge level of a specific topic.

MIPEP 2013 Summer Institute participants were asked to complete a *MIPEP Daily Reflections Survey* at the end of each day. This instrument consisted of five open-ended questions that asked participants to reflect on and discuss their learning for that specific day, concepts for which they believed they needed more help in understanding, and their intent to transfer their learnings to their individual classrooms.

At the conclusion of the final day of the MIPEP 2013 Summer Institute, participants were asked to complete the *MIPEP Final Reflections Survey.* This instrument, which consisted of six open-ended questions, asked participants to reflect on the 2013 Summer Institute as a whole and discuss which aspects of the physics content instruction they had received was most effective in increasing their content knowledge, which aspects of the 2013 Summer Institute were most effective in increasing their physics instructional strategies, barriers they perceived they might face in implementing their new knowledge of physics content and instructional strategies in their own individual classrooms, and specific ways in which they anticipated sharing their learnings from the 2013 Summer Institute with their colleagues on their individual campuses.

## CHAPTER 4: RESULTS

This chapter reports the results of the current study, organized by objectives established in the evaluation plan. First, the results related to positive impacts on physics teaching and learning in Texas are reported. Second, the findings associated with strengthening participating teachers' understanding of physics concepts and with assisting participating teachers to develop and use research-based instructional strategies are provided. Next, results pertaining to efforts to provide laboratory-based learning experiences for MIPEP participants are described. Finally, findings related to efforts to encourage and facilitate collaboration of physics educators in Texas are reported. Each objective concludes with a summary of findings.

## Objective 1: Positively Impact Physics Teaching and Learning in Texas

### Evaluation Questions

Researchers developed the following two evaluation questions related to impact of the MIPEP 2013 Summer Institute on physics teaching and learning in Texas:

Q1.1. To what extent do teachers perceive that the 2013 MIPEP Summer Institute will benefit their physics instruction?

Q1.2. What are potential barriers to implementation of the content learned at the 2013 MIPEP Summer Institute?

The following narrative discusses MIPEP 2013 Summer Institute participants' perceptions of changes in their physics instruction resulting from their experiences in the 2013 Institute, and well as perceived possible barriers to their successful implementation of the physics content into their individual classrooms.

### MIPEP Pre-/Post-Perception Survey Results

Two instruments were used to examine MIPEP participants' perceptions of the extent to which the 2013 Summer Institute would benefit their physics instruction. First, the *MIPEP Pre-Perceptions Survey* was administered to participants on the first day of the 2013 Summer Institute. Of the 18 participants, 18 completed the survey, for a response rate of 100%. Second, the *MIPEP Post-Perceptions* Survey was administered on the last day of the 2013 Institute. Of the 18 participants, 17 completed this survey, for a response rate of survey of 94%.

The 48 items on the pre- and post-perception survey were analyzed using a principal component analysis (PCA) to identify components of analysis. Pre- and post-survey responses were combined to provide 35 responses for each of the 48 items included on the instruments. The pre- and post-survey items matched exactly.

Four primary categories were identified: professional development needs, instructional strategies, physics content topics, and science process. Two components were identified within the professional development category: student-centered instruction and teaching strategies. One item did not load with either component and was considered as a stand-alone item. All five items within instructional strategies loaded as one component, with 79% variance explained. The physics content topics were best explained with two separate components (electricity and mechanics) and two stand-alone items (electromagnetic waves and atomic, nuclear, & quantum physics). Finally, the science process category divided into two components (experimental design and connections & technology) and two stand-alone items (lab safety and reading scientific literature). Table 4.1 provides the categories and components.

Table 4.1

*Components in the Pre-/Post-Perceptions Survey Responses*

| | Perception Survey | | | |
|---|---|---|---|---|
| **Component** | **Items** | **% of var** | **KMO** | **α** |
| Professional development needs | | | | |
| Student-centered instruction | 8, 9, 10, & 11 | 53.6 | 0.62 | 0.83 |
| Teaching strategies | 6 & 7 | 15.6 | 0.62 | 0.75 |
| Teacher's content knowledge | 5 | | | |
| Instructional strategies | | | | |
| Instructional strategies | 12, 13, 14, 15, & 16 | 78.8 | 0.89 | 0.93 |
| Physics content topics | | | | |
| Electricity | 27, 28, 29, 30, 31, 32, 33, & 34 | 73.4 | 0.90 | 0.95 |
| Mechanics | 17, 18, 19, 20, 21, 22, 23, 24, 25, & 26 | 74.4 | 0.93 | 0.96 |
| Electromagnetic waves | 35 | | | |
| Atomic, nuclear, & quantum | 36 | | | |
| Science Process | | | | |
| Experimental design | 37, 38, 39, 40, 41, 42, 43, & 44 | 73.5 | 0.83 | 0.95 |
| Connections & technology | 46, 47, 48, 50, 51, & 52 | 76.1 | 0.80 | 0.94 |
| Lab Safety | 45 | | | |
| Reading scientific literature | 49 | | | |

*Source.* MIPEP Pre/Post Perception Survey

Extraction method: Principal Component Analysis

KMO: Kaiser-Meyer-Olkin measure of sampling adequacy

Participants' perceived need for professional development related to student-centered instruction, teaching strategies, and content knowledge decreased as a result of their participation in the MIPEP 2013 Summer Institute, as illustrated in Table 4.2. Their perceived need for professional development related to physics content knowledge decreased significantly.

Table 4.2
*Perceived Professional Development Needs*

| | Perception Survey | | | |
|---|---|---|---|---|
| **Professional development needs** | **M** | **SD** | **Δ** | **p-value** |
| Student-centered instruction (pre-) | 2.8 | 0.72 | -0.34 | 0.10 |
| Student-centered instruction (post-) | 2.5 | 0.57 | | |
| Teaching strategies (pre-) | 3.2 | 0.83 | -0.47 | 0.06 |
| Teaching strategies (post-) | 2.7 | 0.64 | | |
| Teacher's content knowledge (pre-) | 3.5 | 0.62 | -0.76 | **0.00*** |
| Teacher's content knowledge (post-) | 2.7 | 0.59 | | |

*Source.* MIPEP Pre/Post-Perception survey.
* Significant difference at the 0.05 level (2-tailed).
*Note.* Values for survey items are based on a 4-point scale: 1 = *none needed*, 2 = *minimal need*, 3 = *moderate need*, 4 = *substantial need*.

As Table 4.3 illustrates, participants' self-reported confidence for physics instruction increased as a result of the MIPEP 2013 Summer Institute. Participants believed their physics instruction would benefit due to gains in skills for (a) providing in-depth coverage of physics concepts, (b) making relevant connections among physics and real world scenarios, (c) guiding experimental design, (d) communicating scientific results orally and in writing, and (e) using scientific technology. Significant gains were evident pre- to post-survey administration for all components in the *MIPEP Pre-/Post-Perception Survey* related to confidence for physics instruction.

Table 4.3

*Confidence for Physics Instruction*

| | Perception Survey | | | |
|---|---|---|---|---|
| **Component** | **M** | **SD** | **Δ** | **p-value** |
| **Confidence to use instructional strategies** | | | | |
| Instructional strategies (pre-) | 2.2 | 0.83 | 0.95 | **0.00*** |
| Instructional strategies (post-) | 3.2 | 0.49 | | |
| **Confidence to guide science process** | | | | |
| Experimental design (pre-) | 2.1 | 0.64 | 1.13 | **0.00*** |
| Experimental design (post-) | 3.3 | 0.47 | | |
| Connections & technology (pre-) | 2.4 | 0.74 | 0.77 | **0.00*** |
| Connections & technology (post-) | 3.2 | 0.62 | | |
| Laboratory safety (pre-) | 3.1 | 1.14 | 0.59 | **0.02*** |
| Laboratory safety (post-) | 3.7 | 0.49 | | |
| Reading scientific literature (pre-) | 2.4 | 0.94 | 0.65 | **0.02*** |
| Reading scientific literature (post-) | 3.1 | 0.83 | | |

*Source.* MIPEP Pre-/Post-Perception Survey.

* Significant difference at the 0.05 level (2-tailed).

*Note.* Values for survey items are based on a 4-point scale: 1 = *not at all confident*, 2 = *somewhat confident*, 3 = *confident*, 4 = *extremely confident*.

## Perceived Barriers to Implementation of Physics Content

Qualitative data were also collected to address Objective 1, specifically to address Question 1.2. On the *MIPEP Final Reflections Survey,* participants were asked to identify some possible barriers they might face in implementing the physics content knowledge they had learned at the MIPEP 2013 Summer Institute in their individual classrooms. Teachers across the board expressed concerns that deficiencies in their students' knowledge levels would create a challenge to implementation of new physics content knowledge, as the following comments illustrate: "Sometimes the biggest barrier of getting them to where they understand it, is their background knowledge," "Part of the content was directed at AP level students, so I will have to use the concepts in a more basic way," and "Some of the lessons were beyond the scope of the group of students I will be teaching."

Many participants who were concerned about their students' lack of content knowledge specifically emphasized their students' lack of mathematics knowledge as a significant barrier to implementation of the physics content, or as one participant said, "The level of students I teach. Many of them do not have enough basic math skills." One teacher explained, "I usually spend the 1st 6 weeks of science just teaching students simple math skills for using units of measures and manipulating formulas to solve for unknowns." Another teacher agreed, noting, "The math that is required for even the college based-physics program will be beyond what 90% of the students can do. At our school, math is by far the weakest subject."

A third teacher expounded on the challenges s/he anticipated:

> I am working in a school district whose superintendent does not believe that calculus is necessary to a college-bound student. She wants to replace the core science courses with all CTE courses. The science department at my high school now must teach mathematics in our courses because all the students are getting "dumbed down."

Lack of confidence in their own knowledge levels, or "Not having a solid foundation in content," was a concern discussed by several teachers. One teacher, for example, shared, "I am still weak conceptually when applied to real world phenomena. However, the toys and demos throughout the 2 weeks are extremely helpful!" A second teacher concurred: "I need further academic instruction in various topics such as electricity and magnesium." A third teacher, however, confidently asserted that the content knowledge s/he had gained from the 2013 Summer Institute was sufficient to prepare him/her for any challenges:

> The only barrier would be if I didn't have enough confidence in a particular area to implement it. I believe that with the exposure I have experienced, I will be able to research and write effective lessons to implement certain content.

Finally, a few teachers expressed concerns about the lack of materials and resources in their school and the challenges that that would present in terms of transferring their physics knowledge to improve instruction in their individual classrooms. Comments supporting this theme included "Lack of materials and resources to validate concepts in a lab setting," and "In some cases, it would be lack of equipment."

## Summary

Objective 1 of the MIPEP evaluation addressed the project's impact on physics teaching and learning in Texas. Participants for the MIPEP 2013 Summer Institute were recruited by MIPEP program leaders in spring 2013. They included 18 physics teachers from 18 different high schools in 18 different districts across the state.

Quantitative and qualitative data were collected from three sources and examined to address this objective. First, the *MIPEP Pre-Perceptions Survey*, which was composed of Likert-type items, was administered to participants on the first day of the 2013 Summer Institute. The overall response rate to this instrument was 100%. Second, the *MIPEP Post-Perceptions Survey* was administered on the final day of the 2013 Institute and had an overall response rate of 94%. Items on the two instruments were identical.  Finally, the *MIPEP Final Reflections Survey*, which was composed of six open-ended questions, was administered at the end of the final day of the 2013 Institute.  The overall response rate to this instrument was 94%.

Analysis of the data from the pre- and post-perception survey revealed that participants' perceived need for professional development related to student-centered instruction, teaching strategies, and content knowledge decreased as a result of their participation in the MIPEP 2013 Summer Institute.  Their perceived need for professional development related to physics content knowledge decreased significantly.

Moreover, participants' self-reported confidence for physics instruction increased as a result of the MIPEP 2013 Summer Institute.  Participants believed their physics instruction would benefit due to gains in skills for (a) providing in-depth coverage of physics concepts, (b) making relevant connections among physics and real world scenarios, (c) guiding experimental design, (d) communicating scientific results orally and in writing, and (e) using scientific technology.  Significant gains were evident pre- to post-survey administration, for all components in the *MIPEP Pre-/Post-Perception Survey* related to confidence for physics instruction.

Objective 1 also addressed participants' perceptions regarding possible barriers to implementation of the physics content they had learned at the MIPEP 2013 Summer Institute.  Question 9 on the *MIPEP Final Reflections Survey* asked participants to identify specific potential barriers to implementation in their individual classrooms.

Participants overall expressed concerns that deficiencies in their students' knowledge levels would create a challenge to implementation of new physics content knowledge.  Many participants specifically emphasized their students' lack of mathematics knowledge as a significant barrier to implementation of the physics content.

Some participants also revealed a lack of confidence in their own physics content knowledge, although others asserted that the MIPEP 2013 Summer Institute had provided the content knowledge they needed in order to be successful in the physics classroom.  Finally, a few participants expressed concerns that a lack of materials and resources in their individual schools would present challenges in terms of transferring their physics knowledge to improve instruction.

## Objective 2: Increase Participating Teachers' Understanding of Physics Concepts

The syllabus for the MIPEP 2013 Summer Institute included 20 physics concepts that were taught in 3- to 4-hour blocks of time over a 2-week period:  vectors; kinematics & graph analysis; Newton's laws; work, power, & energy; work-energy theorem; conservation of energy; momentum, impulse, and conservation; rotational motion; modern physics and technology; gravity and law of universal gravitation; electrostatics; current; Ohm's law; capacitors; series & parallel circuits; magnetic field; electromagnetic induction; oscillations and waves; electromagnetic waves and optics; and atomic, nuclear, and quantum physics. Following the daily instruction of physics concepts, the MIPEP master teachers modeled and demonstrated instructional methods for teaching the specific concepts to high school students, and each evening, the participants worked together on practice problems that reflected the physics concepts that had been addressed during that particular day's instruction.

## Evaluation Questions

Researchers developed the following three questions related to increasing participating teachers' understanding of the physics concepts:

Q2.1. To what extent did participants' knowledge of the physics concepts presented at the 2013 MIPEP Summer Institute increase as a result of their participation?

Q2.2. To what extent did participants' confidence in their ability to teach physics concepts increase as a result of their participation in the 2013 MIPEP Summer Institute?

Q2.3. What aspects of the content instruction did participants identify as most effective in increasing their knowledge base?

## Participants' Understanding of Physics Concepts

The *MIPEP Pre-Content Assessment*, containing 62 items, and the *MIPEP Post-Content* Assessment, also containing 62 items, were used to measure changes in participants' understanding of physics concepts. Individual items were scored and coded as either correct (value of 1) or incorrect (value of 0). As Table 4 illustrates, items were grouped based on the physics concept components ($n$ = 4) identified through the principal component analysis of the *Pre/Post Perception Survey* responses and then by physics topic ($n$ = 19).

Table 4.4

*Components in the Content Assessment by Item*

| | Content Assessment | |
|---|---|---|
| **Component** | **Items** | **TEKS** |
| Electricity | | |
| Electrostatics | 21, 23, & 25 | 5C |
| Current | 47 & 60 | 5F |
| Ohm's Law | 48 & 61 | 5E, 5F |
| Series & parallel circuits | 47, 60, & 62 | 5E, 5F |
| Magnetic field | 44, 45, & 46 | 5D |
| Electromagnetic induction | 24, 36, & 27 | 5D, 5G |
| Oscillations & waves | 31, 32, & 36 | 7B, 7C, 7D |
| Mechanics | | |
| Vectors | 11, 18, & 19 | 3F |
| Kinematics & graph analysis | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, & 15 | 4A, 4B, 4F |
| Newton's laws | 15, 16, 17, 18, & 19 | 4D, 4E |
| Work, power, & energy | 51, 52, 53, 54, 55, 56, 57, & 58 | 6B, 6C |
| Work-energy theorem | 51 & 59 | 6A |
| Conservation of energy | 51, 54, 56, & 59 | 6D |
| Momentum, impulse, & conservation | 28, 29, & 30 | 6C, 6D |
| Rotational motion | 12, 13, 14, 49, 50, & 52 | 4C, 6C |
| Modern physics and technology | 39, 40 | 5B, 7B, 7F, 8C |
| Gravity and Law of universal gravitation | 6, 20, & 22 | 5B |
| Electromagnetic waves | | |
| Electromagnetic waves & optics | 33, 34, 35, 37, 38, 42, & 43 | 7C, 7E, 7F |
| Atomic, nuclear, & quantum physics | | |
| Atomic, nuclear, & quantum physics | 39, 40, & 41 | 4I |

*Source.* MIPEP Pre-/Post-Content Assessment developed by Mary Jane Head (MIPEP master teacher)

Overall, participants' knowledge of physics concepts increased as a result of the MIPEP 2013 Summer Institute (see Table 4.5). Participants' knowledge of all four physics concept areas—mechanics; electricity; electromagnetic waves; and atomic, nuclear, & quantum physics—evidenced positive gains pre- to post-. Overall (sum of all content assessment items), mechanics and electricity had statistically significant gains.

Table 4.5
*Physics Concepts – Summary by Components*

| | | Content Assessment (percent scale) | | | |
|---|---|---|---|---|---|
| **Component** | **Items (n)** | **M** | **SD** | **Δ (%)** | **p-value** |
| Overall (pre-) | 62 | 54.8 | 17.3 | 10.4 | **0.00*** |
| Overall (post-) | | 65.2 | 17.3 | | |
| Mechanics (pre-) | 35 | 56.7 | 18.4 | 9.4 | **0.00*** |
| Mechanics (post-) | | 66.0 | 17.7 | | |
| Electricity (pre-) | 19 | 52.9 | 18.0 | 7.3 | **0.04*** |
| Electricity (post-) | | 60.2 | 17.8 | | |
| Electromagnetic waves (pre-) | 7 | 53.2 | 25.8 | 4.5 | 0.37 |
| Electromagnetic waves (post-) | | 57.9 | 25.2 | | |
| Atomic, nuclear, & quantum physics (pre-) | 3 | 59.3 | 31.4 | 9.3 | 0.17 |
| Atomic, nuclear, & quantum physics (post-) | | 68.5 | 24.2 | | |

*Source.* MIPEP Pre/Post Content Assessment
***** Significant difference at the 0.05 level (2-tailed).

When the physics concept areas were subdivided and analyzed by physics topic, more detail regarding participants' knowledge of physics concepts could be inferred. Significant positive gains in participants' knowledge on four of the physics topics were clearly evident for kinematics & graph analysis, Newton's laws, rotational motion, and oscillations & waves. This is due, in part, to a combination of factors. First, the participants scored relatively low on the pre-assessment for these topics, resulting in substantial room for gain. Second, it can be inferred that the instruction and practice for these topics was effective. The MIPEP *Topic session Post-Survey* results for these 4 topics indicate that the majority of participants *agreed* or *strongly agreed* that the instruction was effective. Third, the items on the content assessment were likely well matched in format to the instruction and practice items used for instructing the topics.

Scores pre- to post- for seven of the physics topics indicated very little change as a result of a *ceiling effect*. For these topics, a large number of participants (≥ 6) scored the maximum number of points on the pre-assessment. Thus, they could only remain the same or decrease in the post-assessment—there was no room for an increase in scores. The topics in this category are as follows: (1) work-energy theorem; (2) conservation of energy; (3) momentum, impulse, & conservation; (4) modern physics & technology; (5) gravity and law of universal gravitation; (6) electrostatics; and (7) Ohm's law. Of the seven topics with a ceiling effect, five had small positive gains, and the remaining two indicated a small negative change. The *MIPEP Topic Session Post-Survey* results for all seven topics indicate that the majority of participants *agreed* or *strongly agreed* that instruction on these topics was effective.

A third category of the physics topics to be considered are the topics for which participants had an especially weak knowledge at the start of the MIPEP 2013 Summer Institute. This category was evidenced by low pre-assessment scores, with few or no individuals earning maximum points on the post-assessment. Rotational motion, current, series & parallel circuits, and electromagnetic induction are the four topics for which participants had especially weak knowledge prior to the MIPEP 2013 Summer Institute. Rotational motion, on one hand, started as a topic of weak knowledge but finished with significant gains. No participant earned the maximum points (maximum = 4) on the pre-assessment and only three earned maximum points on the post-assessment. Current, on the other hand, started as a topic of weak knowledge with no individual earning maximum points (maximum = 2) and three earning zero on the pre-content assessment. Current finished with a significant decrease. No participant earned maximum points, and eight participants earned a zero on the post-content assessment. Differences in instruction, time scheduled for practice, and the number of items used to assess the topic on the content assessment are all factors that likely contribute to this discrepancy. In fact, several participants commented on the *MIPEP Topic Sessions Post-Survey* responses that they believed the time allowed for instruction was adequate, but they would have preferred more time structured for practice.

Overall, significant gains were achieved in participants' understanding of physics concepts. Examining change by physics topic, the majority of the 19 topics assessed evidenced gains. Scores for 5 of the 19 topics, however, decreased following the MIPEP 2013 Summer Institute: vectors; work-energy theorem; momentum, impulse, & conservation; current; and series & parallel circuits. Two of these, work-energy theorem and momentum, impulse, & conservation, can be explained by a ceiling effect present in the pre-content assessment. Many of the participants scored the maximum on the pre-assessment. Two topics, however, had significant decreases without an initial ceiling effect: current and series & parallel circuits. This indicates a substantial misalignment among effective instruction, time allocated for practice, and/or assessment. Table 4.6 summarizes the analysis of change to participants' knowledge of physics concepts by physics topic.

Table 4.6
*Physics Concepts – Summary by Physics Topics*

| Physics Topic | Content Assessment (crosstabulation by topic) Increase (n) | No change (n) | Decrease (n) | Δ (%) | p-value |
|---|---|---|---|---|---|
| Vectors | 3 | 8 | 7 | -4.0 | 0.41 |
| Kinematics & graph analysis | 12 | 4 | 4 | 10.6 | **0.01*** |
| Newton's Laws | 7 | 6 | 3 | 13.4 | **0.04*** |
| Work, power, & energy | 9 | 6 | 3 | 8.4 | 0.06 |
| Work-energy theorem | 2 | 13 | 3 | -3.0 | 0.78§ |
| Conservation of energy | 3 | 10 | 2 | 5.5 | 0.31§ |
| Momentum, impulse, & conservation | 3 | 11 | 4 | -2.0 | 0.71§ |
| Rotational motion (W) | 14 | 2 | 2 | 19.5 | **0.00*** |
| Modern physics & technology | 4 | 11 | 3 | 3.0 | 0.71§ |
| Gravity & Law of Universal Gravitation | 5 | 12 | 1 | 11.0 | 0.19§ |
| Electrostatics | 5 | 12 | 1 | 9.3 | 0.10§ |
| Current (W) | 0 | 13 | 5 | -14.0 | **0.03**** |
| Ohm's Law | 4 | 12 | 1 | 8.5 | 0.32§ |
| Series & parallel circuits (W) | 0 | 13 | 5 | -9.3 | **0.03**** |
| Magnetic field | 7 | 9 | 2 | 13.0 | 0.07 |
| Electromagnetic induction (W) | 7 | 8 | 3 | 5.7 | 0.41 |
| Oscillations & waves | 11 | 6 | 1 | 20.3 | **0.01*** |
| Electromagnetic waves & optics | 7 | 6 | 5 | 4.7 | 0.37 |
| Atomic, nuclear, and quantum | 7 | 8 | 3 | 9.3 | 0.17 |

*Source.* MIPEP Pre-/Post-Content Assessment

*Notes.* ***n*** is the number of participants (out of 18) that increased, decreased, or had no change in score pre to post.

***** Significant *positive* difference at the 0.05 level (2-tailed).

****** Significant *negative* difference at the 0.05 level (2-tailed).

**§** Presence of a ceiling effect; substantial number of participants (≥ 6) scored maximum points on the pre-assessment.

**W** Low pre-assessment scores with few or no individuals earning maximum points on the post-assessment indicate this was an especially weak area for the participants

## Participants' Confidence in Their Ability to Teach Physics Concepts

Data used to measure quantitative changes to participants' confidence to teach physics concepts were collected using the *MIPEP Pre-/Post Perceptions Surveys* and Question 12 from the *MIPEP Topic Sessions Post-Surveys*: "Overall, the instruction provided increased my confidence in teaching *X*." The physics content topics were grouped into two separate components (electricity and mechanics) and two stand-alone items (electromagnetic waves and atomic, nuclear, & quantum physics) derived from the principal component analysis of the perception survey.

Participants evidenced an increase in their confidence to teach physics concepts in all four areas: electricity, mechanics, electromagnetic waves, and atomic, nuclear, & quantum physics. As measured by the MIPEP perception survey, confidence to teach electricity concepts and mechanics concepts increased significantly pre- to post- (see Table 4.7).

Table 4.7

*Confidence in Ability to Teach Physics Concepts*

| | Perception Survey | | | |
|---|---|---|---|---|
| **Component** | **M** | **SD** | **Δ** | **p-value** |
| **Confidence to teach physics content topics** | | | | |
| Electricity (pre-) | 2.0 | 0.83 | 0.87 | **0.00*** |
| Electricity (post-) | 2.9 | 0.47 | | |
| Mechanics (pre-) | 2.3 | 0.83 | 0.65 | **0.00*** |
| Mechanics (post-) | 3.0 | 0.61 | | |
| Electromagnetic waves (pre-) | 2.1 | 0.85 | 0.25 | 0.30 |
| Electromagnetic waves (post-) | 2.3 | 0.70 | | |
| Atomic, nuclear, & quantum physics (pre-) | 2.1 | 1.20 | 0.29 | 0.21 |
| Atomic, nuclear, & quantum physics (post-) | 2.4 | 0.93 | | |

*Source.* MIPEP Pre-/Post-Perception Survey.

* Significant difference at the 0.05 level (2-tailed).

*Note.* Values for survey items are based on a 4-point scale: 1 = *not at all confident*, 2 = *somewhat confident*, 3 = *confident*, 4 = *extremely confident*.

Participants were asked to provide their perceptions of the presenter, materials, and extent to which participants were confident in teaching the topic following instruction of each of the 20 physics topics, using the *MIPEP Topic Sessions Post-Survey*. Specifically, participants were asked to rank their confidence with the following statement: "Overall, the instruction provided increased my confidence in teaching [topic X]." The majority of participants either *agreed* or *strongly agreed* that instruction in each of the 20 topics increased their confidence to teach that specific topic. Table 4.8 provides a summary of their responses.

Table 4.8

*Confidence to Teach Physics Concepts – Summary by Physics Topics*

| Physics Topic | Topic Sessions Post Surveys (Q12) | | |
|---|---|---|---|
| | **n** | **M** | **SD** |
| Vectors | 18 | 3.5 | 0.51 |
| Kinematics & graph analysis | 18 | 3.1 | 0.73 |
| Newton's laws | 18 | 3.8 | 0.43 |
| Work, power, & energy | 15 | 3.5 | 0.64 |
| Work-energy theorem | 16 | 3.6 | 0.51 |
| Conservation of energy | 17 | 3.4 | 0.71 |
| Momentum, Impulse, & conservation | 16 | 3.3 | 0.48 |
| Rotational motion | 16 | 3.0 | 0.73 |
| Modern physics & technology | 16 | 3.6 | 0.51 |
| Gravity & Law of Universal gravitation | 18 | 3.6 | 0.50 |
| Electrostatics | 17 | 3.5 | 0.51 |
| Current | 18 | 3.6 | 0.51 |
| Ohm's Law | 18 | 3.5 | 0.51 |
| Capacitors | 18 | 3.4 | 0.71 |
| Series & parallel circuits | 18 | 3.6 | 0.51 |
| Magnetic field | 18 | 3.4 | 0.51 |
| Electromagnetic induction | 18 | 3.4 | 0.78 |
| Oscillations & waves | 17 | 3.7 | 0.47 |
| Electromagnetic waves & optics | 18 | 3.4 | 0.70 |
| Atomic, nuclear, and quantum | 18 | 3.4 | 0.62 |

*Source.* MIPEP Topic Sessions Post-Survey

*Note*. In response to, "Overall, the instruction provided increased my confidence in teaching [topic X]." Values for survey items are based on a 4-point scale: 1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*.

## Perceptions of Effective Content Instruction

Qualitative data were also collected to address Objective 2, specifically Question 2.3. On the *MIPEP Final Reflections Survey,* Question 5 asked participants to describe the aspects of the content instruction provided at the MIPEP 2013 Summer Institute that were most effective in increasing their physics content knowledge. In response to this question, some respondents discussed instruction on specific physics concepts, while others described instructional techniques and strategies employed by MIPEP professors and master teachers that they believed helped them grasp the concepts being taught.

Of the specific physics concept instruction offered in the 2013 Summer Institute, instruction on vectors appeared to be the one that participants identified as most effective in increasing their physics content knowledge. One participant, for instance, noted, “MIPEP was great on many levels. I learned a lot about deriving equations and manipulating vectors.” A second participants said, “Vectors, free body diagrams, & the summarizing sentences after all the math,” while a third participant explained, “I believe that teaching vectors was the most important part of the program. Having professors show us how they teach vectors enhanced my knowledge of vectors.”

Instruction on other specific physics concepts identified as effective in increasing participants’ content knowledge included optics (or as one participant expressed it, “Optics, you can never have too much optics!”), kinematics, electrostatics, work-energy theorem, and waves. Examples of specific comments participants provided include the following: “The actual content I got the most out of was the work–K.E. theorem. I felt like I have been telling students wrong, and it clarified it was the total work,” and “The Kinematrics (*sic*) and Dynamics sections gave me lots of hints on how to make my lessons less boring for my students.” One participant explained:

> The waves, E&M material was super helpful also, cleared up a misconception regarding nonconservative work with Dr. Ford too! I went from very little understanding of nuclear/modern physics to a better grasp of what is involved. (Still a ways to go…)

When discussing helpful instructional techniques and strategies employed by MIPEP professors and master teachers, many participants highlighted the value of the demonstrations provided. For instance, on participant noted, “The aspect of the professors showing us how they teach it because it sort of ‘begins with the end in mind.’” Another participant shared, “The demonstrations from the professors and master teachers which allowed us to ask questions and repeat observations,” and a third participant concurred: “The demo materials and explanations from the master teachers.” One participant elaborated thus:

> For me, I needed the demos. I also needed the review of the advanced materials to help me in my studies. I saw new ways to excite the students into learning. I also made connections to college professors so that I can build a better program for my students.

Finally, instead of identifying specific aspects of the content instruction that were most effective in increasing their physics content knowledge, some participants enthusiastically endorsed the content instruction overall. One participant, for example, disclosed, “I have learned quite a bit of physics concept that I was not aware existed or could not previously explain.“ A second respondent agreed, saying, “The Institute covered all and every important concepts of a physics course so that I could have overall perspective/understanding on my course.”

## Summary

Objective 2 of the MIPEP evaluation focused on increasing participants' understanding of the 20 physics concepts on which the Institute facilitators focused. Qualitative and quantitative data were collected from several sources and examined to address this objective.

First, the *MIPEP Pre-Content Assessment* and the *MIPEP Post-Content* Assessment were used to measure changes in participants' understanding of physics concepts. Overall, significant gains were made in participants' understanding of physics concepts. Examining change by physics topic, the majority of the topics assessed evidenced gains. Scores for five of the topics, however, decreased following the MIPEP 2013 Summer Institute: vectors; work-energy theorem; momentum, impulse, & conservation; current; and series & parallel circuits. Two of these, work-energy theorem and momentum, impulse, & conservation, can be explained by a ceiling effect present in the pre-content assessment. Many of the participants scored the maximum on the pre-assessment. Two topics, however, had significant decreases without an initial ceiling effect: current and series & parallel circuits. This indicates a substantial misalignment among effective instruction, time allocated for practice, and/or assessment.

Data used to measure quantitative changes to participants' confidence to teach physics concepts were collected using the *MIPEP Pre-Perceptions Survey* and the *MIPEP Post-Perceptions Survey* and Question 12 from the *MIPEP Topic Sessions Post-Surveys.* Participants evidenced an increase in their confidence to teach physics concepts in all areas, and confidence to teach electricity concepts and mechanics concepts increased significantly pre- to post-survey.

Participants were asked to provide their perceptions of the presenter, materials, and extent to which they believed they were confident in teaching the topic following instruction of each of the 20 physics topics, using the *MIPEP Topic Sessions Post-Survey.* The majority of participants either *agreed* or *strongly agreed* that instruction in each of the 20 topics increased their confidence to teach that specific topic.

Qualitative data were collected via an open-ended question on the *MIPEP Final Reflections Survey* to address Question 2.3, which addressed participants' perceptions regarding what aspects of the content instruction were most effective in increasing participants' knowledge base. In response to this question, some respondents discussed instruction on specific physics concepts, while others described instructional techniques and strategies employed by MIPEP professors and master teachers that they believed helped them grasp the concepts being taught.

Instruction on vectors appeared to be the specific physics concept instruction that participants believed was most effective in increasing their physics content knowledge. Instruction on other specific physics concepts identified as effective in increasing participants' content knowledge included optics, kinematics, electrostatics, work-energy theorem, and waves.

When discussing helpful instructional techniques and strategies taught and modeled at the 2012 Summer Institute, many participants highlighted the value of the demonstrations provided by professors and master teachers. Other participants, instead of identifying specific aspects of the content instruction that were effective, enthusiastically endorsed the content instruction as having provided an overall understanding of all important aspects of a physics course.

## Objective 3: Assist Participating Teachers to Develop and Use Research-Based Instructional Strategies

Research-based instructional strategies were taught and modeled to participants during the 2-week period of the MIPEP 2013 Summer Institute. Faculty from the Texas A&M Department of Physics and Astronomy utilized lectures and demonstrations to teach college-level physics topics during daily sessions. During evening sessions two master teachers provided instruction and examples on how to teach the concepts covered during the day to high school physics students, focusing on instructional strategies (e.g., the pedagogy) appropriate for the typical high school classroom.

Participants traveled to the Mitchell Physics Building located on the Texas A&M campus on the two Fridays during the Summer Institute. Participants utilized the physics lab classrooms and other facilities to conduct labs, use scientific tools, observe demonstrations, and participate in lectures focused on cutting edge science discoveries in physics and astronomy.

A member of the ERC evaluation team observed the lab, demonstrations, and lecture activities of the MIPEP Summer Institute on both Fridays for evidence of research-based instructional strategies, using the *MIPEP Lab-Based Sessions Observation Protocol.* Additional data related to MIPEP facilitators' use of research-based instructional strategies were collected via the *MIPEP Pre-/Post-Perceptions Surveys* and the *MIPEP Final Reflections Survey.*

Of the 18 participants, 18 completed the *Pre-Perceptions Survey,* 17 completed the *Post-Perceptions Survey,* and 17 completed the *Final Reflections Survey.* Descriptive statistics were used to analyze the quantitative results as well as a comparison of means between the pre and post perception survey to explore changes to their confidence using specific instructional strategies.

### Evaluation Questions

Researchers developed the following three evaluation questions related to assisting participating teachers to develop and use research-based instructional strategies:

Q3.1. What types of research-based instructional strategies were presented at the MIPEP 2013 Summer Institute?

Q3.2. What aspects of the instructional strategies training did participants identify as most effective in increasing their knowledge base?

Q3.3. What are potential barriers to implementation of research-based instructional strategies, as identified by participants in the MIPEP 2013 Summer Institute?

## Instructional Strategies Used

The MIPEP instructional team utilized multiple instructional strategies during the MIPEP 2013 Summer Institute (Table 4.9). An examination of item-by-item results in the *MIPEP Pre-/Post-Perception Survey* revealed that participant confidence with the following instructional strategies significantly improved: inquiry-oriented teaching, assessment-based teaching, making real-world connections to physics during teaching, and designing physics lab-based investigations for teaching. It can therefore be inferred that these four instructional strategies were explicitly modeled for the participants, which had a significant impact on their confidence to teach using the same strategies.

Table 4.9
*Types of Research-Based Instructional Strategies Present*

| | Perception Survey (crosstabulation by strategy) | | | | |
|---|---|---|---|---|---|
| **Instructional Strategies** | **Increase (n)** | **No change (n)** | **Decrease (n)** | **Δ (%)** | **p-value** |
| Inquiry-oriented | 11 | 3 | 3 | 16.3 | **0.02*** |
| Culturally responsive | 4 | 8 | 5 | -1.5 | 0.81 |
| Technology-enriched | 8 | 5 | 4 | 7.4 | 0.29 |
| Assessment-based | 10 | 6 | 1 | 16.2 | **0.00*** |
| Differentiated instruction | 9 | 6 | 2 | 11.8 | 0.07 |
| Real-world connections to physics | 11 | 6 | 0 | 25.0 | **0.00*** |
| Designing physics lab-based investigations | 10 | 6 | 1 | 22.1 | **0.00*** |

*Source.* MIPEP Pre-/Post-Perception Survey
*Notes.* ***n*** is the number of participants (out of 17) that increased, decreased, or had no change in score pre- to post-.
***** Significant *positive* difference at the 0.05 level (2-tailed).

In addition, a member of the ERC evaluation team observed research-based instructional strategies during the Friday lab days at the Mitchell Physics Building on the Texas A&M University campus. Overall, the presenters and lab assistants were very effective at integrating research-based instructional strategies. The structured observations indicate strengths of the labs and demonstrations related to instructional strategies. Strengths include high levels of engagement and collaboration among the participants, instruction presented at a high cognitive level (e.g., less frequency of definitions provided and a higher frequency of feedback and questions intended to facilitate critical thinking), and good organization of the activities.

Other instructional strategies documented through observations and field notes of the Friday experiences include explicit attention to the nature of science; attention to the history of science; use of hand gestures to help participants visualize physics concepts; extensive modeling of transformation of information among verbal, textual, numerical, graphical, and pictorial (sketches) representations; and ongoing formative assessment. As an example, two lecturers linked the history of their research area with the cutting edge topic at hand. They discussed prior work and the individuals who had contributed in a relevant and personal way, adding details about the personality and demeanor of the scientists, which added to the interest and relevance of the topic. As a second example, another professor made regular connections between the physics concepts she was teaching and the level of understanding necessary for high school students to be successful in college physics. The relevance between what the presenters were doing and how it applied to the participants' classroom was an explicit focus during the observed periods on Fridays. However, the most convincing evidence of effective instructional strategies was the high level of participant enthusiasm and engagement. On the second Friday afternoon, after two intense weeks of physics instruction, the participants insisted on remaining well past the scheduled ending time in order to hear every word of a final lecture. A summary of the structured observations, which occurred during the two Fridays, is illustrated in table 4.10.

Table 4.10

*Research-Based Instructional Strategies Observed*

| | MIPEP Labs/Demonstrations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **FSC** | **K** | **PS** | **A** | **AU** | **EO** | **EM** | **RC** |
| **Instructional orientation:** | | | | | | | | |
| Direct Instruction (lecture)/whole group | 2 | 2 | 3 | 3 | 3 | 2 | 1 | 2 |
| Independent/individual work | 0 | 0 | 0 | 2 | N/A | 1 | 1 | 1 |
| Group work | 3 | 3 | 0 | 0 | N/A | 3 | 3 | 3 |
| Cooperative/collaborative learning | 3 | 3 | 0 | 0 | N/A | 3 | 3 | 3 |
| Experiential/hands-on learning | 3 | 3 | 2 | 2 | N/A | 3 | 3 | 3 |
| **Instructor/facilitator practices:** | | | | | | | | |
| Instructor exhibited in-depth knowledge | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| Instructor explained activities | 3 | 3 | 2 | 1 | 3 | 2 | 2 | 2 |
| Instructor gave clear directions | 3 | 3 | N/A | 1 | N/A | 3 | 1 | 2 |
| Instructor defined terms and key vocabulary | 2 | 2 | 0 | 0 | 3 | 1 | 1 | 1 |
| Instructor asked higher level questions | 3 | 3 | 2 | 0 | 3 | 2 | 2 | 2 |
| Instructor gave higher level feedback | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| Instructor summarized main points | 3 | 2 | 2 | 0 | 3 | 3 | 2 | 2 |
| Instructor facilitated group work | 3 | 3 | 0 | N/A | N/A | 3 | 3 | 3 |
| Instructor modeled research-based instructional practices | 3 | 2 | 3 | 0 | 3 | 2 | 2 | 2 |
| Instructor used activities to demonstrate concepts | 3 | 3 | 3 | 2 | N/A | 3 | 3 | 3 |
| **Preparation:** | | | | | | | | |
| Began session on time | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Ended session on time | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Stated session goals and objectives | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| Appeared prepared for session | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Presented an effective introduction | 3 | 3 | 3 | 2 | 3 | 2 | 0 | 2 |
| **Presentation skills/style:** | | | | | | | | |
| Demonstrated creativity | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 3 |
| Connected with participants' prior knowledge | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| Used personal background and experiences appropriately | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 2 |
| Responded confidently to participants' comments | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Used appropriate spoken language | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Articulated clearly | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Effectively maintained attention | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Demonstrated sense of humor | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Instructional pace was too slow | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Instructional pace was too fast | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 2 |
| **Environment, materials, resources:** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Space arrangement conducive to instruction | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Adequate supply of materials | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Technology used effectively by presenter | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Technology used effectively by participants | 3 | 3 | 0 | 3 | N/A | 3 | 3 | 3 |
| Manipulative materials used effectively | 3 | 3 | 3 | 3 | N/A | 3 | 3 | 3 |
| Active participation was encouraged | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |
| Climate of respect | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| Interactions reflected collegial relationships | 3 | 3 | N/A | 1 | 0 | 3 | 3 | 3 |
| Interactions reflected collaborative relationships | 3 | 2 | N/A | 1 | N/A | 3 | 3 | 3 |
| Participants were encouraged to generate ideas, questions, conjectures, and propositions | 2 | 2 | 2 | 1 | 0 | 2 | 2 | 2 |
| Participants demonstrated a willingness to share ideas and take intellectual risks | 3 | 3 | 3 | 2 | 1 | 2 | 2 | 2 |
| Intellectual rigor, constructive criticism, and the challenging of ideas were evident | 3 | 3 | 2 | 1 | 3 | 2 | 2 | 2 |

*Source.* Lab-Based Sessions Observation Protocol.

*Note.* Values for survey items are based on a 4-point scale: 0 = *not observed*, 1 = *rarely observed*, 2 = *somewhat observed*, 3 = *highly observed*, N/A = *not applicable*.

*Note*. Abbreviations for the labs are as follows: FSC = forces & static equilibrium lab; K = kinematics lab; PS = physics show demonstrations; A = astronomy demonstration; AU = lecture on "Age of the Universe"; EO = electricity oscilloscope lab; EM = electrical measurement lab; and RC = RC circuits

## Instructional Strategies Identified as Effective

Qualitative data were also collected to address Objective 3—specifically Questions 3.2 and 3.3. On the *MIPEP Final Reflections Survey*, Question 5 asked participants to describe the instructional strategies demonstrated at the MIPEP 2013 Summer Institute that were most effective in increasing their knowledge base of instructional strategies. Of the 18 participants, 16 responded to this question.

The summaries that professors and master teachers provided at the end of lessons and/or of the day were perceived by many participants as valuable in increasing their own instructional skills. "The instructional strategy I liked from the professors was how they summarized what the lesson was about and asked multiple choice questions at the end," explained one participant. A second participant agreed: "The collaborative instruction at the end of the days was extremely helpful." One participant succinctly noted, "[The master teacher's] short little 2-minute lessons that dumbed it down for me."

Several participants described hands-on activities, such as "all the demos and lab instruction," as valuable to them in increasing their knowledge base of instructional strategies. Comments related to this theme included the following: "The physics and lab demos will be extremely helpful," "The demonstrations and visual aids (pictures, graphs, ppts). Also the labs," and "The demos, they were cheap and effective ways to show every unit of physics." One respondent affirmed, "Labs and demos without a doubt. Working out problems. Physics should be doing."

Other instructional strategies that participants identified as valuable included "reverse lesson plan approach," "peer discussion to determine what has worked (or not)," and "study groups with peers, to broaden understanding."

Finally, although one participant asserted, "I believe that MIPEP needs to include more teaching strategies. The program mostly was about content," a second participant disagreed, pointing out, "Sometimes it's hard to see the pedagogy for the excitement."

## Perceived Barriers to Implementation of Instructional Strategies

Question 8 on the *MIPEP Final Reflections Survey* asked respondents to identify some possible barriers they believed they might face in implementing the instructional strategies they had learned in their individual classrooms. Although 15 of the 18 MIPEP participants responded to this question, several appeared to misunderstand the question and responded by discussing barriers to implementing content rather than barriers to implementing instructional strategies.

Some participants expressed concerns that limited financial resources in their schools would hinder their implementation of new instructional strategies, or as participants expressed it: "Resources are limited due to budget," and "Limited equipment hampering demos and desired labs." One participant explained: "Purchasing equipment. I have a 'budget' from what is left over after biology class gets their needs. $10,000 does not go far for 4 to 5 different classes." A final participant, who also had budget constraints, was more positive, however: "Budget, but enough cheap strategies were given so I think I'll be ok."

Conversely, one participant had an opposite concern: A new classroom with new technology. "We have a brand new classroom with technology I have not been trained on yet. Adjusting to the room will be an issue. We will have more lab access."

Other perceived barriers to implementation of instructional strategies included teacher lack of confidence and lack of time: "Sometimes I feel that I run out of class time to summarize the lesson or ask questions. Students are ready to leave and not focusing as much."

Finally, one participant provided a litany of perceived barriers to implementation of newly-learned instructional strategies:

> Lesson planning, teaching bell to bell, figuring out how to plan, organize time, classroom management, keeping it about learning and playing, not just playing….Motivating kids to try problems on their own after they figure out that I will work out the solution momentarily.

## Summary

Objective 3 of the MIPEP 2013 Summer Institute evaluation addressed assisting participants to develop and use research-based instructional strategies. Qualitative and quantitative data were collected from several sources and examined to address this objective.

Research-based instructional strategies were taught and modeled to participants during the 2-week period of the MIPEP 2013 Summer Institute. Faculty from the Texas A&M Department of Physics and Astronomy utilized lectures and demonstrations to teach college-level physics topics during daily sessions. During evening sessions two master teachers provided instruction and examples on how to teach the concepts covered during the day to high school physics students, focusing on instructional strategies (e.g., the pedagogy) appropriate for the typical high school classroom.

The MIPEP instructional team utilized multiple instructional strategies during the MIPEP 2013 Summer Institute. An examination of item-by-item results in the *MIPEP Pre-/Post-Perception Survey* revealed that participant confidence with the following instructional strategies significantly improved: inquiry-oriented teaching, assessment-based teaching, making real-world connections to physics during teaching, and designing physics lab-based investigations for teaching. Therefore, it can be inferred that these four instructional strategies were explicitly modeled for the participants, which had a significant impact on their confidence to teach using the same strategies.

In addition, a member of the ERC evaluation team observed research-based instructional strategies during the Friday lab days at the Mitchell Physics Building the Texas A&M University campus. It was determined that, overall, the presenters and lab assistants were very effective at integrating research-based instructional strategies. The structured observations indicate strengths of the labs and demonstrations related to instructional strategies. Strengths include high levels of engagement and collaboration among the participants, instruction presented at a high cognitive level (e.g., less frequency of definitions provided and a higher frequency of feedback and questions intended to facilitate critical thinking), and good organization of the activities.

Qualitative data to address Question 3.2 were collected via an open-ended question on the *MIPEP Final Reflections Survey* that asked participants to describe the instructional strategies demonstrated at the 2013 Summer Institute that were most effective in increasing their knowledge base of instructional strategies. Many participants identified the summaries that professors and master teachers provided at the end of lessons and/or of the day as most effective in increasing their own instructional skills. Other valuable instructional strategies that participants identified as valuable included hands-on activities, such as demos and labs; reverse lesson plan approach; peer discussion; and study groups with peers.

Qualitative data to address Question 3.3 were also collected via an open-ended question on the *MIPEP Final Reflections Survey.* Question 8 on the survey asked respondents to identify some possible barriers they believed they might face in implementing the instructional strategies they had learned in their individual classrooms.

Many participants pointed to the limited financial resources to buy materials and equipment as a barrier to implementation of new instructional strategies in their individual schools. Conversely, one participant, who had a new, fully-equipped classroom, was concerned about adjusting to the new technology. Other perceived barriers to implementation of instructional strategies included teacher lack of confidence and limited time.

## Objective 4: Provide Laboratory-Based Learning Experiences

Laboratory-based learning experiences during the MIPEP 2013 Summer Institute were provided in two different settings. Laboratory-based learning experiences written and designed for college-level physics instruction were provided on Fridays at the Mitchell Physics Building on the Texas A&M University campus. These labs, which were observed by a member of the ERC evaluation team, were conducted using scientific instruments and lab equipment typically available at a research university but rarely available at a high school. Conversely, laboratory-based activities appropriate for a high school physics classroom were demonstrated by the master teachers to the participants in the evenings at the Cook's Branch Conservancy. The ERC evaluation team did not observe these evening lab sessions.

Several questions on the *MIPEP Post-Perceptions Survey* asked participants about their laboratory experiences, but the questions did not distinguish between laboratory experiences at Cook's Branch Conservancy and laboratory-based experiences at the Mitchell Physics Building. As a result, evaluator observations of the laboratory-based experiences are used to describe the Texas A&M campus laboratory-based experiences only, and participants' responses on the post perception survey may apply to experiences at Cook's Branch Conservancy, experiences at Texas &M campus, or to both.

### Evaluation Questions

Q4.1. What types of laboratory experiences were provided at the MIPEP 2013 Summer Institutes?

Q4.2. Do participants feel confident in their understanding of physics concepts as a result of their MIPEP 2013 laboratory experiences?

Q4.3. Do participants feel confident in their ability to teach physics concepts as a result of their MIPEP 2013 laboratory experiences?

Q4.4. What are potential barriers to implementation of the laboratory experiences in participants' own classrooms, as identified by participants?

## Types of Laboratory-based Experiences

Two major types of laboratory experiences were observed on Fridays at the Mitchell Physics Building: confirmation labs and demonstrations. Confirmation type labs were conducted on Friday mornings. Confirmation labs typically provide step-by-step procedures with the purpose of *confirming* a relationship or hypothesis. These labs were complex, involving multiple steps, requiring calculations, and utilizing scientific instruments. The scientific instruments used in the labs included oscilloscope, function generator, multimeter, circuit components, track and carts, data loggers, Excel, force table, and physics balance beam. Topics addressed in the labs were kinematics, static equilibrium, Newton's laws, circuits, electrical measurement, Ohm's law, alternating current, and direct current. In addition, references were made by the presenter, teaching assistant, master teachers, and by the participants themselves regarding ways the college-level lab could be adapted for use in a high school physics class.

The second major type of laboratory-based experiences observed was physics demonstrations. The presenter, assisted by several graduate students, exhibited a large number of physics demonstrations. The three main purposes of using the demonstrations, per the presenter, are to convince students that physics is fun, impress students with physics, and convince students that physics does not have to be high-tech. Discussion centered on how the activity could be constructed for the classroom and what physics topics the demonstration could be used to introduce or illustrate. Physics topics covered in the demonstrations included (list is not inclusive of all topics covered): phase transition, evaporative cooling, effects of changing pressure, superconductivity, states of magnetism, center of gravity, Newton's laws, force of friction, conservation of momentum, Bernoulli's principle, rotational motion, angular momentum, buoyancy, and Lenz's law. Effective instructional strategies were modeled by the presenters in a teacher-teaching-teachers style. For example, the presenter reminded the participants to have their students *predict* prior to a demonstration. This is an example of a research-based practice that can have a positive impact on students' scientific literacy.

Non laboratory-based activities were also included on the Friday lab days, including lectures, a tour of the Cyclotron Institute, hands-on play with large interactive physics exhibits, and practice observing the sun using a solar telescope. The participants enthusiastically participated in all the activities on Fridays, and the activities were logically structured to shape a deeper understanding of physics concepts.

## Confidence in Understanding of Physics Concepts Resulting From Laboratory Experiences

Question 51 of the MIPEP post-perception survey asked participants to report their perceptions of the extent to which the laboratory-based experiences increased their confidence for understanding physics concepts. Of the 17 respondents to this survey item, one participant *disagreed* that the lab experiences had increased his/her confidence. The remaining 16 participants *agreed* or *strongly agreed* that the lab experiences increased their confidence for understanding physics concepts (See Table 4.11).

Table 4.11

*Impact of Laboratory-Based Experiences on Confidence in Understanding of Physics Concepts*

| | Post Perception Survey (Q.51) | | | | | |
|---|---|---|---|---|---|---|
| | **SD** | **D** | **A** | **SA** | **M** | **SD** |
| The laboratory experiences increased my confidence in understanding of physics concepts | 0 | 1 | 4 | 12 | 3.7 | 0.61 |

*Source.* MIPEP Post-Perception Survey.

*Note.* Values for survey items are based on a 4-point scale: SD = *strongly disagree*, D = *disagree*, A = *agree,* SA = *strongly agree*

## Impact of Laboratory-based Experiences on Confidence to Teach Physics Concepts

On question 52 of the MIPEP post-perception survey, participants were asked to report their perception of the extent to which the laboratory-based experiences had increased their confidence to teach physics concepts. Of the 17 participants who responded to this survey item, one participant *disagreed* that the lab experiences had increased his/her confidence to teach physics concepts. The remaining 16 participants *agreed* or *strongly agreed* that the lab experiences had increased their confidence to teach physics concepts (see Table 4.12).

Table 4.12
*Impact of Laboratory-Based Experiences on Confidence to Teach Physics Concepts*

| | Post Perception Survey (Q.52) | | | | | |
|---|---|---|---|---|---|---|
| | **SD** | **D** | **A** | **SA** | **M** | **SD** |
| The laboratory experiences increased my confidence in my ability to teach physics concepts | 0 | 1 | 5 | 11 | 3.6 | 0.62 |

*Source.* MIPEP Post-Perception Survey.
*Note.* Values for survey items are based on a 4-point scale: SD = *strongly disagree*, D = *disagree*, A = *agree,* SA = *strongly agree*

Qualitative data were also collected to address Objective 4—specifically Questions 4.3 and 4.4. On the *MIPEP Post-Perceptions Survey*, Question 53 asked participants to describe the lab experiences from the MIPEP 2013 Summer Institute that were most effective in increasing their understanding of how to use labs to increase their students' understanding of physics concepts. Overall, participants' responses to this question covered a wide range.

Many participants pointed to the "Torque lab w/force table" or the "Force table lab" in response to this question. One participant said, "The lab involving the forces table increased my understanding the most because I had never used one before, and I could see how it clearly shows the vector components if one does it correctly." A second participant was already familiar with force labs, but MIPEP demonstrated ways to use force labs in the classroom: "Because I was familiar with the force labs, being given the opportunity to do them with fellow teachers allowed me to develop ways to use them. " A third participant admitted, "Torque and force wheel labs will definitely be used in my physics class. I know we do have a force wheel. I just have never used it."

The "Demos on a Dime" labs were referenced by many of the respondents as something they could easily use in their own classrooms. "All of the hands-on labs were helpful, but the most effective labs were the Labs-on-a-Dime demos & the physics show. Many ideas were spawned from these demos that I plan to implement in my classroom," said one respondent. A second respondent concurred: "The Friday "Labs on a Dime" or "Demos on a Dime" may have been most effective. I believe we needed to have been doing labs every day that we could take home and do with our students."

Some participants highlighted the oscilloscope lab as a particularly useful one. One participant explained that the oscilloscope lab had helped him/her to appreciate the challenges his/her students faced in learning new concepts in physics:

> [The] oscilloscope lab is one I have never done. In doing it I experienced the type of problems my own students might have with something they have never done. It refreshed my perspectives on what types of support my students will need.

Other lab experiences that participants identified as most effective in increasing their understanding of how to increase their own students' physics learning included the circuits lab, the capacitor lab, and the kinematics lab. Finally, one participant summarized the lab experiences thus: "The electronics lab was most memorable, but ALL of the labs were useful."

## Barriers to Implementation of Laboratory Experiences

Question 54 on the *MIPEP Post-Reflections Survey* asked respondents to identify some possible barriers they believed they might face in replicating MIPEP lab experiences in their own individual classrooms. Barriers described by participants fell into 4 categories: (a) resources (b) time, (c) teacher confidence, and (d) student knowledge level.

Lack of resources was a recurrent theme in participants' responses to this question. Many people pointed out that they didn't have the equipment necessary to replicate the labs and there was no money to buy the equipment. "These instruments are expensive and I have no class sets," said one participant, while another participant explained, "One of the barriers with the oscilloscope is the cost for a class set." A third participant revealed that s/he sometimes had to use her/his own money to buy lab equipment for the classroom: "I don't have a LOT of the equipment. I personally purchased the electronics lab equipment for the kids to do electronics." A final participant shared that s/he had a well-equipped lab already, but had no money for repair or replacements:

> I have no share in the departmental budget. However, this is not a large issue, because my lab is already well-equipped with the PASCO system. The only problem is there no budget to repair or replace anything that is broke, like the GLX datalogger. If the system grows more complex, it is easier to break down.

"Time constraints" was also a barrier discussed by many participants in their responses to this question. One participant explained, "Equipment and time are the largest barriers that might interfere with implementing some of the labs." Another participant explained the difficulties of teaching labs in a traditional 45-minute class period:

> The #2 barrier is time. W/only having students 45 minutes per day & teaching multiple sciences, there is not enough time to explain the lab, set it up, run the lab, then analyze the data in 1 day to effectively impact the students.

Teacher lack of confidence was identified as a third theme in participants' responses to this question: As one teacher admitted: "[I] worry about making mistakes with electricity experiments." Other teachers shared concerns such as the following: "I'm not confident that the students will listen to me," "My level of comfort in explaining what is happening in a lab [would be a barrier]," and "My lack of experience would keep me from trying to use such instruments as the oscilloscope."

Finally, some participants expressed that their students' lack of "prior knowledge and skills" would be a barrier to successfully replicating the labs in their own classrooms. One participant, for example, was concerned about "verifying that students grasped lessons the labs were designed to convey," while another participant explained, "[One] barrier is having to teach the students the content they should already know. TAKS & multiple choice math testing have significantly lowered the math skills of high school students."

## Summary

Objective 4 address laboratory-based learning experiences provided during the MIPEP 2013 Summer Institute. Data were collected via observations of the Friday laboratory-based experiences and open-ended questions on the *MIPEP Post-Perception Survey* specific to participants' perceptions of the laboratory experiences.

Two major types of laboratory experiences were observed on Fridays at the Mitchell Physics Building: confirmation labs and demonstrations. Confirmation type labs, conducted on Friday mornings, provided step-by-step procedures with the purpose of *confirming* a relationship or hypothesis. These labs were complex, involving multiple steps, requiring calculations, and utilizing scientific instruments. The second major type of laboratory-based experiences observed was physics demonstrations. The presenter, assisted by several graduate students, exhibited a large number of physics demonstrations. Discussions centered on how the activity could be constructed for the classroom and what physics topics the demonstration could be used to introduce or illustrate.

Non laboratory-based activities included on the Friday lab days included lectures, a tour of the Cyclotron Institute, hands-on play with large interactive physics exhibits, and practice observing the sun using a solar telescope. The participants enthusiastically participated in all the activities on Fridays, and the activities were logically structured to shape a deeper understanding of physics concepts.

Overall, participants believed the laboratory-based experienced had increased their confidence for understanding physics concepts. Of the 17 respondents to this survey item, 16 *agreed* or *strongly agreed* that the lab experiences increased their confidence for understanding physics concepts. One participant *disagreed* that the lab experiences had increased his/her confidence. Moreover, participants agreed overall that the laboratory-based experiences had increased their confidence to teach physics concepts. Of the 17 respondents to this survey item, 16 *agreed* or *strongly agreed* that the lab experiences increased their confidence for understanding physics concepts, while one participant *disagreed* that the lab experiences had increased his/her confidence.

Qualitative data were also collected and examined to address Question 4.3 and 4.4. An open-ended question on the *MIPEP Post-Perception Survey* asked participants to describe the lab experiences from the MIPEP 2013 Summer Institute that were most effective in increasing their understanding of how to use labs to increase their students' understanding of physics concepts. Many participants identified the "Torque lab w/force table" or the "Force table lab" in response to this question. Others pointed to the "Demos on a Dime" labs, the oscilloscope lab, the circuits lab, the capacitor lab, and the kinematics lab. One participant, however, asserted: "ALL the labs were useful."

In regard to barriers to implementation of laboratory experiences, qualitative data from responses to Question 54 on the *MIPEP Post-Reflections Survey*, which asked respondents to identify possible barriers to replicating MIPEP lab experiences in their own individual classrooms, were collected and analyzed. Barriers identified by participants included lack of resources, including equipment and money; time constraints; teacher lack of confidence; and deficiencies in students' knowledge and skills levels.

## Objective 5: Encourage and Facilitate Collaboration of Physics Educators in Texas

Researchers developed the following evaluation question related to encouraging and facilitating collaboration of physics educators in Texas:

### Evaluation Questions

Q5.1. To what extent do participants intend to share the information gained through the MIPEP 2013 Summer Institute with colleagues on their individual campuses?

### Participants' Perceptions Regarding Intent to Collaborate

Of the 18 MIPEP 2013 Summer Institute participants, 17 completed the *MIPEP Final Reflections Survey* for an overall response rate of 94%. Survey Question 9 asked participants to discuss some of the ways in which they anticipated sharing what they had learned at the MIPEP Summer Institute with colleagues on their individual campuses. Overall, participants appeared very positive in regard to sharing materials and ideas from the 2013 Summer Institute.

Some respondents were quite specific about aspects of MIPEP that they planned to share, as the following responses illustrate: "Prepared lessons, PowerPoints, and labs through email and dropboxes," "Demos, ideas, and demonstration items will be shared," and "Show them pictures of activities. Share any labs and demo we received."

Other respondents, however, were more expansive in their goals to disseminate what they had learned. One participant, for example, proclaimed, "I will share the information and help any teacher other than me who has to teach physics next year and will be rewriting curriculum over the summer for next year."

Most participants expressed an intention to share materials and ideas from MIPEP 2013 with other teachers, particularly the materials they had received electronically. "I plan to provide copies of all electronic resources with my colleagues," wrote one respondent, while another participant stated, "The disk I received with be shared with other teachers." A third respondent expounded thus:

> I will share the lesson plans and resources that you have given us on the disc. I have looked at it briefly and already have new ideas about labs and first day activities. I will also share the power points with the AP and pre-AP teachers.

Conversely, some respondents believed the best way to disseminate what they had learned was by sharing materials and ideas with department heads and district administrators, who would then help to distribute to other teachers. One teacher, for example, said, "I will go back to present what I have learned to the curriculum director," while another teacher explained, "[I] will speak with the department head on confirming required discussion/collaboration times….provide an environment more conducive to collaboration." A third respondent elaborated:

> My department head can't wait for me to get back and copy out the thumb drive for her. We are on the same page about the need for rigor to get our students ready for college. Even those students bound for work can benefit from the synergism between science courses, and as for the military-bound students, they need us most of all!

Collaboration within and across departments was also an important theme in participants' responses to this question. "I think the best strategy is using what I have seen and learned as a 'springboard' to discussions [that] our department needs to analyze regarding how and what we teach," said one respondent, and another teacher mused, "I will speak with my department head on confirming required discussion/collaboration times….Provide an environment more conducive to collaboration." A third participant concurred:

> I believe that when writing common lesson plans and "year at a glance," the knowledge that I acquired will help me be a bigger contributor to the process. I will have a deeper understanding of physics to help plan in our department.

Other respondents revealed that they hoped to share the MIPEP experience through establishing a spirit of collaboration with their colleagues in other departments. One teacher asserted that s/he would "Attempt to collaborate with math and history students and teachers," and another specified, "Working with our math instructors to ensure we use similar techniques, processes, language, variable symbols, and any other aspect in which we communicate with our students."

Some teachers attending the 2013 Summer Institute communicated that they were the only physics teacher on their particular campus. Those teachers, however, expressed that they would share their learnings through their involvement in regional collaboratives. One respondent, for example, noted, "I am part of the __ TRC [Texas Regional Cooperative]. I could share with teachers there. I am the only physics teacher at my school, unfortunately." Another teacher agreed: "I'm the only physics teacher on my campus, but I'm in a collaborative for the region and I will be sharing all my stuff with anybody that will listen to me talk."

Finally, some participants expressed that they planned to encourage their colleagues to attend future MIPEP Summer Institutes. For instance, one participant asserted that s/he planned to "Talk, talk, and more talk about how great the program is," and another participant stated, "I will encourage them [colleagues] to attend the Institute." A third participant enthusiastically explained, "First I will tell them they need to participate in this program. Wow, what an awesome experience!"

## Summary

Objective 5 of the MIPEP 2013 Summer Institute evaluation addressed efforts to facilitate collaboration of physics educators in Texas. Qualitative data were collected from one source to address this objective.

The *MIPEP Final Reflections Survey* was completed by 17 of the 18 participants in the 2013 Summer Institute. Question 9 of the survey asked participants to discuss ways in which they anticipated sharing what they had learning at the Summer Institute with their colleagues on their individual campuses. Overall, participants were quite positive about their intentions to disseminate their new learnings when they returned to their home campuses.

Some respondents listed specific aspects of MIPEP that they planned to share, such as lessons, PowerPoints, demonstrations, and labs. Others were less specific in their discussion of ways in which they would share materials and knowledge with colleagues, providing general descriptions of plans to disseminate.

Although some participants discussed intentions to specifically share materials and knowledge with other teachers in their individual buildings, other participants expressed plans to share with campus and district administrators, who would then disseminate the information to teachers. Still other participants planned to share through regional collaboratives, explaining that they were the only physics teacher on their individual campus.

Collaboration, both within and across departments, was an important theme in participants' plans to disseminate. Some participants offered specific ideas for collaborating with other teachers in their departments in order to disseminate the MIPEP materials and ideas, while others shared that they planned to collaborate with teachers in other departments. Several participants expressed the importance of collaborating with teachers in the mathematics department, specifically.

Finally, several participants shared that they planned to "talk, talk, talk" to all their colleagues about their experience in the MIPEP 2013 Summer Institute and encourage them, in turn, to attend the Summer Institute in succeeding years.

## CHAPTER 5: Summary and Conclusions

This chapter presents an overall summary of the results from the MIPEP 2013 Summer Institute evaluation study, as well as a discussion of limitations of the study.

### Summary

Objective 1 of the MIPEP evaluation addressed the project's impact on physics teaching and learning in Texas. Participants for the MIPEP 2013 Summer Institute were recruited by MIPEP program leaders in spring 2013. They included 18 physics teachers from 18 different high schools in 18 different districts across the state.

Quantitative and qualitative data were collected from three sources and examined to address this objective. First, the *MIPEP Pre-Perceptions Survey*, which was composed of Likert-type items, was administered to participants on the first day of the 2013 Summer Institute. The overall response rate to this instrument was 100%. Second, the *MIPEP Post-Perceptions Survey* was administered on the final day of the 2013 Institute and had an overall response rate of 94%. Items on the two instruments were identical. Finally, the *MIPEP Final Reflections Survey*, which was composed of six open-ended questions, was administered at the end of the final day of the Institute. The overall response rate to this instrument was 94%.

Analysis of the data from the pre- and post-perception survey revealed that participants' perceived need for professional development related to student-centered instruction, teaching strategies, and content knowledge decreased as a result of their participation in the MIPEP 2013 Summer Institute. Their perceived need for professional development related to physics content knowledge decreased significantly.

Moreover, participants' self-reported confidence for physics instruction increased as a result of the MIPEP 2013 Summer Institute. Participants believed their physics instruction would benefit due to gains in skills for (a) providing in-depth coverage of physics concepts, (b) making relevant connections among physics and real world scenarios, (c) guiding experimental design, (d) communicating scientific results orally and in writing, and (e) using scientific technology. Significant gains were evident pre- to post-survey administration, for all components in the *MIPEP Pre-/Post-Perception Survey* related to confidence for physics instruction.

Objective 1 also addressed participants' perceptions regarding possible barriers to implementation of the physics content they had learned at the MIPEP 2013 Summer Institute. Question 9 on the *MIPEP*

*Final Reflections Survey* asked participants to identify specific potential barriers to implementation in their individual classrooms.

Participants overall expressed concerns that deficiencies in their students' knowledge levels would create a challenge to implementation of new physics content knowledge. Many participants specifically emphasized their students' lack of mathematics knowledge as a significant barrier to implementation of the physics content.

Some participants also revealed a lack of confidence in their own physics content knowledge, although others asserted that the MIPEP 2013 Summer Institute had provided the content knowledge they needed in order to be successful in the physics classroom. Finally, a few participants expressed concerns that a lack of materials and resources in their individual schools would present challenges in terms of transferring their physics knowledge to improve instruction.

Objective 2 of the MIPEP evaluation focused on increasing participants' understanding of the 20 physics concepts on which the Institute facilitators focused. Qualitative and quantitative data were collected from several sources and examined to address this objective.

First, the *MIPEP Pre- Content Assessment* and the *MIPEP Post-Content* Assessment were used to measure changes in participants' understanding of physics concepts. Overall, significant gains were made in participants' understanding of physics concepts. Examining change by physics topic, the majority of the topics assessed evidenced gains. Scores for 5 of the topics, however, decreased following the MIPEP 2013 Summer Institute: vectors; work-energy theorem; momentum, impulse, & conservation; current; and series & parallel circuits. Two of these, work-energy theorem and momentum, impulse, & conservation, can be explained by a ceiling effect present in the pre-content assessment. Many of the participants scored the maximum on the pre-assessment. Two topics, however, had significant decreases without an initial ceiling effect: current and series & parallel circuits. This indicates a substantial misalignment among effective instruction, time allocated for practice, and/or assessment.

Data used to measure quantitative changes to participants' confidence to teach physics concepts were collected using the *MIPEP Pre- Perceptions Survey* and the *MIPEP Post- Perceptions Surveys* and Question 12 from the *MIPEP Topic Sessions Post-Surveys.* Participants evidenced an increase in their confidence to teach physics concepts in all areas, confidence to teach electricity concepts and mechanics concepts increased significantly pre- to post-survey.

Participants were asked to provide their perceptions of the presenter, materials, and extent to which they believed they were confident in teaching the topic following instruction of each of the 20 physics topics using the *MIPEP Topic Sessions Post-Survey.* The majority of participants either *agreed* or *strongly agreed* that instruction in each of the 20 topics increased their confidence to teach that specific topic.

Qualitative data were collected via an open-ended question on the *MIPEP Final Reflections Survey* to address Question 2.3, which addressed participants' perceptions regarding what aspects of the content instruction were most effective in increasing their knowledge base. In response to this question, some respondents discussed instruction on specific physics concepts, while others described instructional techniques and strategies employed by MIPEP professors and master teachers that they believed helped them grasp the concepts being taught.

Instruction on vectors appeared to be the specific physics concept instruction that participants believed was most effective in increasing their physics content knowledge. Instruction on other specific physics concepts identified as effective in increasing participants' content knowledge included optics, kinematics, electrostatics, work-energy theorem, and waves.

When discussing helpful instructional techniques and strategies taught and modeled at the 2012 Summer Institute, many participants highlighted the value of the demonstrations provided by professors and master teachers. Other participants, instead of identifying specific aspects of the content instruction that were effective, enthusiastically endorsed the content instruction as having provided an overall understanding of all important aspects of a physics course.

Objective 3 of the MIPEP 2013 Summer Institute Evaluation addressed assisting participants to develop and use research-based instructional strategies. Qualitative and quantitative data were collected from several sources and examined to address this objective.

Research-based instructional strategies were taught and modeled to participants during the 2-week period of the MIPEP 2013 Summer Institute. Faculty from the Texas A&M Department of Physics and Astronomy utilized lectures and demonstrations to teach college-level physics topics during daily sessions. During evening sessions two master teachers provided instruction and examples on how to teach the concepts covered during the day to high school physics students, focusing on instructional strategies (e.g., the pedagogy) appropriate for the typical high school classroom.

The MIPEP instructional team utilized multiple instructional strategies during the MIPEP 2013 Summer Institute. An examination of item-by-item results in the *MIPEP Pre-/Post-Perception Survey* revealed that participant confidence with the following instructional strategies significantly improved: inquiry-oriented teaching, assessment-based teaching, making real-world connections to physics during teaching, and designing physics lab-based investigations for teaching. Therefore, it can be inferred that these four instructional strategies were explicitly modeled for the participants, which had a significant impact on their confidence to teach using the same strategies.

In addition, a member of the ERC evaluation team observed research-based instructional strategies during the Friday lab days at the Mitchell Physics Building the Texas A&M University campus. Overall, the presenters and lab assistants were very effective at integrating research-based instructional strategies. The structured observations indicate strengths of the labs and demonstrations related to instructional strategies. Strengths include high levels of engagement and collaboration among the participants, instruction presented at a high cognitive level (e.g., less frequency of definitions provided and a higher frequency of feedback and questions intended to facilitate critical thinking), and good organization of the activities.

Qualitative data to address Question 3.2 were collected via an open-ended question on the *MIPEP Final Reflections Survey* that asked participants to describe the instructional strategies demonstrated at the 2013 Summer Institute that were most effective in increasing their knowledge base of instructional strategies. Many participants identified the summaries that professors and master teachers provided at the end of lessons and/or of the day as most effective in increasing their own instructional skills. Other valuable instructional strategies that participants identified as valuable included hands-on activities, such as demos and labs; reverse lesson plan approach; peer discussion; and study groups with peers.

Qualitative data to address Question 3.3 were also collected via an open-ended question on the *MIPEP Final Reflections Survey.* Question 8 on the survey asked respondents to identify some possible barriers they believed they might face in implementing the instructional strategies they had learned in their individual classrooms.

Many participants pointed to the limited financial resources to buy materials and equipment as a barrier to implementation of new instructional strategies in their individual schools. Conversely, one participant, who had a new, fully-equipped classroom, was concerned about adjusting to the new technology. Other perceived barriers to implementation of instructional strategies included teacher lack of confidence and limited time.

Objective 4 address laboratory-based learning experiences provided during the MIPEP 2013 Summer Institute. Data were collected via observations of the Friday laboratory-based experiences and open-ended questions on the *MIPEP Post-Perception Survey* specific to participants' perceptions of the laboratory experiences.

Two major types of laboratory experiences were observed on Fridays at the Mitchell Physics Building: confirmation labs and demonstrations. Confirmation type labs, conducted on Friday mornings, provided step-by-step procedures with the purpose of *confirming* a relationship or hypothesis. These labs were complex, involving multiple steps, requiring calculations, and utilizing scientific instruments. The second major type of laboratory-based experiences observed was physics demonstrations. The presenter, assisted by several graduate students, exhibited a large number of physics demonstrations. Discussions centered on how the activity could be constructed for the classroom and what physics topics the demonstration could be used to introduce or illustrate.

Non laboratory-based activities included on the Friday lab days included lectures, a tour of the Cyclotron Institute, hands-on play with large interactive physics exhibits, and practice observing the sun using a solar telescope. The participants enthusiastically participated in all the activities on Fridays, and the activities were logically structured to shape a deeper understanding of physics concepts.

Overall, participants believed the laboratory-based experienced had increased their confidence for understanding physics concepts. Of the 17 respondents to this survey item, 16 *agreed* or *strongly agreed* that the lab experiences increased their confidence for understanding physics concepts. One participant *disagreed* that the lab experiences had increased his/her confidence. Moreover, participants agreed overall that the laboratory-based experiences had increased their confidence to teach physics concepts. Of the 17 respondents to this survey item, 16 *agreed* or *strongly agreed* that the lab experiences increased their confidence for understanding physics concepts, while one participant *disagreed* that the lab experiences had increased his/her confidence.

Qualitative data were also collected and examined to address Question 4.3 and 4.4. An open-ended question on the *MIPEP Post-Perception Survey* asked participants to describe the lab experiences from the MIPEP 2013 Summer Institute that were most effective in increasing their understanding of how to use labs to increase their students' understanding of physics concepts. Many participants identified the "Torque lab w/force table" or the "Force table lab" in response to this question. Others pointed to the "Demos on a Dime" lab, the oscilloscope lab, the circuits lab, the capacitor lab, and the kinematics lab. One participant asserted: "ALL the labs were useful."

In regard to barriers to implementation of laboratory experiences, qualitative data from responses to Question 54 on the *MIPEP Post-Reflections Survey*, which asked respondents to identify possible barriers to replicating MIPEP lab experiences in their own individual classrooms, were collected and analyzed. Barriers identified to participants included lack of resources, including equipment and money; time constraints; teacher lack of confidence; and deficiencies in students' knowledge and skills levels.

Objective 5 of the MIPEP 2013 Summer Institute evaluation addressed efforts to facilitate collaboration of physics educators in Texas. Qualitative data were collected from one source to address this objective.

The *MIPEP Final Reflections Survey* was completed by 17 of the 18 participants in the 2013 Summer Institute. Question 9 of the survey asked participants to discuss ways in which they anticipated sharing what they had learning at the Summer Institute with their colleagues on their individual campuses. Overall, participants were quite positive about their intentions to disseminate their new learnings when they returned to their home campuses.

Some respondents listed specific aspects of MIPEP that they planned to share, such as lessons, PowerPoints, demonstrations, and labs. Others were less specific in their discussion of ways in which they would share materials and knowledge with colleagues, providing general descriptions of plans to disseminate.

Although some participants discussed intentions to specifically share materials and knowledge with other teachers in their individual buildings, other participants expressed plans to share with campus and district administrators, who would then disseminate the information to teachers. Still other participants planned to share through regional collaboratives, explaining that they were the only physics teacher on their individual campus.

Collaboration, both within and across departments, was an important theme in participants' plans to disseminate. Some participants offered specific ideas for collaborating with other teachers in their departments in order to disseminate the MIPEP materials and ideas, while others shared that they planned to collaborate with teachers in other departments. Several participants expressed the importance of collaborating with teachers in the mathematics department, specifically.

Finally, several participants shared that they planned to "talk, talk, talk" to all their colleagues about their experience in the MIPEP 2013 Summer Institute and encourage them, in turn, to attend the Summer Institute in succeeding years.

## Limitations of the Study

Several important limitations were noted in regard to this study. First, major portions of the MIPEP 2013 Summer Institute took place on the grounds of the Cook's Branch Conservatory in Montgomery County. Although we were able to conduct full-day observations of the Friday laboratory-based experiences based on the Texas A&M University campus, we were not able to observe the sessions and experiences that took place at the Conservatory.

Second, although we were able to collect significant amounts of qualitative data via open-ended questions on the *MIPEP Post-Perceptions Survey* and the *MIPEP Final Reflections Survey,* because of time constraints related to accomplishing IRB approval in time for the 2013 Summer Institute, we were unable to interview participants. Interview data may have provided a richer illustration of participants' perceptions related to all aspects of the 2013 Summer Institute.

Finally, the lack of longitudinal data is a limitation to the study. Opportunities to follow-up with participants over a period of time and collect data regarding their successes and challenges related to implementing their learnings in their individual classrooms and disseminating the materials and knowledge to their colleagues would add a significant component to this evaluation.

## References

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