

PHYSICS TEACHER EDUCATION COALITION (PhysTEC)

1. INTRODUCTION

The American Physical Society (APS), in partnership with the American Association of Physics Teachers (AAPT) and the American Institute of Physics (AIP), proposes to dramatically improve the science preparation of physics, physical science, and elementary teachers, nation-wide. This project will greatly increase the role of physics departments, in collaboration with education departments, to create more and better-prepared future teachers. Over the next five years, the Physics Teacher Education Coalition (PhysTEC) will be established with an initial membership of more than twenty-five universities and colleges that share an increasing interest in revising their program in teacher preparation.

PhysTEC initiated the Coalition through the leadership, facilitation, and dissemination resources of APS/AAPT/AIP. PhysTEC inverts the strategy of a university-based project involving all science disciplines, to a coalition of three professional societies as well as physics departments throughout the country to address the issue of improving the physical science preparation of future teachers. The APS/AAPT/AIP will provide leadership to the Coalition and will promote access to, and dissemination of information and results of the Coalition's activities. These findings will be transmitted to the broad physical science community through national meetings, conferences, workshops, and publications (including electronic sites). A one-year development grant from the NSF enabled the PhysTEC Leadership Team to make three-day site visits to nine universities each seeking to become Primary Program Institution (PPI). Each site later submitted a complete portfolio containing a signed MOU, a signed budget, a detailed Scope of Work, and Vitae of participating faculty. The planning grant activities culminated with a conference held at the American Center for Physics in November 2000. The award of a one-year development grant from the Fund for the Improvement of Post Secondary Education (FIPSE) enabled the PhysTEC leadership engaged an external evaluator to guide the staff in the initial planning phase and to develop a detailed five-year formative and summative evaluation

plan (see **Appendix C**). Following the November Conference, the PhysTEC leadership selected six PPIs who will receive support through the grant beginning in Year One. Two additional institutions will be added beginning in Year Three. The six include a diverse mix of large, medium and small institutions, one of which is a Historically Black College or University (HBCU). They will become the first exemplars within a larger “community of practice” consisting of a Coalition of twenty-five or more colleges and universities. The initial six PPIs are:

- Ball State University
- Oregon State University
- University of Arizona
- University of Arkansas
- Western Michigan University
- Xavier University of Louisiana

The Primary Program Institutions (see PPIs in Section 5.3) as lead institutions within the Coalition will engage in creating, implementing, and evaluating a set of model programs, as described in Section 6. The Coalition will also consist of two additional sets of institutions. Universities with significant track records and experience in teacher preparation who will serve as “Resource Institutions” (see RIs in Section 5.5). Their faculty will offer professional development workshops and advice within the Coalition. The third group consists of institutions that have demonstrated interest but are presently not prepared to become involved in a major revision of their teacher preparation program. All members of the Coalition will be invited to participate in PhysTEC workshops and conferences.

2. GOALS, AND OBJECTIVES

APS/AAPT/AIP identified preservice teacher preparation recently as a key issue for the physics community by approving a joint statement in which they: “Urge the physics community, specifically physical science and engineering departments and their faculty members, to take an active role in improving the preservice training of physics/science teachers.”

The three societies recognize their responsibility to assist physics departments and faculty in developing strategies for implementing changes that allow them to respond constructively to this challenge. PhysTEC is proposed as the mechanism to support their responses. PhysTEC's three goals follow:

- To encourage physics departments, in collaboration with departments of education, to dramatically improve the preparation of physics, physical science, and elementary teachers who will teach physical science, and to provide the institutions with the support and technical assistance necessary to undertake the task
- To disseminate widely the outcomes, scholarship, and exemplary programs of study through the resources, national conferences, and publications of the APS, AAPT, AIP.
- To produce more and better-prepared science teachers who are committed to student-centered, inquiry-based approaches to teaching and to the objectives and process the skills associated with the expectations of the national reform movements such as the *National Science Education Standards* (NRC) and the *Benchmarks of Project 2061* (AAAS).

PhysTEC will recommend and monitor the changes that are implemented. There is preliminary evidence from the NSF/CETP program that an effort to improve the physics and physical science education of elementary and secondary preservice teachers can contribute to the general revitalization of undergraduate science education. Physics departments that focus on providing good models in their introductory courses for preservice teachers will learn to adapt these efforts to improve the teaching and learning for *all* students. There are several obstacles to the success of PhysTEC that are recognized and will be addressed. Enticing faculty members at research universities to turn their creativity toward improving teaching and persuading physics departments and schools of education to communicate and work together are two of the most obvious. In both of these, the direct involvement of the key physics professional societies can play a major role in producing positive, lasting changes in the way universities interact with undergraduate students and thus prospective teachers. To achieve the above goals,

PhysTEC has defined four objectives:

- **Objective One:** To establish a productive Teacher-in-Residence (TIR) program that will serve as a “reality check” for the changes in the teacher preparation program.
- **Objective Two:** To redesign targeted physics and pedagogy courses based on the results from physics education research.
- **Objective Three:** To make full use of the APS/AAPT/AIP leadership, infrastructure, conferences, publications, web sites, and committees to promote widespread dissemination of the scholarly work and to promote adoption, adaptation, and implementation of PhysTEC models.
- **Objective Four:** To determine how well PhysTEC meets its goals. To collect qualitative and quantitative data related both to the scholarly products and programs of the PPIs and coalition members through continuous, rigorously planned, formative and summative evaluation.

3. THE PROBLEM

If it is true that teachers “teach as they were taught,” then to improve physics and physical science learning in K-12, universities must model effective teaching/learning approaches in courses for prospective teachers, which include prospective chemistry, biology, mathematics, and elementary teachers (most of whom will teach science). As a consequence of this Coalition, the number of physicists, scientists, and academic departments that will take an active role in the education of future teachers can be increased, and their professional interactions strengthened and informed. The professional societies must play a pivotal role in supporting faculty and departmental interactions and recognizing and rewarding involvement in teacher preparation as a societal responsibility of a physics department. Two recent national reports have made recommendations that are embodied in the PhysTEC project. The Glenn Commission’s report, *Before It’s Too Late (2000)* calls for strategies to “increase significantly the number of mathematics and science teachers and improve the quality of their preparation (from Goal 2).” The report states further that “identifying exemplary programs of

teacher preparation around the country, and finding ways to encourage others to multiply their successes, are basic to reach [this] goal.” The PPI departments are expected to do precisely this within the physics and education communities. The NRC report, *Educating Teachers of Science, Mathematics, and Technology: New Practices for the New Millennium* (The National Academy of Sciences, 2000), recommends that, “colleges and universities should reexamine and redesign introductory college-level courses on science and mathematics to better accommodate the needs of future teachers.” They further “envision master teachers in partner school districts [having] adjunct faculty appointments in the partner two- and four-year colleges and universities.” They would “take on a much more significant role in the mentoring of future teachers.” The PhysTEC proposal identifies the Teacher-in Residence to fulfill this need.

Beginning with *A Nation at Risk* (US Department of Education, National Commission on Excellence in Education, 1983) through *Shaping the Future* (National Science Foundation, 1996), and recently with *To Touch the Future: Transforming the Way Teachers are Taught* (American Council on Education, 1999), national reports have decried the inadequate preparation and lack of competency of new science teachers at all levels K-12. The reports call for the radical reform of ineffective and antiquated teacher preparation programs. The reports cite inadequate understanding of science content (physics, in particular) and the lack of student-centered, inquiry-based approaches in science classrooms. Currently, 28% of our nation’s high school students take physics, which is a significant improvement over the last decade. However, many of our high school physics courses are still modeled after university and college courses. Many of these courses are not inquiry-based, do not develop good conceptual understanding and are not found to be exciting by students. The ongoing and overwhelming need for inservice teacher enhancement programs in physics at the most basic level points to the failure of programs in our colleges and universities to adequately prepare students for teaching. As stated in *Shaping the Future*, “Lack of interaction among SME&T faculty and schools of education is a serious flaw in much of pre-college teacher preparation, arising in a separation of methods from

content.” (NSF, 1996). *To Touch the Future* states that, “The responsibility for preparing prospective teachers in the subject areas they will teach rests not only with school of education faculty but also with faculty of the institution as a whole, especially the arts and science faculty” (ACE, 1999).

4. BACKGROUND

4.1 The Professional Societies

Brief descriptions of the American Physical Society, the American Association of Physics Teachers, and American Institute of Physics can be found in **Appendix A**; these descriptions provide background information as to the organizations’ capacity to lead, implement, and disseminate the products of this project.

4.2 Relation between PhysTEC and Other Teacher Preparation Initiatives

Since 1993 over twenty NSF CETP projects (Collaboratives for Excellence in Teacher Preparation) have documented program successes (and failures) and have disseminated their results through forums, web pages, and PI meetings. PhysTEC will evaluate and include some of the exemplary program elements from the CETPs. However, the CETPs were a collection of university-based projects and did not emerge as a national coalition. PhysTEC, on the other hand, begins with the Coalition concept through the leadership, facilitation, and dissemination resources of APS/AAPT/AIP. PhysTEC inverts the CETP strategy from a university-based focus on many science disciplines to that of a nationally recognized Coalition within a single discipline aimed at a large number of colleges and universities that are linked through the professional societies.

PhysTEC builds on a broad array of successful teacher preparation projects as well as *elements* from NSF CETP projects. The Teacher-in-Residence element (Section 6.2), which is identified as vital to ensure a sustained program of reform, emerged from a CETP project recently completed at Colorado State University. From a CETP project at the University of Maryland comes the element of a redesigned introductory physics course for preservice elementary teachers utilizing the approach of the AAPT/AIP *Powerful Ideas in Physical Science* and changes in the science methods course. PhysTEC will employ elements from the programs of

Lillian McDermott at the University of Washington (*Physics by Inquiry and Tutorials in Introductory Physics*), Pricilla Laws at Dickinson College (*Workshop Physics*), Ron Thornton at Tufts University (*RealTime Physics*), and David Hestenes at Arizona State University (*Force Concept Inventory and Modeling Project*), all of whom have long-running programs to address the science preparation of future teachers and provide specific curricular materials to do so. The CETP project at Colorado State University encouraged and enabled the renewal of several science departments, the mathematics and education departments, and the revitalization of many participating faculty members. The PhysTEC evaluation program will be influenced by the summative evaluation of the Colorado CETP project. Preliminary results, focusing on teachers produced by the project have been positive.

5. PROJECT ACTIVITIES: RESULTS OF THE DEVELOPMENT GRANTS

5.1 Selection of Primary Program Institutions

The PPI selection process has been completed with the support of NSF and FIPSE development grants. Over the course of twelve weeks, the four members of the PhysTEC leadership made three-day site visits to nine institutions. Visits were made to Florida State University, the University of Arkansas, Fayetteville, Western Michigan University, the University of Maryland, Oregon State University, Xavier University in New Orleans, the University of Arizona, Ball State University, and the University of Virginia. Each were judged on the following criteria:

- Commitment to become actively involved with teacher preparation reform as demonstrated by their degree of effectiveness (success) with previous efforts,
- Readiness to work in collaboration with faculty from the school of education,
- Degree of enthusiasm to model good teaching practices
- Capacity to document their work and serve as a model for others within the higher education community,
- Willingness to shift some of their own resources toward PhysTEC, and
- Capability for program institutionalization after funding has ceased.

PhysTEC leaders looked for a critical mass of faculty from physics and education willing to participate. This included the physics department chair (or head) and two or three tenured and untenured physics faculty members. It also included, as full partners, faculty members from the school of education who are involved in the pedagogy (or science methods) courses, the student teacher placements, and the certification process. The staff also met with Deans and other higher administrators, and all showed a great deal of enthusiasm. Several made commitments to provide institutional funds during and after the five-year project. PhysTEC leaders reviewed the elements of collaboration between the physics and education departments and with local community colleges and school districts. Institutions that were recipients of previous external support for teacher preparation had to demonstrate that PhysTEC would support new and previously missing program components, such as a focus on secondary rather than elementary teachers (or vice versa). The overall objective of these discussions was to judge whether there existed a good fit between the institutions' objectives and those of PhysTEC. A Memorandum of Understanding was negotiated with each institution including a signed budget and a detailed Scope of Work. The PhysTEC leadership decided that a yearly award to a site that averaged \$70,000 would help catalyze the project, and would enable the institution to continue activities at a sustainable level. The leadership also decided that six sites in Years One and Two were manageable and enabled a well-informed scale-up of the number of PPI sites by the PhysTEC leadership in Year Three.

5.2 The November Conference

With the support of the development grants from the NSF and FIPSE, PhysTEC sponsored a "closure of the planning grant" conference to bring together key players in the emerging PhysTEC community. This was a working meeting that focused on interactions (via conversations) among twenty faculty from the visited institutions, five members of the PhysTEC Advisory Committee, the PhysTEC external evaluator, executive officers from the three physics societies, two division directors and two program directors from the NSF, one program director from FIPSE, and one from the Knowles Foundation. This was the first opportunity for all of the present players in the PhysTEC community to convene and interact with each other in order to begin to create a shared view of and vision for PhysTEC.

More details can be found in **Appendix B**.

After the November Conference, the PhysTEC leadership rated each institution (points 1 through 7) based upon a ten-part rubric of selection criteria: the potential to make effective utilization of the TIR; the scope of design for new or revised physics courses; the scope of design for new or revised pedagogy courses; the attitude and degree of commitment by key faculty; the track record of the departments for change and innovation; the degree of support from department chairs; the degree of support from upper administrators; the size of the institution's critical mass of key faculty; the attention for following guidelines in a timely fashion; and the overall fit of PhysTEC within the institution (for the detailed grid of PPI characteristics see **Appendix C**).

The PhysTEC leadership selected six initial PPIs to support beginning in Year One. In Year Three PhysTEC will scale up by supporting two more sites. The six include a mix of very large, medium-sized and smaller institutions, as well as an Historically Black College (HBCU):

- Ball State University
- Oregon State University
- University of Arizona
- University of Arkansas
- Western Michigan University
- Xavier University of Louisiana

5.3 Summaries of the Six Primary Program Sites (Complete Portfolios from each site containing a signed MOU signed budgets, justification, Scope of Work, and Vitae of key Faculty can be found in Appendix D.

Ball State University

Ball State University is a publicly funded Doctoral I university with seven colleges: Applied Sciences and Technology; Architecture and Planning; Business; Communication, Information, and Media; Fine Arts; Sciences and Humanities,

and the Teachers College. Undergraduate enrollment is currently 17,500 students, mostly from Indiana and eastern Ohio. Founded as a normal school in 1918, the university has retained a commitment to training excellent teachers. Science education faculty members hold rank in the science departments and science methods courses are taught within the science departments. Students preparing to be secondary teachers complete science majors as well as the education courses required for certification offered in the Teachers College. Ball State will recruit a middle or high school teacher for the Teacher in Residence (TIR) position. The TIR will hold faculty rank in the Department of Physics and Astronomy. Because of a very successful summer inservice program, the department is aware of many excellent physics and middle school science teachers who are well qualified for the TIR position. The university has experience in recruiting teachers for one-year positions at the residential Indiana Academy for Science, Mathematics, and Humanities located on campus.

Recognizing that many teachers who teach the physics and physical science courses have majors in mathematics or another science, Ball State will revise the algebra-based physics sequence, Physics 110-112. Preservice middle and secondary teachers majoring in another science or mathematics take this course. The course is taught in sections of up to 48 students and all preservice teachers will be placed in the same section. The section will be taught with the assistance of the Teacher-in-Residence and changed to include pedagogies based on physics education research such as *Just-In-Time-Teaching*, *Powerful Ideas in Physical Science* and *Workshop Physics*. In addition to revising Physics 110-112, Ball State will increase the physics content of Science 395: Teaching of Science in the Secondary and Junior High/Middle School, a one semester, six-hour science methods course required of all preservice science teaching majors. The course meets three days a week for two hours each day.

Ball State has been successful in revising their physical science course for preservice elementary teachers so that it is inquiry-based and includes microcomputer-based laboratory instruction. Based on this experience, the department should be successful in revising the proposed Physics 110-112 sequence. Plans are in place to institutionalize these changes in other sections of

the course, as facilities become available. There is strong support for the proposed changes by the chair of the Physics Department, department faculty, and higher-level administration and there is an excellent working relationship between the Teachers College and the College of Applied Science and Technology. Ball State is unique among PPIs because it is able to identify preservice teachers early in their program of study and place them in courses where they can benefit from pedagogy that has been proven successful by researchers in physics education. It is also unique because of its historical ties to teacher preparation and the regional reputation the institution has for preparing teachers.

Oregon State University

Oregon State University is classified as a Research 1 institution with over 16,000 students. The Department of Physics consists of 15 tenured and tenure-track faculty, about 50 graduate students, and 100 undergraduate students. The undergraduate program includes majors in physics and engineering physics, along with a wide range of physics options including such areas as applied physics, optical physics, and geophysics; the options allow students to substitute a coherent set (usually 12 credits) of upper-division courses in an allied area for an equivalent number of upper-division physics credits. The Department has awarded an average of about 15 undergraduate degrees each year for the past 5 years, but based on the current number of enrolled majors we expect about 25 graduates in each of the next 4 years. A unique characteristic of OSU's structure is that the Department of Science and Mathematics Education (SMED) resides in the College of Science rather than the School of Education; both department chairs report to the same dean. Pre-service teachers in science and mathematics take all of their content and methods courses within the College of Science.

OSU's nationally recognized Paradigms project (<http://www.physics.orst.edu/paradigms>) will play a significant role in the new program for secondary teachers in physics and related areas. This NSF-sponsored project provides a radically different approach to the undergraduate curriculum for

physics majors that is flexible in accommodating students with widely divergent backgrounds and career goals, emphasizes the interconnections between different fields of physics, incorporates modern pedagogic techniques and information from physics education research, and promotes the development of problem-solving and mathematical skills. The integrated nature of these courses will provide especially valuable experiences to students training to be secondary teachers. Moreover, the pedagogy, which features group learning, computer-based visualization techniques, and integrated laboratory activities, sets a good example for college as well as pre-college instruction. Under the PhysTEC program, the department will develop and implement an inquiry-based physics or physical science course specifically for undergraduate students with an interest elementary education. Using a resource such as *Powerful Ideas in Physical Science* or *McDermott Physics by Inquiry*, which offer curricula based on results from physics education research, we will establish a course that is intellectually challenging but that retains a mathematics level appropriate to the audience. This course will be designed so that it fulfills the University's general education requirement for laboratory-based science.

The department will create a new B.S. in Physics with option in physics education, taking advantage of their undergraduate options that would allow students to substitute an advanced and coherent set of courses in science education. Students may reserve certain of the senior-year capstone courses for graduate credit, thereby providing additional depth to the training and satisfying the Oregon requirement of 9 hours of graduate credit in the specialty area. In this way, the department will provide a seamless transition between the 4-year undergraduate physics degree and the 5th-year M.S. in Science Education leading to licensure.

University of Arizona

The University is a Carnegie Research 1 institution with over 38,000 students on the Tucson Campus. Physics programs are distributed among 5 divisions on the campus. During the 1998-99 academic year, the College of Science embarked on a new project in teacher preparation the underlying theme of which was to closely

couple science content and science-teaching pedagogy. They consulted local science teachers during the design process, and worked with 15 area science teachers in a summer workshop to design classroom activities for the pre-service teachers. They also have experience with local Teachers in Residence. The new program includes 30 hours of science-pedagogy courses, ranging from an introduction to teaching science, through a general science methods course, to subject-specific methods courses in each of the disciplines. The department affirmed its commitment to supporting research on the teaching and learning of physics, by hiring a new faculty member for the science teacher preparation program and committing 1300 square feet of lab space, five offices, and resources to this effort. Many of the junior faculty members have also expressed interest in making their teaching more student-centered and interactive. Several faculty members are using Eric Mazur Concept Tests as part of their lectures, as well as white boards on which students make predictions and answer questions. A student-response system is being installed in our large lecture hall, and Interactive Lecture Demonstrations will be introduced during the spring semester.

Pima Community College campuses work in close collaboration with the Physics Department. A bridge Program lets prospective physics majors work in a laboratory in the Physics Department during the summer, to acclimatize them to the university before they transfer. The department will extend this program to prospective physics teachers who begin their education at Pima Community College. PhysTEC will add value to the program by allowing the inclusion of key components such as the Physics Teacher in Residence. Biology TIRs are currently working with our program, and we are anxious to expand that component to include physics teachers. The University of Arizona participation in PhysTEC will provide immediate support to begin reform of the introductory physics sequence to make it more student centered and interactive. This course, taken by those planning to teach biology, chemistry and geology can have a broad influence on the preparation of teachers in disciplines beyond physics. There are also plans to collaborate with faculty from Geosciences, Chemistry, and Molecular and Cellular Biology in other aspects of the general teacher preparation programs. PhysTEC would allow the program to provide the research based teaching/learning information to support the young faculty member interests and needs.

University of Arkansas

Established in 1871, the University of Arkansas is the only comprehensive doctoral degree granting institution in Arkansas. It is classified as a Carnegie II Research Institution. The 1999 Fall enrollment was 15,226 which includes 2,259 graduate and 377 law students. Their largest minority group, African Americans, represent 7.4% of all students. The plans surrounding the TIR position will integrate not only professional development of the TIR and the TIR's input into preparing classes for future teachers, but also an Internet-based mentoring program for teachers throughout the state, and a special focus on induction in the critical early years of a teacher's career. General classes affecting as many future teachers as possible will undergo significant revision, as well as the University Physics sequence taken by future high school physics, chemistry and math teachers. PHYS 2074/2070, University Physics II (UPII) the second semester introductory calculus-based physics course, covering electricity, magnetism and geometric optics, has already been revised through a NSF-CCD grant. The following additional courses will be revised:

- PHYS 1021L, Laboratory to accompany Physics and Human Affairs.
- PHYS 2054/2050, University Physics I (UPI) the first semester introductory calculus-based physics course, covering mechanics and a brief introduction to thermodynamics.
- PHYS 2094/2090, University Physics III (UPIII) the third semester introductory calculus-based physics course.
- PHYS 400V Lab and Classroom Practices in Physics (1-3 hours) emphasizes the pedagogy behind curricular materials.
- PHYS 2011L College Physics I Laboratory and PHYS 2031L College Physics II Laboratory. The algebra-based classes are the most likely classes to have been taken by prospective teachers. The class sessions utilize Mazur's peer instruction techniques, as well as elements of Just in Time teaching and web-based homework grading. Appropriate UPI, UPII, UPIII, and PHA labs will be adapted for these classes.

The education faculty primary request for strengthening the science methods courses, in addition to the pairing with the special section of PHYS 400V, is to

utilize the TIR to bring material learned in the physics department to the relevant Education classes:

- CIED 4128 Elementary Education Content Integration.
- CIED 5243 and CIED 5253 Special Methods of Instruction I. and II.
- Special Methods of Instruction II
- CIED 5293 Special Methods for Interdisciplinary Instruction.

Western Michigan University

Western Michigan University (WMU) was established in 1903 as a teacher preparation institution. It has grown to a multipurpose university of seven colleges, two schools, and over 28,000 students with a Carnegie classification of "Doctoral Research Universities- Extensive." However, the university views itself as a "student-centered research institution" stressing its initial function and obligation to teachers and education. WMU is one of the largest teacher preparation institutions in the United States graduating approximately 400 elementary teachers and 200 secondary teachers per year with about 50 awarded science teaching certificates with a major or minor in their discipline and another 25 receiving a group science major. The Dean of Arts & Sciences has clearly stated that the education and the preparation of K-12 teachers are the core commitments of each department in the College and not just a service function to the College of Education.

The Departments of Physics and the Department of Science Studies (soon to become the Center for Science Education) in the College of Arts & Sciences are integral parts of efforts to fulfill the science education mission. The Department of Science Studies offers a nationally recognized, exemplary program of science education (6 courses in the physical, life, and earth sciences) for over 400 pre-service elementary teachers per year using inquiry-based teaching strategies and an integrated lecture/lab course structure. The Center for Science Education offers professional development programs for K-12 science teachers, standards-based curriculum development assistance for area school districts, and active collaboration with several NSF funded national projects (including Operation Physics (OP), Operation Primary Physical Science (OPPS), Powerful Ideas in

Physical Science (PIPS), Constructing Physics Understanding (CPU), and Constructing Ideas in Physical Science (CIPS)). The Department of Physics offers a full range of undergraduate programs including a Secondary Education major and minor. The Teacher in Residence (TIR) will be fully integrated into both departments. Faculty involved will include a wide range of experience and most are tenured with current research programs. The areas of change associated with PhysTEC will include the TIR consulting for the *Teaching and Learning* course in the College of Education and serving as a primary liaison with the local schools and “critic teachers.” During the spring and summer of 2001 faculty will plan and develop a revised introductory calculus-based physics course and a science methods course for prospective science teachers. This work will use the extensive research base in teaching and learning of the last decade including the work of Sherwood and Chabay at Carnegie-Mellon University; and Laws, Sokolof, and Thornton (Workshop Physics, Real-Time Physics, and Interactive Laboratory Demonstrations). The revised targeted physics courses will be offered in tandem with a traditional lecture-format version of these same courses. This dual track comparison will be a key factor in the formative evaluation activities and should provide important information about the impact of the revisions. Each year of the project an internal formative evaluation process will be undertaken to document the development and revision activities and to determine the impact of these activities on student understanding and achievement. The evaluation will include assessing student and faculty reaction to the new learning environment.

Xavier University

Xavier University of Louisiana is a historically Black university (89.7%, this year). Begun as a normal school in 1925, it is now ranked number one in the nation for the number of African American graduates in physics, the physical sciences, and biology. The 2000 Fall enrollment is 3,797 students and its retention rate of freshman to sophomore is 78.2% this year. The PhysTEC

program will provide faculty support for course revision, a key element to improve pre-service teacher preparation. Xavier is already on the cutting edge of implementing requirements that will allow elementary education graduates to obtain minors in science and mathematics. Since the spring 1993, the Physics Department at Xavier University introduced a new format and teaching approach in the introductory calculus-based physics course (PHYS 1121-2111-2121) based on the experience of Priscilla Laws' Workshop Physics. In the course lecture and laboratory were integrated so that class discussions, personal reflections, observations and experiments enhance the students' understanding of physics. The interactive environment and cooperative learning fostered by the new teaching approach combined with strong nurturing typical of Xavier's teaching philosophy led to a tremendous improvement in students' learning. As a direct result of the new approach more students felt attracted to the physics discipline and more recently we had a significant increase in the number of physics majors in the Department

An aspect of the PhysTEC model, which would enhance the existing program, is the TIR. This project would allow more collaboration between pre-service and in-service teachers with the assistance of a TIR with science education experience. It would also provide a practitioner to assist the Physics faculty with the current experiences needed by practicing teachers. The GLOBE program would also be enhanced because the TIR would be able to become a GLOBE Trainer through this initiative. The TIR would be able to work with pre-service and in-service teachers by observing them teach these concepts and providing supportive feedback to the participants. Although students who enter the graduate program

for certification in Physics education already have an undergraduate degree in Physics, the TIR could assist the Physics faculty to develop appropriate courses to coincide with the revised undergraduate curriculum in Physics education. These courses would include the inquiry approach to teaching and learning and would allow the pre-service teachers to work with the in-service teachers for further growth and mentor/mentee relationships to develop.

During fall, 2001, we will begin the process to identify, recruit, and hire a TIR from Region One of the Louisiana school districts, using strategy suggested to us by the PhysTEC staff. During the spring and summer of 2001, two faculty (Steve Rodrigue and Lisa Pollack) from the physics department will meet regularly with faculty from the Division of Education (Rosalind P. Hale and a new education faculty) to plan and implement the design of content and pedagogy for targeted physics and secondary education courses based on results from the physics education research. The following courses will be revised: (e.g. PHYS1121/2121, PHYS3510/3520, PHYS1530, IPSC2010/2020/4010, and EDCS3010). A key component of a good teacher education program is the participation of content faculty in improving field/practicum experiences. PhysTEC will provide for implementation of a faculty component to develop this participation. Physics and Education faculty who receive release time to work on this project will go to the local schools to observe their students. In addition, Physics majors will be provided stipends to participate in field experiences at local schools during the spring semester of their sophomore year. The Physics and Education faculty will team-up to observe these participants at least once each month during the semester. The student participants will be required to teach a mini lesson during the last month of their field experience. This will allow Physics content majors to experience secondary teaching and may encourage some of them to either major in Physics education as an undergraduate or pursue teacher certification at the graduate level.

5.4 Technical Assistance and Faculty Development

Professional development workshops for participating faculty will be provided at regional or national meetings, some specially convened for this purpose, others associated with the national meetings (most likely, at AAPT meetings). The

workshops will be inquiry-based and utilize constructivist physics teaching strategies. (Constructivist methods emphasize the active engagement of the student in the learning process and recognizes the importance of prior knowledge for new learning.) The workshops will also focus on state and national *Science Standards*, laboratory and technology innovations, student-centered techniques in large classrooms, the issues pertaining to diversity and underrepresentation in science, and best practices from universities and colleges associated with the Coalition. All PPIs must articulate how they will produce more and better-prepared teachers who possess an extensive content background complemented by a thorough understanding of and commitment to inquiry-based methods of teaching. Preservice teachers need various strategies for classroom management and facilitating open-ended experiments and projects. The PPI faculty also needs to provide their preservice teachers with an increased awareness and understanding of equity and diversity issues. PhysTEC will also help develop and test strategies for recruiting and retaining certification candidates from underrepresented groups, transfer students, and nontraditional students. Connections with local AAPT and APS activities, particularly the local Physics Teacher Resource Agents (PTRAs) will be utilized. Contacts will be established with local school system officials, such as superintendents and principals, to begin discussions about the arrangements to release an elementary or secondary master teacher to serve as a TIR. Channels of communication with the Resource Institutions will be established.

5.5 Role of Resource Institutions (RIs)

In the last decade, the physics community has seen a clear self-identification of a group of physicists interested in physics education research (PER) emerging as a subfield of physics itself. This group, such as the Physics Education Group (PEG) at the University of Washington, has been quite successful in generating enthusiasm and promoting scholarship in the field, as well as, hosting meeting sessions and conferences, forming special interest committees, stimulating publication, and creating a real sense of community. A major outcome of the PhysTEC effort will be the emergence of a group of institutions and faculty

members in both physics and education interested in the preparation of future teachers. Three tiers of institutions are identified, the first being the set of six PPIs. The Coalition will also consist of universities with significant track records and experience in teacher preparation who will serve as ‘Resource Institutions’ (RIs). Their faculty will offer professional development workshops and advice to the PPIs and other members of the Coalition. The third group consists of institutions that have demonstrated interest but are presently not ready to become involved in revising their teacher preparation programs. They will also be invited to participate in the PhysTEC workshops and conferences. The PPIs and other members of the Coalition will be encouraged to build upon one or more of the successful approaches to physics teaching (though, not limited to): *Real time Physics* by Sokoloff, Thornton, and Laws (1999); *Physics by Inquiry* by McDermott (1996); *Modeling Approaches to Physics* by Hestenes (1992, *The Physics Teacher*); *Powerful Ideas in Physical Science* by AAPT (1995); *CPU Project* by Fred Goldberg (1995, *Am. J. Phys*), *Just-in-Time Teaching* by Patterson et.al. (1999); and *Peer Instruction* by Mazur (1997). (Please see detailed **References**.)

6. PhysTEC MODEL COMPONENTS

The following program components are based on elements of previously successful projects and will be common to all PPIs. Each PPI will, in collaboration with PhysTEC leadership, create a strategic plan to facilitate the adaptation, adoption, implementation, and the evaluation of these components.

6.1 Partnerships with Schools of Education and Local School Districts

From the beginning of the project, the faculty members from physics and from education must agree to work together as full partners. Key personnel from education should include the science education specialist or a faculty member who usually teaches the science methods course and the person who is directly involved with the placement of student teachers.

6.2 Teachers in Residence

Each PPI will employ a Teacher-in-Residence (TIR) who brings the knowledge and experience of managing a student-centered science class. The TIR will assist

physics and education faculty in revising targeted physics and education courses and will help team-teach the courses. The TIR will assist in all components of the teacher preparation program and will provide continuity between the education methods courses, the physics courses, and the activities in the local schools. The university will reimburse the school district for the cost for the TIR's replacement (usually at an entry-level salary) while the TIR continues to receive his or her current salary from the district. Later, the university will provide the TIR with a mini-grant for classroom supplies when the TIR returns to the classroom. The TIR will offer valuable contacts with local teachers and school districts and provide insights that will significantly improve practicum activities and the placement of student teachers. PhysTEC will provide a web site and listserv for the exclusive communication between TIRs and to provide important information that will orient them to PhysTEC. There will be an annual meeting for TIRs to establish and support a network. The local Physics Teaching Resource Agents (PTRAs) will facilitate the identification and selection of the TIRs when possible. If feasible, the TIR may spend the summer prior to the academic year in a physics research laboratory with faculty and students from the physics department. This would enable the TIR and faculty to discuss ways to integrate research and education. The research experience would acquaint the TIR with the department and the faculty.

6.3 Targeted Physics Courses

Central to PhysTEC is the restructuring of courses and instructional approaches. Since preservice K-8 teachers usually take different physics courses than those taken by preservice high school science teachers, PPIs may choose to aim their initial reform efforts at either K-8 or 9-12 teachers. In either case, the appropriate sections of the first-year introductory physics course should be redeveloped to promote active learning, such as in an integrated lecture and laboratory or total laboratory format. The redesigned courses will likely encourage less reliance on the authoritarian, teacher-dominated, transfer model of science instruction and require a more spontaneous interchange of ideas. Other changes in the physics department's instructional strategies might include bringing more inquiry-based, student-centered experiences into lecture sections through cooperative learning and peer-coaching techniques, enhancing learning using technology, and other

successful delivery systems aimed at actively engaging students. PPIs will share syllabi and other course documentation to assist each other in developing courses.

6.4 Science Methods Courses

The six PPIs differ in the way they offer courses and activities on “how to teach science” and differ greatly in their planned revisions. At one PPI, the secondary science methods course is taught by faculty from the College of Sciences, and the elementary course is located in the School of Education. In another, the secondary science methods course is taught in the School of Education and the elementary science methods course is located in the College of Sciences. Another site proposes to combine the General Methods of Teaching and Science Methods into one two-semester course and will team-teach the course with physics faculty (and other science faculty), education faculty, and the TIR. All revised courses will strive to model innovative (and tested) teaching methods, which are student-centered and inquiry-based. Included will be in-depth discussions of state and national content *Standards*, techniques for effective classroom management, skills in lesson development and planning, and experience in inquiry-based and constructivist theory and practice in teaching and learning. Integrated into this course will be an on-going study of issues relating to equity and diversity. PhysTEC students will be expected to understand and practice research-based strategies for overcoming the educational barriers experienced by women and minority students in their study of science. The PPIs will also be encouraged to offer a curriculum that engages the broadest spectrum of students and to use technology effectively to enhance learning.

6.5 Field-Based Experiences

The quality of field experiences of future teachers is a central concern of PhysTEC. Contact between the campus program and teachers in the local schools must be strengthened to establish a cadre of reform-minded cooperating teachers who will receive and help prepare the preservice teachers. Initially, outstanding teachers and later former TIRs could serve as cooperating teachers for new student teachers whenever possible. Ideal practices would include two years of supervised practicum activities (observations and classroom aides) in local K-12 schools with monthly seminars given by the supervising team (the education specialist and the

physicist). Then, the student would have one full year of supervised student teaching which may also include occasional school visits by physics faculty during the first year of employment (the *Induction* year) for in-school coaching, evaluating, mentoring, and other supportive activities. To carry out such an extensive Induction program, prospective teachers would have to be identified early in their undergraduate studies. PPIs could undertake a campus-wide advertising campaign to identify prospective teachers.

7. EVALUATION

7.1 Overview of Evaluation Team and Design

Evaluation will be undertaken through both internal and external efforts. Dr. Karen Johnston of the *Momentum Group* will handle the external evaluation and provide advice for the internal evaluations. The one-year development grant from the Fund for the Improvement of Post Secondary Education (FIPSE), was used to support the external evaluation of the planning process and the November PPI Conference. Dr. Johnston was also asked to help develop a detailed five-year formative and summative evaluation plan for the grant (for the detailed evaluation plan, see **Appendix C**). Program documentation will be compiled internally by each PPI site team who may also participate in other research elements within the program. PhysTEC must produce *change* in order to be successful: change within departments, of faculty members, and of future teachers. Significant efforts will be focused on measuring this change and documenting that it is leading to better-prepared teachers and verifying that the physics departments are providing a better learning environment for all undergraduates. Another significant focus will be tracking and contacting PhysTEC graduates. PPI sites will be required to follow up their graduates and to provide on-going inservice activities, especially in the critical *induction* year and beyond. Alumni lists must be kept up to date to extend the evaluation process into the later years. To assess the effectiveness of the implementation of project components, a variety of quantitative and qualitative data collection techniques and monitoring will take place including:

- Surveys by paper mail, email, follow up phone calls, site visits.
- Focus group discussions with students and faculty involved in revised PhysTEC courses.
- Summaries of preservice students' anonymously written comments to open-

ended questions about their experiences in university courses and other activities

- Interviews with faculty, TIRs, student teachers, cooperating teachers, and principals.
- Collection of baseline (numbers) and programmatic data (descriptions, identities, and attitudes) on participating faculty, preservice students, cooperating teachers, supervising teachers, and TIR.
- Collection of syllabi, assessments, and activities of new and revised PhysTEC courses.
- Collection of program and course-generated materials and of assessments of teachers' and students' understandings and skills. Collection of proceedings from workshops, symposia, and conferences.

7.2 Formative Evaluation

The formative evaluation of this project will be designed to provide PhysTEC with feedback on a continuing basis to facilitate ongoing revision of project goals and activities. It will be concerned with effective implementation and project improvement. Project staff will assemble a list of activities, a description of personnel and students associated with the project. In order to monitor the implementation of project objectives, semester reports will be prepared by PhysTEC staff. A Progress Evaluation Report will be developed and shared with the Advisory Committee at regular meetings. A computerized tracking system will be used to maintain individual files of students and their courses, teachers, projects, research, etc. This database will be useful in analyzing data elements and fields across the components and observing interactions between them.

7.3 Summative Evaluation

In order to provide evidence of how well the goals and objectives of the project have been realized, the external evaluation team will carry out a summative evaluation. The PhysTEC evaluation reports, including the quantitative and qualitative data and the report of the Advisory Committee, will be summarized on an annual basis. The evaluation will involve monitoring the success of each of the PhysTEC components. PhysTEC Objectives to be evaluated lead to the following questions:

- Did PhysTEC make a significant difference in the teaching skills of the PhysTEC graduates?
- Was there a significant difference in the teachers' understandings in physics/physical science?
- How many PhysTEC teachers received their degree and certification? Was this an increase when compared to the numbers graduated prior to the PhysTEC program? Where did they go?
- How effective was the collaboration between the physics departments and the schools of education at each PPI? Is there evidence that this will be an on-going collaboration?
- How many faculty were involved during PhysTEC funding and how many continued to be involved after the external support was completed?
- How many courses were redesigned, revised, and institutionalized at each site?
- What significant unintended impacts did PhysTEC have on the university environment?
- Did the APS/AAPT dissemination model attract a significant array of key institutions?

8. PhysTEC LEADERSHIP

8.1 Leadership Team

The Leadership Team will be responsible for the PhysTEC mission and policies, financial decisions, and the day-to-day operation of the project. . This team has many years of experience in managing large and complex projects. The fiscal agent for PhysTEC will be the American Physical Society. The Leadership Team will work with the external evaluator, members of the Advisory Committee, staff members of the various societies, the PhysTEC Leadership Teams from each PPI, and faculty from the RIs and from other Coalition members. They will organize and lead conferences and be responsible for publications and other dissemination components. They will be responsible for communicating the progress and results of PhysTEC to the physics community and to other SMET (Science, Mathematics, Engineering, and Technology) communities, including discipline and teacher-related societies, federal agencies, and those interested in K-12 SMET reform. The Leadership Team will make regular reports to and meet annually with the Advisory Committee and members of the evaluation team. Email and conference

calls will be used to communicate between meetings, and an active Web Site will be constantly updated and maintained to enable frequent communications. The PhysTEC Leadership Team is as follows (Brief bios can be found in **Appendix E**):

Fredrick M. Stein, the principal investigator, is the Director of Education and Outreach for the American Physical Society. Stein will be responsible for the overall direction, implementation, and fiscal management of the project. He will be the primary contact with the NSF and will be responsible for the on-going communication and timely reporting. **John Layman**, CO-principal investigator, is a Professor Emeritus of the University of Maryland where he held a joint appointment between the Physics Department and the Science Teaching Center within the College of education, will assist the PI in formulating the program, in site visits, orientation meetings, workshops, and preparing publications and presentations. **Jack Hehn**, CO-principal investigator, is the Manager of the Education Division for the American Institute of Physics. Hehn will assist in site visits, orientation meetings, workshops, and in preparing publications. **Warren W. Hein**, AAPT Staff Liaison, is the Associate Executive Officer for the American Association of Physics Teachers. Hein will be responsible for coordinating PhysTEC activities that involve AAPT programs and staff.

A **Project Coordinator** will be hired for the day-to-day coordination and management of the project. She or he will be in constant contact with each site, monitoring and documenting each of the site activities as they develop. The coordinator will help the PIs organize and arrange the PhysTEC workshops and orientation events; will gather information and coordinate the activities of the external and internal evaluation effort; will assist the PIs in preparing the annual report; and will be the editor of web services and electronic services associated with the project.

The PhysTEC Leadership Team and coordinator will work in concert with the external evaluator, members of the Advisory Committee, staff members of the various societies, and the Leadership Teams from each PPI. The PhysTEC Leadership Team will undertake activities to initiate the project at each of the PPIs and those activities will be planned specifically for that site in collaboration with

the Leadership Team of the PPI. The PhysTEC Leadership Team will monitor each PPI, undertake internal evaluation procedures, and assist the external evaluation team in their formative evaluations. They will organize and lead conferences and be responsible for publications and other dissemination components. They will be responsible for communicating the progress and results of PhysTEC to the physics community and to other SMET communities, including discipline and teacher-related societies, federal agencies, and those interested in K-12 SMET reform. The PhysTEC Leadership Team will make regular reports to and meet annually with the Advisory Committee and members of the evaluation team. Email and conference calls will be used to communicate between meetings, and an active Web Site will be constantly updated and maintained to enable frequent communications.

8.2 Advisory Committee

The Advisory Committee, composed of representatives from each of the partners (APS, AAPT, AIP), will review policy and programmatic decisions and offer advice and consultation on a timely basis. The Advisory Committee will be an active partner in planning, administering, and monitoring the project. George Trilling, President-Elect of APS, from the Lawrence Berkeley National Laboratory, will chair the committee. Other members will include Lillian McDermott, professor of physics from the University of Washington; Robert Beck Clark, professor of physics from Brigham Young University; Norman Webb from the University of Wisconsin and a member of the National Institute for Science Education, Sandra Harpole, from Mississippi State University, and Paul Hickman, staff member of the Center for the Enhancement of Science and Mathematics Education, Northeastern University. Paul Hickman, who has extensive experience as a high school teacher, has received AAPT's pre-college teaching award. Other consultants may be brought into the process to offer expert opinion and advice to the PhysTEC Leadership Team and the Advisory Committee.

8.3 PPI Leadership Teams

The work of the PPIs will be supported through this grant according to the budget and the scope of the work described in each MOU (see each detailed portfolio in **Appendix D**). Each site will have a PhysTEC Leadership Team including faculty

from the departments of physics and education plus the Teacher-in-Residence and other members. The Leadership Team will meet regularly, will establish and monitor progress toward the goals for their particular PPI, and will report to the PhysTEC Leadership Team. They will be responsible for each PPI's program planning, development, and fiscal management. At least four representatives from each PPI will meet periodically with the PhysTEC Leadership and the evaluator to refine plans and activities. TIRs, a unique set of colleagues, will also meet regularly to compare experiences and successes. These meetings may coincide with faculty development efforts such as workshops or conferences. At least one member of the PhysTEC Leadership Team will visit each site annually to monitor progress toward the PPI's goals, to share and record experiences, and possibly to suggest improvements and innovation. A detailed timeline of PhysTEC activities can be found in **Appendix E**

9. DISSEMINATION ACTIVITIES AND PhysTEC PRODUCTS

PhysTEC workshops, papers and presentations will be featured in sessions at AAPT and APS meetings. The APS meetings are March and April and the AAPT meetings are January and July or August. In addition, APS has fourteen divisions, many of which hold their own meetings and activities each year. These meetings provide a national forum for the presentation and discussion of PhysTEC issues and outcomes. A full description of APS/AAPT/AIP conferences, workshops, and other dissemination meetings and products (both print and electronic) are detailed in **Appendix F**.