

Proposal submitted to the National Science Foundation
PUERTO RICO GRADUATE TEACHING FELLOWS IN K-12 EDUCATION PROGRAM

Introduction:

The **University of Puerto Rico (UPR) system**, through the Resource Center for Science and Engineering (RCSE), proposes to establish a Graduate Teaching Fellows in K-12 Education Program (GK-12) as a joint effort between the Río Piedras Campus and the Mayaguez Campus, the two graduate centers of the UPR system, in partnership with the Puerto Rico Department of Education (PRDE). The central goal of this Program is to recruit, train and engage excellent graduate students in the areas of science, mathematics, engineering and technology (SMET) as professional development resources to promote the conceptual understanding of content knowledge from a constructivist and interdisciplinary perspective among K-12 science and mathematics teachers in the Island's public educational system participating in the **PR Statewide Systemic Initiative (PR-SSI)**. The GK-12 Fellows will play a fundamental role in advancing the systemic reform of K-12 education on the Island by:

- ! Serving as professional development resources in the scaling-up effort of the PRSSI reform-Phase II, as part of the team of university faculty and lead teachers who will reach 400 additional schools (25% of the Island's 1,538 schools in the public system) to be inducted into the standards-based reform during 2000-2002;
- ! Providing follow-up to teachers from among the 200 PR-SSI schools that initiated the whole school based strategy during Phase II in 1998, which are currently completing the professional development program and require assistance in the effective implementation of the standards based curriculum;
- ! Providing support to cooperating and mentor teachers in the preparation of future and novice teachers participating in the **Puerto Rico Collaborative for Excellence in Teacher Preparation (PR-CETP)** who are carrying out their practicums and induction experience in PR-SSI schools;
- ! Co-teaching with K-12 teachers and serving as role models of future scientists, mathematicians and engineers for K-12 students.

The main focus of the professional development assistance to be provided by the Fellows will be in the enhancement of learning processes leading to conceptual understanding of disciplinary knowledge, with emphasis on the establishment of interdisciplinary connections, a constructivist teaching-learning approach that promotes higher order learning skills and depth of understanding needed to enhance the scientific literacy of all students and to improve the preparation of the future scientific workforce. Graduates from undergraduate institutions who are members of the **PR Alliance for Minority Participation (PR-AMP)** and are reforming the SMET curriculum based on an inquiry approach to learning will be targeted as candidates for the Fellowships. The professional development activities to be provided by the Fellows will place special emphasis on content areas of need identified through various assessment strategies, including the student performance assessment based on NAEP and TIMSS equivalent items carried out by the PR-SSI as a component of the systemic reform.

The UPR is the largest Hispanic serving institution in the Nation and is making strides in becoming one of the top-producers of Hispanic PhDs in SMET. The Rio Piedras Campus, located in the San Juan metropolitan area on the northeastern coast, has a total enrollment of 23,000 students of which 13% are in SMET, and the Mayaguez Campus, the Land-Grant institution located in the western coast of the Island, has a total enrollment of 13,000 students of which 50% are in SMET.

The PR/GK-12 Program will be developed as a pilot project to institutionalize a K-12 teaching practicum for graduate SMET programs at the Río Piedras and Mayaguez Campuses. The proposed endeavor will provide for the recruitment, preparation, and engagement of graduate students as professional development resources for teachers in the fields of Biology, Chemistry, Physics, Mathematics, Geology, Marine Sciences, and Engineering. Up to 45 graduate students from the SMET Graduate Centers at UPR will be selected through an annual competitive process during a three year period, and provided with NSF Fellowships to serve as professional development resources for K-12 teachers during a minimum of 10 hours per week, devoting at least 5 additional hours of preparation per week. SMET faculty members from both campuses identified as exemplars of inquiry-based teaching and PR-SSI Lead Teachers and Coordinators will work closely with the Fellows during their service. These mentors will serve as professional development resources to ensure an optimal and productive experience for the students both in terms of their own learning and professional development as well as the impact on the quality of K-12 education.

Results from Prior NSF Support:

The Resource Center for Science and Engineering strategy for the statewide systemic reform of K-16 education in Science, Mathematics, Engineering and Technology (SMET) Education

Puerto Rico is undertaking the systemic reform of K- 16 science, mathematics, engineering, and technology education (SMET), through a partnership among the Resource Center for Science and Engineering (RCSE)- a consortium of the major higher education institutions on the Island, the Puerto Rico Department of Education (PRDE), and the Community at Large. This reform is spearheaded through three major initiatives: the PR-Statewide Systemic Initiative (PR-SSI), the Collaborative for Excellence in Teacher Preparation, (PR-CETP) and the Alliance for Minority Participation (PR-AMP), co-funded by the National Science Foundation (NSF) and local institutions. The coordination of these initiatives by the RCSE has promoted their articulation as components of a unified and seamless K-16 system, fostering a shared vision for SMET education, the transfer of educational strategies among all partners, the cross-fertilization of efforts and the pooling of resources among all levels of the system, leading to a synergistic effect that is critical for achieving lasting change. The effectiveness of the articulation of the systemic projects under the RCSE as well as the quality of the reforms and the achievements attained have been recognized by national experts as models of excellence that are transferable to mainland counterparts.

I. PR-Statewide Systemic Initiative (PRSSI) Phase I (OSR 9250052) Annual funding levels \$2 M NSF + \$2.3 M average local matching funds per year, 09/92-08/97; and Phase II (ESR 9711999) \$1.2 M NSF + \$3.7 M Local, 9/97-08/02.

The central goal of the PR-SSI is the transformation of the K-12 science and mathematics educational system to provide all K-12 students with high quality standards-based education. The PRSSI has focused on the development and dissemination of an effective working model for the transformation of the teaching/learning environment at the school level while building systemwide mechanisms to promote and sustain this transformation.

As of 1999, the major accomplishments of the PRSSI are: (1) the elaboration and dissemination of K-12 educational standards for science and for mathematics based on those of the National Council of Mathematics Teachers (NCTM), the National Research Council (NRC), AAAS Project 2061 Benchmarks for Science Literacy, and the precepts of the National Science Teachers Association (NSTA); (2) the development of curricular frameworks for K-12 mathematics and

science which are aligned with national and local standards; (3) the design of conceptually-driven, inquiry-based science and mathematics curricular programs for K-9, and curricular models for the high school level which are aligned with national standards; (4) the design of authentic assessment methods aligned with the standards-based curricula and their integration into the teaching-learning process; (5) the development of a whole school-based strategy to implement standards-based curricula and empower the school to transform the teaching/learning culture; (6) the establishment of 27 school-based Regional Professional Development and Dissemination Centers to scale-up the whole-school based strategy, where leader teachers work in partnership with university faculty; (7) articulation of State Dwight D. Eisenhower Programs that reach over 1,300 science and mathematics teachers annually through continued education programs aligned with the systemic reform; (8) the creation of a Three-Tiered Student Assessment System to measure the progress of the reform which includes assessment strategies that are based on the NAEP and TIMSS; (9) development of Professional Standards for Teachers of Science and Mathematics that are aligned with national standards; (10) creation of a pilot induction program for novice science and mathematics teachers with exemplary teacher mentors; and (11) the support of pilot science and education faculty initiatives for the improvement of teacher preparation courses in alignment with the K-12 educational reform and national standards (RCSE 1997; PRDE, 1996; Commission on Professional Standards, 1994)

PRSSI defines the school as the basic unit for educational change to ensure that the teaching of science and mathematics is transformed within the school as whole, reaching all science and mathematics teachers and students in all grades within each school. The PRSSI has designed the Whole School Based Strategy (WSBS) as an integrated and coherent approach which addresses all the fundamental elements of the school culture that affect the teaching-learning process, leading to changes in educational paradigm, and creating a student-centered learning environment to enhance learning for all students. By 1999, a total of 377 schools have participated in the WSBS, representing 25% of all schools in the system, and through Phase II, the PR-SSI will scale-up the reform to 800 schools or 50% of all schools in the system by the year 2002 (Gómez & Dávila, 1997).

The success of the PR-SSI is evidenced through the significant results accrued in the improvement of student performance as indicated through a multi-level assessment system. Due to its successful performance, the PRSSI has become one of eight of the SSI projects at the national level to be co-funded by the NSF for Phase II. Most notable among the indicators of the PRSSI Three Tiered Student Assessment Model are the standardized tests developed to measure the added value of the reform in improving student achievement. The Puerto Rico Assessment of Educational Progress (PRAEP), a translated and adapted version of the NAEP science and mathematics tests, was administered in 1994 to students from PR-SSI pilot schools and a representative sample of those from public and private schools on the Island. The results of the PRAEP demonstrated that PRSSI students performed significantly better than those from other public schools, indicating a reduction of 50% (7 points out of 14) in mathematics and close to one third of the points in science, of the performance gap that exists between public and private schools.

In 1997, in collaboration with the Puerto Rico College Entrance Examination Board, pre/posttests were developed using public-released items from the Third International Mathematics and Science Study (TIMSS) and the National Assessment of Educational Progress (NAEP). The College Board equated the scales of these tests to those of the TIMSS international test scales which permits a valid comparison of international scores allowing the use of these scores to benchmark the progress of the PR-SSI. Results of the tests administered to representative samples of students in PR-SSI indicate that students performance improves significantly as their time exposure to the PR-

SSI reform increases. For example, whereas students with one year in PR-SSI schools performed similar to students in Norway and Iceland, which ranked 4th and 3rd in the TIMSS respectively, students with four years in a PR-SSI school surpass those in Sweden, the lead country in the world, by 25 points. Another critical indicator of the effectiveness of the PR-SSI is the achievement of graduating students in the College Board Exam, which has a 0.87 correlation with the SAT Math test. PR-SSI students who had been during 6 years in the PR-SSI outperformed private school students in the Math Reasoning Test by 58 points, while students who had been in PR-SSI for three years outperformed non-PR-SSI public school counterparts by 32 points.

II. The Puerto Rico Collaborative for Excellence in Teacher Preparation (PR-CETP)(DUE 9753543) Annual Funding NSF : \$1 M + \$750,000 local costsharing, 07/99-06/03

The Puerto Rico Collaborative for Excellence in Teacher Preparation (PR-CETP) is currently in its first year of funding which started on July 1, 1998. The PR-CETP is an **alliance** of the six main higher education institutions which prepare close to 80% future science and mathematics teachers (S&MTs) in Puerto Rico: University of Puerto Rico, Río Piedras Campus (UPR-RP, leading institution); Cayey University College-University of Puerto Rico (CUC-UPR); Pontifical Catholic University of Puerto Rico (PCUPR); Mayagüez Campus - University of Puerto Rico (UPR-MC); University College of the East (UCE); and Inter-American University System (IAU-S). Other main partner institutions in the PR-CETP are the Puerto Rico Department of Education (PRDE), exemplary K-12 schools, including those participating in the PR-SSI, the National Ionospheric and Astronomy Center -Arecibo Observatory, local industry, and local professional teacher associations.

The **main goal** of the PR-CETP is to redesign teacher preparation programs to enhance conceptual understanding of the disciplines to be taught by the future science and mathematics teachers (S&MTs) as well as their mastery of content-specific teaching methodology in alignment with local and national standards. This redesign of the main K-12 science and mathematics teacher preparation programs on the Island will be achieved by promoting intra- and inter- institutional collaboration among science, mathematics, and education faculty, exemplary K-12 teachers, and academic officials from the university and the school system. PR-CETP is **building upon the ongoing local reform** efforts in science and mathematics at the K-12 and undergraduate level sponsored by NSF, including the PR-SSI and the Puerto Rico Alliance for Minority Participation (PR-AMP). Once funded, PR-CETP assumed responsibility for the Teacher Preparation (TP) activities previously developed by PR-SSI, including the dissemination of the results of the two principal PR-SSI curricular reform projects for future S & MTs: the alignment of the Science Methodology and Practicum Courses at the Secondary level with the standards of excellence, developed at the UPR-Río Piedras Campus, and the redesign of the K-6 Science and Mathematics Methodology Course by the Inter-American University of Puerto Rico. The PR-CETP also is building on the pilot induction program for novice teachers initiated by the PR-SSI. PR-CETP draws upon PR-SSI personnel as resources for the Professional Development of the TP professors, in the identification of the PR-SSI schools that will serve as practicum sites for the PR-CETP students, and in sharing information needed to align the K-12 curricular reform with the TP curriculum reform to ensure that future teachers are fully prepared to teach according to the standards of excellence and to sustain the K-12 science and math reform.

During the first year of the PR-CETP, the main accomplishments include: 1) Full establishment of the PR-CETP **organizational and communications infrastructure** required to achieve the reform goals, including the creation of the PR-CETP Center for Excellence in Science and Mathematics Teacher Preparation as the central coordinating unit to facilitate and promote inter-

institutional collaboration, and the major working groups that will carry out the actual implementation of the reform; 2) Elaboration of **five year institutional strategic work plans** to achieve the PR-CETP overall objectives through intra and inter-institutional collaboration among science, mathematics, and education faculty, academic administrators, and K-12 science and mathematics teachers; 3) Articulation of the PR-CETP with **ongoing local reform efforts** for K-16 science and mathematics education and establishment of collaboration with the PRDE, Arecibo Observatory, major professional teacher associations, and industry; 4) Participation of the PR-CETP in the design of the Puerto Rico **science teacher certification exam** in collaboration with the PRDE and the PR College Board; 5) Initiation of **curricular reform efforts** with a set of key teacher preparation content and methods courses at each institution to align them with national standards of excellence, infuse the use of educational technology, and strengthen and expand practicum and field experiences in exemplary schools; 6) Implementation of a **faculty development program** for the adoption of best practices and access to the knowledge base required for high quality curricular revision through a series of conferences, workshops and seminars, electronic discussions, collaborative action- research projects, and faculty advisors; 7) Development of **student support activities** to recruit the best students at the high school and undergraduate level into teaching careers, to retain students who require academic support, and provide induction into teaching for graduates to support them during the beginning of their teaching career; and the 8) Engagement of top level academic administrators in identifying **key policy issues** related to excellence in teacher preparation and exploring mechanisms to promote and institutionalize the PR-CETP reform. The PR-CETP submitted a proposal for supplemental funding from NSF to develop a Teaching Scholars Component through which 25 excellent undergraduate science/mathematics education students will be recruited with emphasis in areas in which there is a shortage of certified teachers, and provided support until graduation and certification as exemplary teachers and professional development resources (RCSE, 1999).

III. PR AMP Phase I (HRD 9153687)- 07/91-12/96, Average annual funding \$1M= NSF + \$1M local matching per year; Phase II HRD 9623943 11/96-10/2001; NSF=\$880,000 and cost sharing \$1.48 M

The goal of the PR-AMP is to increase the number of students who obtain a BS degree in science, mathematics, engineering and technology (SMET) fields and the number of BS graduates who complete a Ph.D. in SMET by transforming the teaching/learning culture of participating institutions through a systemic approach to improve the effectiveness and efficiency of the undergraduate SMET enterprise. All universities on the Island that emphasize science and mathematics programs are participating in the PRAMP. The major components to address key areas in the improvement of undergraduate SMET education are: Curricular Revision, Technology, Student Development, Faculty Development, Teacher Preparation, Special Engineering Component; and Transition to Graduate Programs. The PR-AMP follows a two-pronged approach with participating institutions, promoting the development of policies and system-wide strategies for reform, while providing professional development and facilitating the formation of leadership, and a cadre of reform professors empowered to pioneer the educational reform (PR-AMP 1996).

The PR-AMP Curriculum Development and Assessment Center is spearheading the transformation of the undergraduate curriculum through a collaborative effort of faculty from all participating institutions and disciplines. The main thrust of this transformation has been the shift in the focus of teaching from breadth of content to depth of understanding and integration of knowledge within and between disciplines. This effort has initially concentrated on five gatekeeper courses:

Introductory Physics, General Chemistry, Introductory Biology, Precalculus and Calculus-- courses in which there has been high levels of student failure. The emphasis of the reform is on: incorporating a constructivist approach to the teaching-learning process and emphasizing conceptual understanding rather than algorithmic procedures; transformation of the laboratory experience to follow an inquiry-based approach and application of knowledge to a new situation through experimental design; integrating the class and laboratory into a single academic unit; development of diagnostic exams and the design of learning modules to address areas of student need; and the incorporation of technology, such as the graphing calculator and CBLs (Calculator-Based Laboratories) in both science and mathematics courses. Fundamental changes in assessment have also been pioneered, including performance-based tests with open-ended questions that require multiple solutions, and multiple choice questions that test depth of understanding and problem solving skills, minimizing rote memory. Results of pilot course sections are highly positive; some courses in which satisfactory grades (A,B, or C) totaled 40% to 60% prior to PR-AMP, have increased grades to 85% with less than 10% failures (F's) and withdrawals. Institutional metrics have been developed to assess the improvement of SMET undergraduate education, such as: student performance in pre-test/post-tests, graduation rates, average number of years required to complete a BS degree, and the Index of Course Efficiency. Academic CEOs are using these metrics as a guiding force for planning and institutional research, and for establishing accountability procedures to promote systemic transformation.

Strategies to develop learning/study skills have been incorporated into courses through weekly workshops by faculty mentors and upper division students as peer mentors who guide students and model effective study strategies, providing assistance in areas of need, and offering feedback on their progress. Findings of a PRAMP study comparing the grades of students participating in the workshops and comparable non-participating students in the General Chemistry course indicate that A and B grades doubled while Fs and withdrawals were reduced to a third. Officials of PRAMP institutions are scaling up the pilot efforts, and extending them to upper level courses to promote the total transformation of undergraduate SMET education.

In 1997, the number of degrees conferred by PRAMP institutions had increased from 1,709 in 1991 to 2,726, an increase of 60% in the rate of annual degrees conferred. Data from the National Research Council, based on a five-year running average shows that PRAMP institutions contributed 22% of the Hispanic graduates who subsequently earn a Ph.D. in SMET, either in Puerto Rico or the Mainland.

The PRAMP Teacher Preparation Component seeks to increase the number of graduates qualified for teacher certification in areas of identified teacher shortage- chemistry, physics and mathematics. Students are provided with enrichment activities that improve their performance in science and mathematics courses, such as special workshops and scientific and educational research internships, and engage them in professional development activities in the PR-SSI schools. Most students are from low-income families and stipends are provided to help them with the costs of education.

The **PR-AMP National Advisory Board**, composed of outstanding national leaders in SMET education, in their October 1995 report to the NSF, recognized the excellence of the PR-AMP and its contribution as a national model for the education of minority students: *"The Board is highly impressed by the success of Phase I and convinced that Phase II plans and proposals will succeed even more, while institutionalizing the various successful PR-AMP program components by the year 2001... We are convinced that PR-AMP will strengthen not only PR's ability to lead the Nation in the supply of Hispanic-American PhDs but will provide models that can be easily replicated by*

mainland institutions serving disadvantaged groups". The PR-AMP has established a Virtual Center funded by NSF to collect, evaluate and disseminate the best practices in SMET curriculum and teaching strategies to all AMP institutions nationwide

List of Faculty Participants in the PR/GK-12 Teaching Fellows Program

A group of exemplary faculty members from the SMET Departments at both the Río Piedras and Mayaguez Campuses will coach the fellows during their participation as professional development resources for K-12 teachers. Each Fellow will be assigned a specific mentor responsible for the supervision of his/her work and for providing them support. A group of at least 14-15 faculty members will be part of the team. The faculty team are leaders in the K-16 science and educational reform and are recognized in the SMET Departments for the quality of their teaching, and their initiatives and commitment to the improvement of SMET education. They have had extensive experience in the professional development of K-12 science and mathematics teachers, and in the K-12 curricular reform and development of educational standards. Most of them have also been key players in the undergraduate reform of the PRAMP and the PRCETP. The following faculty members have already been recruited to form part of the team:

- ! Josefina Arce, Ph.D., Principal Investigator, and Mentor-Department of Chemistry, Río Piedras Campus;
- ! Héctor Joel Alvarez, Ph.D., in Biology, Co-Principal Investigator and Mentor- Department of Education, Río Piedras Campus;
- ! María Aponte, Ph.D., Co-Principal Investigator and Mentor, Professor of Chemistry and Dean of Graduate Studies, Mayaguez Campus;
- ! José Roberto López, Ph.D., Mentor- Department of Physics, Mayaguez Campus;
- ! Ana Guadalupe, Ph.D. Mentor- Department of Chemistry, Río Piedras Campus;
- ! Luis Fonseca, Ph.D., Mentor, Professor and Researcher, Graduate Program of Chemical-Physics, Río Piedras Campus;
- ! Gary Toranzos, Ph.D., Mentor- Professor of Biology and Researcher, Graduate Program of Biology, Río Piedras Campus;
- ! Pablo Salzburg, Ph.D., Mentor- Professor of Mathematics and Researcher, Graduate Program of Mathematics, Río Piedras Campus;
- ! Gladys Nazario, Ph.D., Mentor- Department of Biology, Río Piedras Campus;
- ! Juan Gerardo González Lagoa, Ph.D., Mentor- Professor and Researchers in Marine Sciences, Graduate Program of Marine Sciences, Mayaguez Campus;
- ! Johannes Scellekens, Ph.D., Mentor, Professor, Department of Geology, Mayaguez Campus;
- ! Lueny Morell, Ph.D., PR-AMP Curricular Development Coordinator, Graduate Program of Engineering, Mayaguez Campus;
- ! Betty Ramirez, Ph.D., Mentor-Department of Mathematics, Mayaguez Campus;
- ! Deborah Moore, Ph.D., Mentor- Department of Mathematics, Mayaguez Campus.

Along with the Faculty mentors, a group of fifteen K-12 science and mathematics teachers selected from among lead teachers participating as professional development resources in the PR-SSI and the PR-CETP will form part of the GK-12 Program team of mentors. They will participate in the professional development of the Fellows and will assist them by providing support and coaching during their performance as professional development resources in the schools.

School District Support

The Puerto Rico Department of Education is a single school district comprising 1,538 K-12 public schools. The Secretary of Education is the chief executive official for the school system and has been fully involved in the planning and implementation of the PR-SSI reform which serves as the main foundation for this proposal, establishing it as the central strategy to promote the reform of K-12 science and mathematics education for all students in the system, and adopting the curricular standards and curricular programs developed through the PR-SSI in the PRDE Science and Mathematics Programs. To ensure the fulfillment of the reform goals and the permanent transformation of the system, Professor Fajardo has assigned substantial financial resources for the successful implementation of the PR-SSI reform. A letter of support signed by the Secretary, indicating an assurance of the participation of the schools in the PR/GK-12 Fellows Program, is included at the end of this narrative. The following text summarizes the main points of the letter:

The proposed GK-12 Project represents an integral and key component of the ongoing educational reform of K-12 science and mathematics carried out through the collaboration between the Puerto Rico Department of Education (PRDE) and the RCSE, and spearheaded through the Puerto Rico Statewide Systemic Initiative (PR-SSI), with the co-sponsorship of NSF. Through the alliance of the (PRDE), the RCSE, and the Community-At-Large we are striving to provide high quality standards-based education for all our students at the K-12 level. The GK-12 Project will contribute in a unique and highly significant way to strengthen our joint endeavor to address critical areas which are magnified through the scaling-up of the systemic reform.

Our K-12 science and mathematics teachers currently face the challenge of aligning their teaching practices with national and local standards of excellence. To achieve this alignment, considerable strengthening of the depth and breadth of their conceptual understanding of the key science and mathematics concepts is required as well as learning more effective ways of teaching these concepts to students with diverse learning needs. The graduate and advanced undergraduate students being developed by the RCSE consortium institutions in the areas of science, mathematics, engineering, and technology (SMET) constitute a wealth of resources that can be harnessed to fulfill this need. We envision the GK-12 Fellows to be an invaluable resource that will greatly further our achievement of the science and mathematics reform, particularly as we are in the midst of Phase II which entails the scaling up of the Whole School-Based Strategy (WSBS) from the 200 schools that participated in Phase I, to an additional 600 schools by the year 2003.

Besides the immediate benefits that our teachers and students will receive through their access to the assistance to be provided by the Fellows, the GK-12 Program also provides a mechanism to induct and nurture a group of future scientists, mathematicians and engineers with the skills and experience needed to be productively engaged as long term partners and resources to K-12 science and mathematics, thus contributing to the long term sustainability of the systemic reform. It is our hope that the GK-12 Fellows will serve as leaders, role models and advocates in the local scientific community to augment the pool of talented professionals in these fields who are committed and willing to become agents of excellence in the K-12 educational system.

The public school system in Puerto Rico is organized into a single islandwide district, and the Secretary of Education is the top executive officer for the system of 1,538 schools. Prof. Fajardo has pledged full collaboration in all aspects of planning and implementation of the Project, and will issue an official assurance to provide access of the GK-12 Fellows to the schools in which they will be carrying out their field experiences to provide professional development and serve as educational resources for teachers and students. Each Fellow will be directly engaged in providing assistance to K-12 teachers for a minimum of ten hours per week. He will also ensure that exemplary cooperating

teachers are assigned as needed to serve as mentors of these students and to provide them support in their work at the various school sites. He will maintain close communication with the pertinent Regional Directors, Superintendents and School Directors to make certain that the Fellows receive full support at the local level.

During the ten year period from 1992 to 2003, the PRDE will have invested substantial resources in the science and mathematics reform spearheaded through the PR-SSI, at the average rate of \$2.6 M per year, to ensure the profound and permanent transformation of our educational system towards the achievement of standards of excellence. **As required in the Program guidelines, the Secretary of Education has assured that the resources to be provided by the NSF through the GK-12 grant will not in any way supplant extant financial resources assigned to science and mathematics education.** (See signed letter with assurance at the end of the narrative section).

Goals, Objectives and Thematic Basis

The central theme of the PR/Graduate Teaching Fellows in K-12 Education Program will be: Advancing the Constructivist and Interdisciplinary Approach to Learning Science, Mathematics, and Technology. The **main goal** of this Program is to enhance the content knowledge of K-12 science and mathematics teachers through a constructivist and interdisciplinary approach to strengthen the effectiveness of their teaching practices to develop students' higher order learning skills, depth of conceptual understanding, and the ability to integrate knowledge among and between disciplines. This effort will improve the performance of K-12 students in science and mathematics and will optimize their development as self-directed and lifelong learners, contributing to improve the quality of future generations of the scientific and technological workforce. The **fundamental strategy** to achieve this goal through the PR/GK-12 Program is to recruit, train, and engage a cadre of excellent graduate SMET students as professional development resources for K-12 science and mathematics teachers to participate in the PR-SSI K-12 standards-based reform.

The selection of the focal themes that will be emphasized in the training of the Fellows in this Program is based on the needs assessment of K-12 teachers implementing the PR-SSI standards-based curriculum, as determined through various means. One of the main sources for the needs assessment are the results of the PRSSI Three Tiered Student Performance Assessment System, which is being implemented in collaboration with the College Board. The pre/posttests include publicly released items from NAEP and TIMSS. Teachers participate in workshops where they discuss the results of the tests and identify areas in which they need to improve their teaching effectiveness. The analysis of the results of the pretest clearly point towards specific areas of conceptual knowledge that need to be addressed through the professional development of teachers. These areas of need are confirmed through additional sources of information: 1) the formative evaluation process of the PRSSI Professional Development Staff who are in charge of the design, implementation, and evaluation of the professional development of K-12 teachers and the follow up of teachers in the classroom; 2) the schools improvement plans prepared annually by each school; and 3) the working knowledge of the PR-SSI Curricular and Professional Development Staff developed over eight years of educational reform.

The following table provides a summary of major areas of need which have been identified and which will be addressed by the PR/GK-12 Program through the professional development of K-12 teachers:

Science	Mathematics
<ul style="list-style-type: none"> ! K-12: Physical and Chemical Properties of Matter; Light and Sound ! Energy ! 7-12 grade: Physical and Chemical Environmental Analysis ! Genetic concepts- Population and human genetics ! Earth Sciences: Atmospheric phenomena, Plate Tectonics. 	<ul style="list-style-type: none"> ! K-6: Patterns and Relationships ! K-12 Statistics & Probability- Collection, Interpretation and Analysis of Data; Preparation of Graphs ! 7-12: Algebraic concepts using physical & biological concepts ! 7-12 Mathematical functions and relations among variables ! Mathematics modelling to explain phenomena

In addition to the needs assessment formulated through the PR-SSI Student Performance Assessment System, general trends of professional development needs have been established by educational level as follows:

- ! Elementary Level- teachers need to strengthen science and mathematics content in general as teachers at this level are required a minimum number of content courses in science and mathematics for certification;
- ! Intermediate level: teachers need to strengthen both content and interdisciplinary connections, with emphasis on Earth Sciences;
- ! High school level: most teachers specialize in Biology, and there is a scarcity of teachers prepared in Physics and Chemistry as well as in Mathematics.

Based on these broad areas of need, the PR/GK-12 Program will address the three themes set forth by the NSF in the GK-12 guidelines as follows:

1) Learning processes: K-12 teachers need to develop knowledge of the learning processes related to teaching concepts based on a constructivist and interdisciplinary approach which emphasizes inquiry-based learning experiences, incorporating developments of cognitive sciences research that evidence effectiveness of particular strategies for teaching science and mathematics at each grade level. Knowledge of the cognitive processes involved in promoting an interdisciplinary understanding of concepts needs to be strengthened at all levels. The teaching of content knowledge in the PR-SSI curricular program emphasizes the connections among all science and mathematics disciplines and between sciences and mathematics in all grades, therefore the GK-12 Program will focus on a theme-based interdisciplinary perspective that allows for the integration of knowledge from the different disciplines in the understanding of the core concepts, particularly those focal themes identified by the PR-SSI in the assessment of K-12 teachers professional development needs.

2) Knowledge Transfer: Teachers need to update their knowledge of developments in the different disciplines by acquiring the know-how that will allow them access to this knowledge and to its effective incorporation into the standards-based curriculum. GK-12 Fellows will serve as links between the scientific knowledge base and will facilitate its transfer to the classroom particularly in relation to the adaptation/integration of the scientific research methodology as an integral part of learning science and mathematics. GK-12 Fellows will assist teachers in accessing and understanding this knowledge and bringing it to the classroom setting through real-life activities,

including experiments, case studies, and research projects that will enhance and build upon the implementation of the PRSSI standards based curricular materials;

3) Uses of technology as teaching and learning tools: Fellows will assist teachers in the use of several technologies that facilitate the development of conceptual understanding through a constructivist approach, including the use of hand-held and graphing calculators, CBLs, computer-based instruction and the Internet. The PR-SSI is placing special emphasis on the integration of the hand-held calculator at all grade levels, specifically the graphing calculator coupled with physical and chemical sensors, to facilitate understanding the connections between science and mathematics, and promoting the development of statistical representation and mathematical modelling of phenomena at the intermediate and high school level.

To address all the areas of need for professional development identified through the PRSSI, the PR/GK-12 Teaching Fellows will be recruited from all disciplines of UPR graduate programs including biology, chemistry, physics, mathematics, engineering, marine sciences and geology. At least five students will be recruited in the area of Mathematics, one in Engineering and the remaining 9 in the different sciences. The aim is to have broad representation of students from these areas to prepare an interdisciplinary team who can learn and work together forming a **Community of Learners** who will assist teachers in promoting connections among disciplines in their efforts to enhance conceptual knowledge in all areas of science and mathematics. The **specific objectives** of the PR/GK-12 Program to be achieved by 2003 are:

- ! To **expand the pool of high quality professional development resources available for PR-SSI Phase II** required for the intensification of the scaling-up effort by recruiting, training and engaging up to **45 high quality graduate students in SMET fields** who will serve as professional development resources for K-12 science and mathematics teachers as well as for cooperating and mentor teachers of future and novice teachers;
- ! To provide **professional development for K-12 science and mathematics teachers to strengthen their conceptual knowledge and content specific teaching strategies** to improve student learning and performance through depth of understanding and interdisciplinary knowledge in key concepts according to national and local standards;
- ! To **improve the use of the existing knowledge base in the different SMET disciplines** among K-12 teachers to enhance their professional development and the quality of their teaching practices by incorporating this knowledge into the K-12 curriculum;
- ! To **expand the effective use of educational technology in K-12 science and mathematics education** based on a constructivist approach, particularly the use of hand-held and graphing calculators, computer based instruction, and the Internet;
- ! To develop a **model program that will enhance partnerships between universities, the scientific community, and K-12 schools** to enhance scientific literacy for all students and the preparation of future scientific workforce and sustain the systemic reform of K-16 SMET education; and
- ! To **improve the teaching skills of graduate SMET students** as future scientists, mathematicians, engineers, and faculty members and as potential long term resources and advocates for the ongoing improvement of K-12 science and mathematics reform.

PROJECT PLAN

The Puerto Rico Statewide Systemic Reform as Foundation for the PR/GK-12

Teaching Fellows Program

The PR-SSI constitutes an alliance established since 1991 between the Puerto Rico Department of Education (PRDE), which comprises 1,538 K-12 community schools, and the RCSE, a consortium of the main higher education institutions on the Island created in 1980, including the Río Piedras and Mayaguez Campuses which are the principal graduate centers that will provide the candidates for the PR/GK-12 Teaching Fellows. The proposed Program will be also be articulated with ongoing efforts to transform the preparation of future science and mathematics teachers through the Puerto Rico Collaborative for Excellence in Teacher Preparation (PR-CETP) and will build on the the PRAlliance for Minority Participation (PR-AMP). **These programs and their major accomplishments have been described in detail in the Results of Prior NSF Support Section of this proposal (pages 2-6).** The RCSE, as the grantee of these three systemic programs, has established a long term and successful alliance between the consortium of the main higher education institutions on the Island, the K-12 public educational system and the community-at-large to undertake the transformation of K-16 science and mathematics education throughout the Island. Through the articulation and synergy of these three programs, the RCSE will provide a sound foundation for the productive and optimal preparation and utilization of the NSF GK-12 Teaching Fellows.

The two main graduate institutions that are key players in this Project, the Río Piedras Campus and the Mayaguez Campus of the University of Puerto Rico System, are playing a main role in all three systemic reform programs through a significant group of SMET faculty from these institutions who have been extensively involved in all phases of the systemic reform as well as in numerous other specific science and mathematics teacher enhancement programs funded mainly by the U. S. Department of Education State Dwight D. Eisenhower Program and NASA. The **Río Piedras Campus**, located in the metropolitan San Juan area in the northeastern region of the Island, offers PhD degrees in Chemistry, Physical Chemistry and Biology, and a Masters Degree in Mathematics. As part of the Biology Graduate Program, Masters level students have the option of specializing in the field of Ecology. The **Mayaguez Campus**, the Land-Grant Institution of the Island located on the western coast, offers PhD degrees in Marine Sciences and Civil Engineering, and Masters degrees in Physics, Chemistry, Biology, and Geology. Students from all these programs will be recruited to participate in the GK-12 Fellows Project to form a broad spectrum of professional development resources.

The articulation of the ongoing systemic reform programs with the proposed GK-12 Teaching Fellows Program will be ensured in the following ways:

- ! ***GK-12 Fellows will participate as resources for the PR-SSI K-12 Professional Development Component in scaling-up and strengthening the standards-based reform;***
- ! ***The PR-SSI, PR-CETP and PR-AMP Professional Development Programs will provide training activities for the GK-12 Fellows as part of their preparation as professional development resources for K-12 teachers; and***
- ! ***GK-12 Fellows will serve as professional development resources for the PR-CETP student teachers in practicum and novice teachers and their cooperating and mentor teachers.***

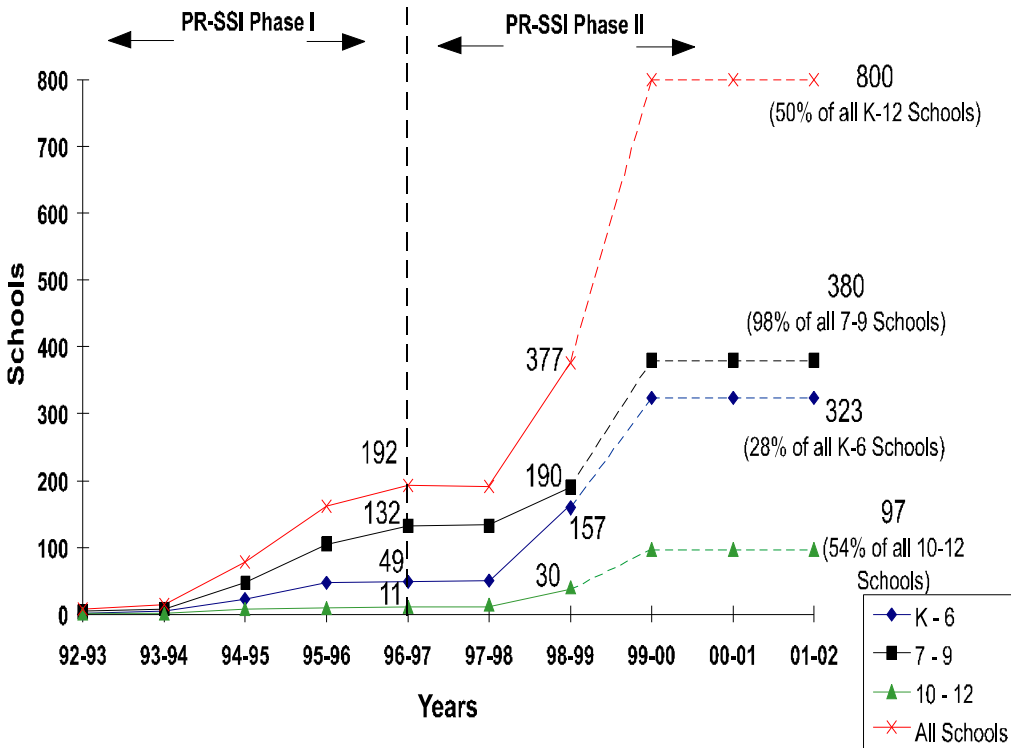
The Principal Investigator of the PR/GK-12 Program, Dr. Josefina Arce, Professor of Chemistry of the Río Piedras Campus, and Co-Principal Investigator Dr. Maria A. Aponte, Dean of Graduate Studies of the Mayaguez Campus, will be directly involved in the overall coordination of the Program, and will serve as resources for the preparation of Fellows and as Mentors. Dr. Hector

Joel Alvarez and Prof. Frances Figarella, Coordinators of the PR-SSI Curricular and Professional Development Components, will work with Dr. Arce in the design, implementation of the professional development program for the Fellows and in the coordination of PR-SSI school staff who will make the arrangements for placing the Fellows in the schools. The Team of GK-12 Faculty and Teacher mentors will work as professional development resources for the Fellows and will serve as mentors to provide ongoing support and assistance to the Fellows during their work as professional development resources. Each Fellow will be assigned a faculty mentor and a lead teacher.

The Role of PR/GK-12 Teaching Fellows as PR-SSI Professional Development Resources in the K-12 School System:

The PRSSI is currently undertaking Phase II as one of eight SSI programs nationwide co-sponsored by the NSF to serve as models of systemic reform. Funding will be provided for the PR-SSI by NSF until August of 2002, and for the PR-CETP until June 2003, based on an annual performance review. The major goal of PR-SSI Phase II is to expand the reform from the total of 197 schools that participated in Phase I, to a total of 800 schools by 2002, an increase of 600 additional schools. In 1998, 200 schools were incorporated and in the year 2000, 400 more will be inducted. The following diagram illustrates the PR-SSI scaling-up impact.

Impact of PR-SSI Reform on Puerto Rico's Schools Scaling-Up of "Whole School Strategy" (Years 1992 - 2002)



To achieve this goal the PR-SSI has begun to recruit and train additional faculty and teachers to expand the pool of human resources available and highly qualified to undertake the scaling-up effort in 2000. The PR/GK-12 constitutes a timely endeavor that will enhance and facilitate the ongoing PR-SSI scaling-up process because Fellows will play a crucial role 1) participating as content specialists in the PR-SSI Professional Development Program and Follow-Up for the incoming generation of 400 new schools; and 2) providing support teachers from the 200 schools who entered in 1998 and need follow-up to strengthen their mastery of specific content knowledge and the incorporation of educational technology into the implementation of the standards-based curriculum. The Teaching Fellows will provide assistance to K-12 science and mathematics teachers in coordination with the PR-SSI school-based Regional Professional Development and Dissemination Centers, and the support of the PRSSI Central Staff. Each of these Centers organizes and offers a 100 hour per year minimum professional development program to the teachers in their respective regions for the implementation of the PRSSI standards-based curricular program. Fellows will concentrate on schools located in the six educational regions (out of a total of 10 on the Island) that surround the area in which the graduate campuses are located to facilitate their participation as resources and safeguard the time they require to complete their degrees on time.

The Scaling- Up of the PR-SSI Whole School Based Professional Development Program

Schools are recruited to participate in the PR-SSI on a voluntary basis and are provided a professional development program through a Whole School Based Strategy (WSBS). All science and mathematics teachers in each school are required to complete the 200+ hour professional development program which spans over two years. This inquiry-based professional development program prepares teachers in the fundamentals required to implement a standards-based curriculum and assessment program and to develop effective inquiry-based teaching strategies. The PRSSI program includes a two-week summer program and ten Saturday sessions during the year, which provides an overview of the local science and mathematics standards, fundamental principles of constructivist teaching strategies, demonstrations and hands-on/minds-on curricular activities to promote learning of science and mathematics concepts, and authentic assessment methods.

In addition to the 200 hour Professional Development Program, the Coordinators of the PR-SSI Regional Centers, who are exemplary teachers dedicated full time to the PRSSI, provide on-site follow-up visits to teachers on an individual and group basis to observe classes focusing on the teaching strategies, to provide support for teachers related to their concerns in the implementation of the curriculum as well as to assess further professional development needs. The PR-SSI Curricular Development team also conducts formative evaluation visits to monitor the implementation of the PR-SSI curriculum and identify areas of need for further professional development.

The PR/GK-12 Fellows will be trained to serve as professional development resources in the PR-SSI Summer and Saturday workshops and in providing follow-up activities to teachers both at the PR-SSI school-based Regional Professional Development Centers and in the participating school sites as well as in the classrooms. Fellows will serve as the content expert pairing up with a veteran teacher to offer the workshops to groups of around 20 teachers per session. The Saturday workshops are 5-hour sessions held once per month during the academic year and the Summer sessions consist of 12 five hour sessions. The PR-SSI Professional Development Program is offered at the school-based Regional Centers, and each Center will be serving an average of 150 teachers. It is estimated that each Fellow could provide close to 50 hours of professional development throughout the year to these teachers as part of the PR-SSI workshops. In addition to the 50 hours of professional development in the workshops, the Fellows will provide 470 hours in follow-up to PR-SSI teachers for the implementation of standards-based curriculum. In this strategy, schools that are being initiated in the PR-SSI during the year 2000, as well as those that entered in 1998 will be invited to participate. The PR-SSI Coordinator will prepare a monthly schedule with the Fellow to visit PR-SSI schools, based on the rate of 10 hours per week. The Coordinators continuously assess the professional development needs of the particular schools in their region and they will arrange for the services of their assigned Fellow according to the priorities of these schools. Each school will prepare for receiving the Fellow and will group a number of science and mathematics teachers, including the cooperating teachers and mentors from the PR-CETP, to participate in the professional development activities to be offered by the Fellow. Each school will indicate the specific areas of need they confront in the implementation of the PR-SSI curriculum as the basis for the assistance of the Fellow. The Coordinator will also identify clusters of schools that share common areas of need and arrange for special workshops to address the needs of various schools and therefore optimize the use of the Fellows' time and reaching a broader population of teachers.

Fellows will work with the PR-SSI Coordinators and their assigned faculty and lead teacher mentors to design professional development activities according to the specific areas of need. Emphasis will be placed on strengthening content knowledge and its application in the development of innovative learning activities including laboratories, experiments, and research projects based on the PRSSI curricular framework and standards, providing the teachers access to scientific resources, and demonstrating the use and integration of different educational technologies. The Fellow and the teachers will also design activities together and implement them as a team in the classroom so that Fellows are engaged in direct instruction and can gain first hand knowledge of the teaching experience. Each Fellow will be required a minimum of five hours of preparation per week during which they will document and evaluate their activities, design the new activities and prepare materials for implementation. Each Fellow will be supplied with the materials they require to carry out the professional development activities, including a graphing calculator with sensors and others.

Fellows will also be available to assist teachers through electronic communications (e-mail and telephone) to enhance the access for consulting with the Fellows. The use of e-mail among teachers will be stimulated as very few teachers are regular users of this technology and need to improve the use of this tool for their ongoing professional development.

Training Program for PR/GK-12 Teaching Fellows as Professional Development Resources for K-12 Science and Mathematics Teachers:

The selected PR/GK-12 Teaching Fellows will be prepared as K-12 Professional

Development Resources through a yearlong program designed jointly by the PR-SSI Professional Development and Dissemination staff and the PR/GK-12 Staff. The experience of the PR-SSI in working with university faculty over the years establishes the need to provide professional development for them to ensure their effective participation as resources for K-12 teachers. The following is a general outline of the professional development program to be provided to the Fellows:

1) PR-SSI Professional Development Program: Summer retreat and two follow up workshops (50 hours).

The PR-SSI will offer a four day retreat during the summer, and a minimum of two follow-up workshops during the year for the new professional development resources recruited from the SMET faculty and teachers who are to participate in the PR-SSI scaling-up strategy beginning in Y2K, and the Fellows will be required to participate. This program will include:

- ! Synthesis of the research in cognitive sciences applied to K-12 teaching and learning of science and mathematics;
- ! General knowledge of the national and local K-12 science and mathematics standards;
- ! An overview of the PR-SSI principles, reform strategy and K-12 curricular matrix, program and curricular units,
- ! Emphasis on the constructivist approach to teaching science and mathematics concepts focusing on the integration of knowledge and connections among and between disciplines, inquiry-based and cooperative learning teaching strategies, and authentic assessment methods;
- ! Principles and strategies of effective communication and adult education.

Throughout the training program, fellows will be engaged in hands-on/minds-on teaching activities and will be videotaped to analyze their effectiveness and receive feedback on their performance and communication skills.

The following is an example of a training activity of the PR-SSI Professional Development Resources based on the concept of Osmosis:

* In-depth discussion of **constructivism** and the teaching-learning environment that promotes learning based on the latest research in cognitive science.

* Exemplify, by modeling, what is meant by teacher-centered vs. **student-centered** teaching-learning environment.

***Model an active-learning activity** to promote conceptual understanding. **Interactive demonstrations** that follow the Prediction-Observation-Explanation approach will be modeled. First the demonstration of placing HCl and Ammonia at the two extremes of a tube to "discover" the concept of diffusion is presented. Participants must predict what they expect will happen, then observe the phenomena and later engage in a thorough discussion of the observed results and possible explanations. The Fellows then will draw a concrete microscopic representation of the observed phenomena and share it with the group.

*A second interactive demonstration to escalate the concept to diffusion through a membrane is modeled where three systems are presented: (1) a solution of iodine inside a membrane with a starch solution outside (2) a starch solution inside a membrane with an iodine outside (3) a solution of

iodine inside a test tube with a starch solution outside. Again the Fellows make predictions, observe what happens and explain their observations.

* The use of **educational technology** to develop depth of conceptual understanding is modeled by having Fellows work in cooperative learning groups using graphing calculators -coupled to a pressure sensor- to measure changes in pressure over time inside a membrane immersed in a solution of pure water and sugar. With this activity the proper use of educational technology using an inquiry-based activity is modeled.

* A discussion of how the modeled activities integrate the content and professional standards ensues. Each fellow is provided with a copy of the local standards and must place a check mark next to each fundamental idea each standard that was addressed in the discussion.

* Interdisciplinary connections are identified through a concept mapping exercise. Discussions of the applications of the concept to everyday life situations are promoted.

* Alternative ways of assessing the understanding of the osmosis concept are presented and discussed, such as, concept maps, Gowin V microscopic representations and drawings, and conceptual questions.

2) Faculty/Teacher Mentors and Community of Learners:

Prior to the PR-SSI Summer program, the PR/GK-12 Faculty and Teacher Mentors will be assigned to each fellow according to their respective disciplinary area to coach and provide them with ongoing support on one-to-one and group basis during their service as K-12 professional development resources. Throughout the year, projectwide monthly meetings will be held at each campus to follow -up on the Fellows activities and promote discussion of professional development issues and experiences among fellows, faculty and leader teachers to provide ongoing support and identify areas of further need of support and to promote the formation of a community of learners among them. Special workshops in key areas will be provided for fellows during the year to be complemented with participation in the PR-AMP and PR-CETP Faculty Development Workshops as pertinent to the specific interests of each Fellow, coordinated with the advice of his/her Faculty Mentor.

Fellows will also be invited to group discussions of PR-SSI Professional Development resources. The Faculty and Lead Teacher Mentors will carry out on-site visits to the Fellows at the schools 2-3 times per semester to observe them during their work and provide them with feedback for improvement. A Website linked to the PR-SSI and the PR-CETP will be created to include electronic discussions among Fellows, Mentors and teachers, and to present exemplary activities developed by Fellows and Teachers.

Mentors will be required to prepare semestral evaluation reports of the Fellows work that include self evaluations of the Fellows, and evaluations by teachers who received assistance from the Fellows. Evaluation criteria will include completion of the time requirements in direct assistance, effectiveness in achieving the professional development goals, commitment to K-12 reform,

Training Program Work Keys to Teaching Excellence
constructivist approach & PR-SSI reform
Field experiences in PRSSI Schools and Professional Development Program
Fellows engage in hands-on/minds-on teaching activities and receive feedback
Faculty and teacher mentors coach and provide ongoing support during the year
Project meetings to promote discussion of professional development issues and experiences and formation of community of learners
Participation in periodic PR-SSI/PR-CETP and PR-AMP workshops during the year in key areas of professional development

understanding of the constructivist approach to teaching, and mastery of effective professional development strategies among others.

3) Field Experiences in PR-SSI schools:

To complement the PR-SSITraining Program, Fellows will participate in field experiences in PR-SSI schools and teacher workshops so that they can observe PRSSI faculty and exemplary teachers modelling the professional development and teaching strategies. During these workshops they can be participant observers, participating as co-resources with PRSSI faculty and teachers to gain first hand knowledge of the professional development activities they will be building on through their school-based mentoring activities, and establish relationships with the teachers they will be assisting. It is estimated that altogether, including the Summer session, the field experiences, the professional development workshops, and follow-up by mentors, each fellow will have participated in over 120 hours of formal professional development activities focusing on the constructivist and interdisciplinary approach to K-12 science and mathematics education. Each Fellow will receive a Certificate upon completing the one year training and service experience.

Benefits of the Project to the GK-12 Fellows and K-12 Education

The envisioned program presents a very unique and creative endeavor that will generate multiple benefits for all parties involved, most of all for the Fellows themselves and the teachers and students who will interact with them. For Fellows participating in this Program, it will provide an invaluable experience and opportunities for professional growth which broaden the scope of their graduate experience, in line with recommendations set forth in recent reports by the National Science Board (1997) and the National Academy of Sciences (1995). We envision the following benefits:

- ! It is known that in teaching others, the teacher develops a deeper understanding of the subject he/she teaches, particularly so when the learning process itself becomes an object of reflection. Furthermore, in learning about cognitive sciences applied to learning science and mathematics from a constructivist approach, students will become aware of metacognitive processes which will have a spillover effect to their preparation in graduate school. Therefore, in engaging in the teaching of concepts to K-12 teachers and students, the Fellows will also gain a better understanding of their discipline;
- ! The interdisciplinary focus of the PR-SSI curricular program, which will be emphasized in preparing Fellows as professional development resources and in their assistance activities with teachers, will strengthen the Fellow's interdisciplinary perspective which will allow for higher level learning in his/her graduate studies, and substantially enhance their preparation for interdisciplinary scientific research and problem solving;
- ! In enhancing Fellows' teaching and communication skills they will improve their capabilities as potential future faculty members, particularly their ability to teach to diverse learners. They will also improve their skills as scientific lecturers to the general public, and heighten their awareness of ways to increase scientific literacy, enhancing both their professional careers and potential contribution to increase public support for scientific enterprise;
- ! Given the growing diversity of the occupational outlook for future PhDs in SMET, it is increasingly important for graduate students to develop skills that prepare them for untraditional work settings. Being involved in the public schools will give the Fellows key skills such as teamwork with a heterogenous group of people, and creative problem solving

applied to the teaching-learning process that are very important for student to perform in and adapt to in an everchanging job market;

- ! The experience of participating in the improvement of K-12 science and mathematics education will foster a new and more meaningful perspective of the Fellow towards his/her profession, by broadening their understanding of the importance of scientific literacy among the general population, the importance of helping students mostly from disadvantaged backgrounds learn better and become more empowered as citizens, will strengthen the students motivation in his/her career, developing awareness of their role and responsibility as future scientists, mathematicians and engineers in contributing toward the community.

The benefits of the Fellows for the K-12 community are also numerous as this Program represents a rare opportunity to access to a group of unique professional development resources who are experts in disciplinary content areas that are related to their specific learning needs and who will work closely with teachers in the classroom to tackle the situations they confront in the transformation of the teaching-learning practices. Fellows will have a fresh perspective and a more open mind towards learning than more senior scientists and will be able to develop a more collegial relationship with teachers, thus facilitating the professional development process, while also serving as a link between teachers and the leading edge research and knowledge in the SMET fields. Fellows will also serve as role models of scientists, mathematicians and engineers in the classroom for K-12 students from disadvantaged backgrounds who mostly have not had any experience with this kind of specialist, in this case a young person with whom they can more readily identify as a role model. **Over 85% of the student population of the public school system in Puerto Rico come from families below the Federal established poverty level.**

For the faculty and teachers who are leading the systemic reform in K-16 education, the value-added to the reform effort will be considerable, as the Fellows will be expanding the pool of high quality human resources needed to advance the PR-SSI professional development program in particular areas of need. It is anticipated that the experience will be highly motivational for Fellows, and will promote their long-term involvement with K-12 education as future scientists, mathematicians and engineers, contributing to the sustainability of the reform beyond the PRSSI, and even become advocates to attract their colleagues to follow suit. Furthermore, the Fellows will also contribute a new perspective for the team, hopefully bringing with them creative approaches to the challenges posed by the professional development. The local universities on the Island as well as many in the mainland will gain highly competent faculty for their SMET programs, as a high percentage of the PhD graduates in SMET programs at the Río Piedras and Mayaguez Campuses become SMET faculty members.

Recruitment, Selection and Retention

Key information on recruitment and graduation of students for each one of the Departments that will be participating in the PR/GK-12 Program is presented in Table I (see next page). Each year, a total of fifteen \$18,000 Fellowships will be awarded on a competitive basis, in addition to a \$5,300¹ fee for costs of education to be provided to each institution per Fellow. The Fellowships will

¹ The cost of graduate credit at the UPR is \$75.00, and the normal credit load per graduate student is 15 credits per semester, therefore a total of 30 credits per year will amount to \$2,250,

be announced and awarded each year. To ensure broad awareness of the availability of the Teaching Fellowships starting in January of 2000, , the GK-12 Staff will carry out a campaign including special meetings, posters, and brochures through the Offices of the Deans of Graduate Studies and Departments of the Río Piedras and Mayaguez Campuses. The information to be disseminated to students, faculty and administrators will convey the central objective of the GK-12 Program, the benefits of participating in this unique experience, as well as the criteria and procedure for selection, and conditions for the fellowships, and will provide an application form. Second year students in both Masters and Doctoral programs will be targetted. Candidates must be students enrolled in one of the SMET graduate programs, U.S. citizens, nationals or permanent residents. Students who were former

plus \$2,000 for books and other materials, and \$1,050 for travel will be allowed per student.

PR-AMP participants will be tracked and targeted as special candidates for the Fellowships since they will have participated in the redesigned the undergraduate curriculum of SMET programs based on an inquiry approach that emphasizes conceptual understanding, and will have therefore experienced learning with faculty who model innovative teaching methods through this non-traditional approach. Many of these students continue graduate education at the Mayaguez and Río Piedras Campuses. It is anticipated that there may be a shortage of graduate candidates in the Mathematics Programs at Río Piedras and particularly in Mayaguez. To overcome the potential shortage, a group of highly qualified advanced undergraduate students participating in PR-AMP will be identified and invited to compete for the fellowships. In the case that all five graduate students required for the field of Mathematics are not available, up to two advanced undergraduate students will take the place of each graduate slot.

It is estimated that a pool of at least 45 students will be eligible for, and interested in the GK-12 Fellowships each year, considering the amount of students enrolled in the targeted graduate programs in their second and third year of studies (over 150 students per year), the benefits to be attained through this unique experience which will be emphasized through the awareness campaign, and the amount to be provided which exceeds other currently available research stipends. To apply for the fellowship, students must present: an official copy of their academic record evidencing a minimum GPA of 3.0, two letters of recommendation from faculty, and an essay on their motivation to participate as resources for K-12 science /mathematics education and their commitment to fulfill all the requirements and conditions of the fellowship. The deadline for submitting an application will be in April of each year. The GK-12 Faculty Team will evaluate candidates qualifications. After an initial screening, candidates who qualify will be called for a group interview with K-12 leader teachers in which they will discuss their interest in science/mathematics education. A total of 15 students will be selected, 7-8 each at Río Piedras and Mayaguez. Priority will given to selecting at least one student in each of the fields, except in Mathematics which will require five students. The final selection of awardees will be completed in each May. Awardees will be announced through a press conference and will be formally presented in a recognition ceremony.

To promote the retention of fellows they will be provided with continuous support through the Faculty Mentors and the GK-12 Staff. At the outstart of their participation, a general meeting for all Fellows, faculty mentors and collaborating teachers will be held to discuss the details of the program and expectations by both students and faculty members. A faculty mentor will be assigned to each fellow according to their discipline to provide support and follow-up to on the student's request to address students concerns and difficulties. The PI and CoPIs will coordinate the selection and support of the Fellows and work closely with SMET Deans, Department Chairpersons and Directors of graduate programs to enlist their full understanding and cooperation with the program and support to the faculty mentors and Fellows in their work. Monthly meetings with mentors and ongoing electronic discussions will be held to assess and discuss progress, issues and strategies to improve support for Fellows and address difficulties that arise in a timely fashion.

Organization and Management

The PR/GK-12 Teaching Fellows Program will be directed and managed by the Resource Center for Science and Engineering (RCSE), a consortium of the main higher education institutions on the Island, which is directly under the Office President of the University of Puerto Rico System. The RCSE is the site of the PR-SSI, the PR-CETP, and the PR-AMP, as well as of the PR-Experimental Program to Stimulate Competitive Research (EPSCoR) which is strengthening the infrastructure for competitive research on the Island funded by the NSF and four other Federal agencies, and is fostering the enhancement of graduate SMET programs at the Río Piedras and Mayaguez Campuses. The direction of the PR/GK-12 Program from the RCSE, therefore, will facilitate the full participation and collaboration of both the Río Piedras and Mayaguez Campuses which are major partners in the consortium, and direct access to and coordination with PR-SSI schools through the existing partnership with the PRDE. The 27 PR-SSI School-Based Regional Professional Development and Dissemination Centers, from which the scaling-up of the PR-SSI will be undertaken and where the Fellows will conduct many of the professional development activities, are directly coordinated and supervised by the RCSE.

The Principal Investigator (PI) of the PR/GK-12 Teaching Fellows Program is Josefina Arce, PhD, faculty member of the Department of Chemistry of the Río Piedras Campus and Principal Investigator of the PR-CETP. Dr. Arce has been an outstanding leader in the K-12 science and mathematics reform, and has been active in the professional development of teachers and the improvement of K-16 SMET education since 1980. She has participated in the elaboration of the local science standards for K-12 education and the Professional Development Standards for science and mathematics teachers, and has served as professional development resource and consultant for the PR-SSI K-12 reform. She was formerly the Coordinator of the PR AMP Curriculum Development and Assessment Center during three years. Dr. Arce will be responsible for the overall direction, planning, implementation and supervision of the project to achieve the stated goals and objectives. She will also be actively involved in all aspects of the program, particularly as a professional development resource for the Fellows and as a Mentor. As PI of the PR-CETP, Dr. Arce is ideally poised to articulate the PR/GK-12 Program with the K-16 reform, promoting the synergy among efforts.

Dr. Arce will work closely with the Deans of Graduate Programs of the Río Piedras and Mayaguez Campuses in the design and development of the program. Dr. María A. Aponte, Associate Dean of Academic Affairs and Director of Graduate Studies at the Mayaguez Campus will serve as liaison for the Campus. She is a recognized researcher and has been involved in professional development for science and mathematics teachers and as a mentor for precollege students in the area of research. A second Co-PI is Héctor Joel Alvarez, PhD, member of the Faculty of Education of the Río Piedras Campus, who is Coordinator of the PR-SSI K-12 Curriculum Development Component, in the design and implementation of the Fellows professional development program and supervision.

Prof. Frances Figarella, Coordinator of the PR-SSI Professional Development and Dissemination Component will collaborate with the PR-GK-12 Project in the design and implementation of the professional development program for the Fellows and in coordinating the logistics for placement of the Fellows in the PR-SSI schools. The Team of Faculty Mentors to participate in the Program will be faculty from the SMET Departments of Mayaguez and Río Piedras, ensuring a balanced representation among the Departments (see page 7 of proposal). Each fellow will be assigned a faculty mentor and a leader teacher from the PR-SSI to provide ongoing support.

The development of the PR/GK-12 Program will be overseen by Dr. Manuel Gómez,

VicePresident for Research and Academic Programs, who has been designated by the UPR President to organize the top level academic leadership of the UPR SMET programs to undertake the improvement of graduate education. Dr. Gómez is Professor of Physics of the Río Piedras Campus, Director of the RCSE, and Principal Investigator of the PR-SSI and PR-AMP. He is also member of the Governor's Science and Technology Council and served as advisor in the elaboration of the Science and Technology Policy.

The Team of PI and Co-PIs will be in charge of the program implementation ensuring the articulation and integration of all activities through monthly meetings for the discussion of central issues and decision-making related to all aspects of the program. The Office of the PR-CETP Center for Excellence in Teacher Preparation located at the RCSE, will provide the management infrastructure for the PR/GK-12 Project, assisting the PI and CoPIs in the day-to-day implementation of activities and in the administration of the project. The fiscal administration of the project will be channeled through the UPR's Resource Center for Science and Engineering (RCSE), which has developed a highly efficient post-award system for the support of grants. *At the end of this proposal narrative will be found a letter of the President of the UPR Dr. Norman I. Maldonado, certifying that the NSF GK-12 Funds will not be used to supplant other extant federal fund. The Letter of support from the school district signed by Secretary of Education, Víctor Fajardo, also assures that NSF funds will not supplant extant financial resources.*

The **distribution of fellowships** will be decided by the PI and Co-PIs. As described in the Section on Recruitment and Retention, the selection of fellows will be based on a set of criteria that include excellence in academic progress, study and career interests, letters of recommendation, an essay on their vision of science and mathematics education and their potential role as fellows, and an interview with the Selection Committee. Students will be ranked by Committee members and those with the highest scores will be selected for award. Fellowships will be renewable for up to 3 years in cases that provide justification, and will depend on a satisfactory review of progress. An equitable distribution of the fellowships among the diverse participating graduate programs will be ensured—there are ten programs, therefore the intent is to award at least one fellowship per program, and five graduate/advanced undergraduate students from programs in Mathematics.

The plan for achieving maximum leverage at the K-12 school level from the limited number of Fellows, as explained in the Project Plan, consists in incorporating them into the PR-SSI Professional Development Program and follow-up system where they will reach a broad audience of teachers that will have been recruited. Furthermore, the availability of the Fellows will be announced to all PR-SSI schools in the appropriate regions, those currently completing the professional development program and those that will enter in Y2K. The PR-SSI will identify the schools in which the Fellows will provide assistance and will make arrangements to facilitate the provision of their services. Schools requesting the services of the fellows will be selected according to the number of teachers to participate in the activities, including teachers from neighboring schools, and PR-CETP participants which include novice teachers and preservice students, and their cooperating and mentor teachers.

To promote the **continuation of this program beyond the NSF funding period**, the PI and CoPIs together with the VicePresident and Deans of Graduate Programs will work during the development of the grant to propose the establishment of internships or practicums for graduate students in SMET programs as a valuable opportunity to enhance their preparation as future professionals. A proposal will be presented highlighting the benefits of the internship as a learning

experience for the students and will request the establishment of this experience as an option for graduate credit.

Performance Assessment

The evaluation of the PR/GK-12 program will be closely articulated with those of PR-SSI, and the PR-CETP by a part-time evaluation and assessment specialist. The main purpose of this research-based evaluation will be to translate data from multiple sources into meaningful information that will be used to drive this important component of the systemic reform in Puerto Rico. Following NSF guidelines, baseline data will be obtained to measure trends in the following indicators that will provide a profile of the population being served: 1) time to degree; 2) number of and type of higher education participants' placements; 3) age and gender distributions; 4) subject area of undergraduate degree; 5) employment expectations upon graduation; 6) previous teaching experience; 7) previous professional development experience within the reform; 8) attitudes towards teaching Science and Mathematics; and 9) willingness to remain involved in the reform, among other variables of interest.

The impact of the PR/GK-12 program will be determined at the classroom, school, and higher education institution levels. Semi-structured interviews will be conducted with the fellows, their faculty and teacher mentors, their cooperating teachers, and the school principals to assess the contributions of the fellows to the overall reform in terms of the objectives stated in this proposal as well as to obtain information that will enable the program to make mid-course corrections to its overall design. Semi-structured interviews will also be conducted as a formative evaluation mechanism with teachers who participate in the professional development provided by the fellows to assess the overall effectiveness of the program in meeting their own professional development needs and to identify additional areas of need. Special attention will be given to the progress made by PR-SSI schools where fellows are assigned in terms of overall performance and student academic achievement.

Fellows will be required to participate in workshops designed by PR-SSI to assess teacher mastery of content and to determine professional development needs. These workshops will allow them to undergo the experience of responding to sets of items analogous to those included in the PR-SSI's pre/post tests, which are based on NAEP and TIMSS. Fellows will further be required to prepare and maintain portfolios of their experiences with the program where they will keep samples of their work and evidence of the activities in which they participated. Fellows will work on reflections and self-assessments to keep track of their progress in the program. Videotapes of a sample of professional development activities offered by the fellow to teachers will be analyzed by their mentors who will also provide onsite visits for academic and technical assistance. Monthly meetings between fellows and mentors will provide an opportunity for the fellows to share their experiences and for the mentors to obtain direct feedback about the program from the perspective of the fellows.

A global analysis of the data produced through the performance assessment will be carried out through joint sessions between the program evaluator and program staff to identify and synthesize evidence of the best practices in terms of the various components of the training program and support for fellows and the components related to the services provided by the fellows in the PR-SSI Regional Professional Development Centers and schools. The following table indicates the

timeframe for the development of the program and evaluation data will be collected to document and analyze the effectiveness of each major milestone. The evidence produced will be used to prepare an evaluation report with recommendations for the future improvement of the program and specific activities.

ANNUAL TIMELINE 1999-2002 FOR PR/GK-12 IMPLEMENTATION

Activity/Milestones
<p><u>October -March:</u> Carry out campaign announcing availability of fellowships among pertinent departments to disseminate the Program and recruit candidates, distribute applications. At least 40 top-rate students apply from all departments. Select the fifteen best students among the different areas as fellows and ensure equitable distribution among disciplines, with at least five Fellows in the discipline of Mathematics. Announce Fellows awarded among the educational and scientific community. Each year select fellows as needed.</p>
<p><u>March-May:</u> Design and implement training retreat with PR-SSI staf and assign faculty and lead teacher mentors to each Fellow. Fellows complete 50 hour program and evidence mastery of constructivist/interdisciplinary approach to teaching and understanding of PR-SSI reform. Each fellow is assigned a Faculty and Teacher Mentor and is assigned to work at a PR-SSI Regional Professional Development Center.</p>
<p><u>June:</u> Fellows participate as resources in the PR-SSI Summer Professional Development program. Announce the availability of Fellows to schools in their assigned regions. Distribute applications to request services of Fellow among schools.</p>
<p><u>July- October:</u> Schools submit applications for services of NSF Fellows. Needs analysis of schools participating in PR-SSI Phase II as basis to prepare overall schedule for Fellows to offer professional development workshops and follow-up and support. Schedule prepared to optimize the use of the fellows among schools that require their services.</p>
<p><u>August-May:</u> Fellows implement professional development plan in cluster of PR-SSI schools to provide follow-up for PR-SSI teachers in the implementation of the standards-based curriculum. Also serve as resources in professional development for future and novice teachers, cooperating, and mentor teachers participating in PR-CETP at these schools. Fellows offer additional professional development monthly Saturday workshops as part of PR-SSI Professional development program. Teachers participating in the professional development with Fellows indicate effectiveness of their services in strengthening the implementation of standards-based curriculum and in developing depth of understanding and interdisciplinary connections and incorporation of educational technology.</p>
<p><u>June to May:</u> Mentors provide support for fellows in offering the professional development services and monitor their participation. They gather evidence of the effective implementation of fellows professional development plan in the schools. Fellows express adequate support by mentors. Participation of fellows in periodic GK-12 meetings to form a community of learners that fosters peer learning on their experiences in the program, discussion of issues and transfer to their graduate preparation, as well as to strengthen interdisciplinary collaboration and conceptual connections. Fellows participate in additional PR-SSI, PR-CETP and PR-AMP workshops and discussion sessions as part of training. Fellows evidence development of further knowledge and skills in areas needed to provide improved services to schools.</p>
<p><u>June to May:</u> Global analysis of evidence of professional development and impact of fellows on K-12 reform as basis for identifying best practices and formulating recommendations to other sites for implementation of similar efforts. Prepare and present institutional proposal to establish regular internship in K-12 schools as credit course for SMET graduate students, to promote institutionalization</p>

of the Program beyond NSF funding.